PROCEEDINGS OF
A WORKSHOP ON
WATER QUALITY MANAGEMENT AND POLLUTION CONTROL

Lake Basin Development Authority
25 July - 5 August 1982

Sponsored by:

GOVERNMENT OF KENYA: National Environment Secretariat
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Conducted by:

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and

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In Cooperation with: Government of Tanzania
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THE CHAIRMAN'S OFFICIAL ADDRESS

STATEMENT OF

MR. NATHAN W. MUNOKO
CHAIRMAN OF THE BOARD

LAKE BASIN DEVELOPMENT AUTHORITY

WEDNESDAY MORNING
4TH AUGUST, 1982.

Ladies and Gentlemen,

It gives me great pleasure to address this very important workshop which has been organized and hosted by the Lake Basin Development Authority so as to create a two stage forum to discuss at the technical level, Water Quality and Pollution Control in the Lake Basin Area of Kenya and also endeavour to identify the global problems in this area that may originate from the other sectors of the Greater Lake Victoria Basin. To achieve both goals, participants were invited from the United Republic of Tanzania, Uganda and an official of the Kagera River Basin Development Organization We have closely followed the proceedings of your deliberations but before I make specific comments that directly touch upon the theme of this workshop, let me on behalf of the Authority extend a very warm welcome to you and further express the hope that those participants who have come from Tanzania, Uganda, Ruanda and the United States of America will find time to familiarise themselves with the projects and programmes in which the Authority is involved and generally visit Western Kenya and meet our people.

The Government of Kenya has done an excellent job in locating major agro-based industries in Western Kenya which provide thousands of jobs to our people and a steady outlet for the manufacture of sugar, paper, the processing of coffee, tea and the manufacture of textiles. This impressive development has brought with it major environmental problems that must be addressed and resolved in order to assure our people of living in a healthy environment, drinking clean and unpolluted water and I am aware that the technical session of this workshop which you are involved in will advance firm recommendations and draw up a Plan of Action which the L.B.D.A. will study carefully and to ensure its implementation with the support from the Government of Kenya and from International Organizations.

We expect that this workshop will focus on policy matters relating firm commitments from Industry, Local Authorities and the Government to act in a co-ordinated manner to ensure the availability of high Quality Water for our People and the promotion of a pollution free environment for the future. You should now or at a latter but immediate session also deliverate how best to plan and manage the development of the Lake Basin Area in an integrated manner as we are convinced that this integrated approach to planning holds the best hope for the rapid development of this area.

I now wish to address myself to the important issue of Regional Co-operation at the technical, operational and other levels if we hope to safeguard and manage the use of the Waters of Lake Victoria. I am delighted to note that participants from Tanzania, Uganda and the Kagera River Basin Organization are here with us to discuss the important matters I have touched upon at the Regional level and that we will be able to work out mechanisms of co-operation at all levels and appropriately advise our respective governments to support these arrangements and put them into effect at the earliest possible time.

To conclude my remarks I wish to express our sincere appreciation to UNEP for the financial and moral support it has extended to L.B.D.A. towards the realization of staging this workshop and express the hope that UNEP will join hands with the Authority in the implementation of the recommendations and the Plan of Action that are being formulated by this Workshop on a continuing basis.

I also thank ETMA for the full support it has extended to the L.B.D.A. towards the realization of holding this Workshop by making it possible for Lecturers and Resource persons to travel to Kisumu to share their experience with you. I also thank the USAID, the University of North Carolina and the Southeast Consortium for International Development for their full support and co-operation.

Finally, I would like to point out the obvious, namely, that development takes place in an atmosphere of peace and where law and order prevails. Kenya has been fortunate in this respect, thanks to the wise leadership which we have enjoyed since Independence under the leadership of the Lake President Jomo Kenyatta and our beloved President Daniel Toroitich arap Moi. We do not boast, but we feel we have achieved a measure of development commensurate with our resources which we have used to the best of our ability and we hope to continue in the same vain.

The disruptive elements that disrupted the peace and led to loss of life and looting in Nairobi and Nanyuki is the work of a few disgruntled elements who were led by the Kenya Air Force. These people will never be satisfied even with their own deeds. All they want is POWER, the product of which we saw in Nairobi and Nanyuki, i.e. loss of life and looting. This disturbance has been brought under control by the Armed Forces loyal to the President and the Republic of Kenya. Kenyans are grateful to them and feel they are secure and free. The Lake Basin Development Authority wishes to put on record its total loyalty to His Excellency President Daniel Toroitich arap Moi, his Government and the Ruling Party KANU. I can assure you that you can deliberate on what you have set out to do knowing that you are safe under the Nyayo Government. I would also like to ask you to visit other areas of Kenya to acquaint yourselves with the life of the people in this Republic. Everywhere else except Nairobi and Nanyuki, life continued normally, except for the anxiety which relatives had of members of their families in the two towns.

Feel at home and you are welcome to stay as long as you wish. I now have the pleasure of declaring this Workshop formally open.

NYAYO!

COMMENT

BY

MR JOEL N BONUKE
REGIONAL PLANNER

ON BEHALF OF THE MANAGING DIRECTOR

LAKE BASIN DEVELOPMENT AUTHORITY

Moved a vote of thanks to the Chairman and proceeded to give background to the L.B.D.A. The Authority was first declared by His Excellency, the President in 1979 after which an Act of Parliament was adopted establishing the Lake Basin Development Authority.

The purpose of the Authority was manifold but with an emphasis that the Authority be a national organization focusing on the ecological region which, though diverse, has certain unique characteristics. It is a catchment area in the strictest sense of the word. That is what makes it into an identifiable unit. Water resources of the catchment area give unique characteristic to the natural resources of the area.

The Authority is required to act as a catalyst in the development by eradicating the unique problems of under-development. The implication is that to develop the area enhances national goals. The Authority is to carry out planning of the area; identify projects for development in a manner that supercedes the conventional sectoral approaches.

Authority was to distinguish the development area made up of two Provinces: Nyanza and Western but then within the context of the catchment area. Thus the thrust of the development was to focus on the two Provinces but without losing sight of the outer zone, within the catchment area. Development cannot ignore the catchment area as a whole but will conduct conservation studies of that area and ensure its rehabilitation. That is related to the purpose of the present workshop which focuses on water quality and Integrated River Basin Planning and Management. The Planner is therefore required to perceive the development needs in a comprehensible sense.

The analogies are broad between the Lake Basin Development Authority and that of the Tana River Development Authority which has been expanded to include Athi River Basin.

The second role of the Authority is "Coordination". There is a recognition that there are other Ministries working in the same area. However, their work is often unco-ordinated and it is rarely a surprise that they either duplicate or conflict with each other in development planning and implementation. This obviously leads to conflicts.

Thus, the role of Lake Basin Development Authority is sensitive. We have to discuss and compromise until we find a Modus vivendi for achieving our stated goals. This is the case with our work on Upland Rice undertaken in conjunction with the Ministry of Agriculture or the immunization project with Ministry of Health. The projects are of the L.B.D.A. but they have had to get active co-operation and agreement of the respective Ministries of our Government.

It will be possible to do the reverse as well. We can identify desirable projects and defer the execution to the Ministries concerned. We can cause and effect a project or development programmes.

The study of the Authority is ominous. We are expected to correct an anomaly. The anomaly is that in national terms, the region was not developed adequately. Relative to its actual and potential resource, the region was not developed enough to make its correct contribution to the national economy. Our duty is to correct that anomaly and we are expected to husband the natural resources including water. So this Workshop is expected to give guidance to the Authority in the strategies for rational management of the water resources.

Todate, we have undertaken recruitment of professionals to do the work and we have tried to do it carefully. We have a core team of specialists in public health, water, agriculture, fisheries, industries and more are still to come. Our activities will cover the full range of development and rehabilitation work. Perhaps it is important to note that our activities have ranged from public health issue such as tsetse fly extermination in Lambwe Valley (which has implication for animal husbandry too) to upland rice programme (which has implication for agriculture and nutrition).

The negotiations for our development needs has also included discussions with the financial institutions such as AFC and the East African Development Bank. We expect 100,000 bags of additional rice as a result of our project and we intend to expand this project in the coming years. We intend to expand immunization programmes to attach the infant mortality in the area. The infant mortality rate in the Lake Basin area is the highest in the country. An area which loses its youth does not develop.

We have conducted a number of studies including hydrological work for hydro-power potentials and this should give us a source of energy for development of our industries.

I have been impressed by the seriousness of attending the present workshop, which includes a representative of the Kagera Basin Organization. The paper from the latter shows that we have a lot to learn from that experience. Thank you.

Question: Mr Bonuke has outlined the role of the Lake Basin Development Authority as planning as well as coordination. But what are some of the constraints realized in the process?

Answer: One of the greatest constraints is finance. This is a difficult time in our national economy. We have received co-operation in planning but the money for investment is still a bottleneck.

There have been some problems in finding the proper manpower but we have gone a long way in getting local people; but we have also relied on foreign consultants.

We were allocated only Shs. 8 million last year. That gives us the equivalent of a shilling a head for people in the Lake Basin area. What investment is that? We pressed harder and this year we are allocated Kenya Pounds 1.5 million for development. That is still too small in terms of development financing.

Comment: There are internal/organizational problems of developing a new institution. Co-ordination must start from the office that will do the job, and this is a hard task.

Coordination belonged to the District Development Committees and therefore to have a new body to have a finger on the same task creates its own problems but we have been fairing on well.

The idea that the LBDA should go out and assess projects is bound to be slow. As a consequence, there may be loss of funds.

There is the issue of regional distribution of services and projects within the Basin. Very often the criteria is likely to be misunderstood with possible conflicts in the region as a whole.

The implementing ministries have presented no special problem to the L.B.D.A; there are budgetary questions which might cause inconvenience However, every Ministry officials in the field are often very co-operative and enthusiastic to work with the L.B.D.A. The Authority should continue to co-operate with the field officials from the Provincial level downwards. It facilitates rational and mutual balancing of the use of financial resources. The point here is that the Ministry officials and the L.B.D.A. can, and have actually co-operated in joint funding of projects and this approach is to continue.

Comment from a Participant

Co-ordination of aid agents is a point that is worth mentioning. Very often donors have their own preferences based on their knowledge of the country and even Basin Area.

Question Does the L.B.D.A. have problems in marrying the development interests of the Districts at a time when the districts are the focal point for national development?

Answer The L.B.D.A. has a regional mandate but this can be divided to the district level. There is no serious problem since the L.B.D.A. is a member of the District Development Committee in each of the Districts in the Development area. We co-operate in the consideration of government as well as Harambee projects.

The L.B.D.A. expects to assist the districts in feasibility studies and securing the requisite personnel, to ensure rational Planning and execution of the projects. The L.B.D.A. can, for instance, secure services of the National Youth Services to build a bridge which the Ministry of Transport and Communication will not construct.

Question Is the L.B.D.A. involved in second level planning to ensure balancing of contending interests. Are you involved in comprehensive physical plans?

Answer Comprehensive and longterm regional master plans are costly and require more resources than we have. We need external assistance.

The example of Kagera is impressive because they have extensive studies. We would like to do that.

Comment: Overall development planning is an imperative. You need that before you start on clusters of projects. It may be realized that if you wait too long, with small stop-gap measures in projects after which some of the mistakes may be impossible to reverse. Mistakes in water quality, for instance, cannot be reversed easily. Mistakes can be very costly and our objective is to avoid this.

Comment: The Authority is doing some data collection and with proper financial backing from the Exchaquer giving us adequate funds, we shall be able to facilitate research work towards a comprehensive development plan for the region. The L.B.D.A. will also need a fully professional documentation system.

Comment: Usually in projects, one looks at the goal and focus on implementation. It will be important to stress that goal to the exchaquer but at the same time there is a need to consult with consortia of Ministries. The L.B.D.A. has to catalyse and therefore must seek receptivity. Whoever takes credit for the project is immaterial. There are projects that can be best done by L.B.D.A. In Kenya there is a Ministry for overall national planning. But none for overall execution. Therefore the L.B.D.A. has to use the best judgement and decide which Ministry it will work with and which one will execute and with what resources.

We suspect that ultimately, if the rate of development does not rise in the catchment area, the L.B.D.A. will be blamed for it. Therefore we are determined to catalyse and initiate.

Question: Does the L.B.D.A. have any fund for generating projects?

Answer : The L.B.D.A. cannot rely on handouts indefinitely. It will have to embark on fund generating projects. An example is power-generation. Hydro-power potentials are abundant in this region. We can borrow or receive grants for such projects, generate power and sell it.

Water resource use is another example: We could make money by abstracting and selling the water or we could charge users provided that we have an imput in the conservation measures.

Most of the people in this region have invested in the traditional municipal centres. The L.B.D.A. plans to go into joint ventures with the people in the area, sell the shares to any investors and move to new projects in a revolving way. In order to alleviate urban housing, the L.B.D.A. can go into real estate: build houses and generate income from rent.

Comment: The Tana River Development Authority is at this stage getting token amounts. Just now it is planning to embark on finance projects. The Tana and Athi River Development Authority is planning to raise the level of the river.

Comment: The Lake Basin Development Authority could start a company for treatment of wastes and charge the industries or municipalities accordingly.

Comment: The Lake Basin Development Authority could charge for costs, but not just for abstraction of the water generally. Water ownership in the country is vested in the Government, which can appoint water undertakers.

The Authority can enter into agreement with specific local authorities around the lake and assist in marshalling finances. In the process the Lake Basin Development Authority can help alleviate the current problem of water delivery to the municipalities and County Councils.

The L.B.D.A.'s mandate derives from an Act of Parliament, However, there is a whole list of legislation that tend to compromise the activities of the L.B.D.A. e.g. Water Act, Electric Power Act which give monopoly to East African Power and Lighting Company in the marketing of electricity in this country. Kenya/Delmonte Co. - Agreement in regard to Pineapple industry would tend to inhibit any plans to expand and process pineapples in the L.B.D.A. region and elsewhere in the country etc.

CHAPTER 1

IDENTIFYING WATER AND ITS CONTAMINANTS

BY

F. PFAENDER
P.C. SINGER

WATER AND IT'S CONTAMINENTS

By
Dr. F.K. Pfaender

This presentation will address three major questions: First, What is Water? Secondly What do we use it for? and thirdly, What things do we find in water?

1. What is Water? H_2O H-O-H; Its Main qualities are:
   i. it is very stable
   ii. it holds heat
   iii. and water dissolves things.

Water Quality: Fitness of a water for a beneficial use especially drinking, recreation, irrigation, fishing, among others.

Pollution: Addition of undesirable foreign matter that deteriorates the quality of water.

Where is our Water?

Over 99% in oceans and ice caps

- The water we use most - rivers, lakes, groundwater constitutes less than 0.5% of total.
- Worldwide the hydrological system is in balance.
  Oceans evaporate more than get in precipitation
  Land has more precipitation than evaporation
  Balance is stream flow to oceans.

II. What Do We use Water For?

Biggest use is for irrigation, industrial, public water supply.
Then hydroelectric cooling water
Most of U.S. uses surface water supplies, over 60% of total.

WATER CHARACTERISTICS (H_2O)

1. Very Stable
2. Heat Holding Capacity
3. Dissolves Things

Water Quality: Fitness of a water for a beneficial use: Drinking, Recreation, Irrigation, etc.

Pollution: Addition of undesirable foreign matter which deteriorates the quality of the water.

Earth's Water Balance:

TABLE 8-1 LOCATIONS OF THE WORLD'S WATERS (1)

LOCATION		Volume (km^3)	Fraction (%)
Surface water:	Freshwater lakes	120,000	0.009
	Saline lakes, inland seas	100,000	0.008
	Stream channels (average)	1,200	0.0001
Subsurface water:	Soil and vadosewater	65,000	0.005
	Groundwater (to 800m)	4,000 000	0.3
	Groundwater (deep lying)	4,000,000	0.3
Other water:	Ice caps and glaciers	29,000,000	2.1
	Atmosphere	13,000	0.00.
	Oceans	1,315,000,000	97.3
Total (rounded)		1,350,000,000	100.0

Water Pollution: Introduction .8

TABLE 8-2 WATER BALANCE OF THE EARTH (2)	Oceans	Continents	Whole Earth
Precipitation (km^3/yr)	324,000	99,000	423,000
Evaporation (km^3/yr)	361,000	62,000	423,000
Gain by inflow (km^3/yr)	+37,000	-37,000	0
Preceipitation (cm/yr)	90	67	83
Evaporation (cm/yr)	100	42	83
Gain by inflow (cm/yr)	+10	-25	0

U.S. WATER SUPPLY AND PROJECTED WATER USES IN KM^3/YR

	ANNUAL USAGE IN KM^3		
	1965	1980	2000
Rural Domestic	3.3	3.4	4.0
Municipal (Public Supplied)	32.7	46.3	70.0
Industrial (Not Public Supplied)	64	104	176
Agriculture	155	191	212
Steam-Electric Power	117	267	650
TOTALS	372	611	1110
Consumptive Use	118	144	177

U.S. SOURCES - 1975	% OF TOTAL
Ground-Water	20
Surface Water	63
Saline Surface Water	16
Reclaimed Sewage	.001

It is important to keep in mind that any use of water, no matter how benevolent, will contaminate the water with something. Because of waters' extraordinary solvent properties it is easily contaminated.

III. What is in Water?

- Just about everything
- Not all material in water is a pollutant. All materials except synthetic organics occur naturally. What man's activities do is change concentrations and distributions of materials.

Major Pollutants - Categories

Infectious Agents
Chemical Nutrients
Oxygen Demanding Substances
Sediments
Inorganics - toxic and non-toxic
Organics - toxic and non-toxic

1. Infectious Agents:
   - Water can contain a variety of pathogenic organisms. These include the viruses, bacteria, protozoa as well as flukes and worms.
   - Normally transmitted by the oral-anal route.
   - Pathogens in sewage - Table.2.
   - Disease outbreaks - Table.4.
   - To protect people from infectious agents we need to detect their presence. We use Coliform bacteria as indicator organism, because we do not have reliable methods for direct measurement of pathogens.

   Indicator Characteristics

   1. Must come from some source as pathogens.
   2. Must occur in higher numbers than pathogens so easier to detect.
   3. Equally sensitive to environmental factors and disinfectants.

      To be a good indicator must react like pathogen.
   4. Easily quantifiable.

   Coliforms - ferment lactose with production of gas in 48 hrs. at $35^{o}C$.

MAJOR TYPES OF POLLUTANTS

INFACTIOUS AGENTS
CHEMICAL NUTRIENTS
OXYGEN DEMANDING SUBSTANCES
SEDIMENTS
INORGANIX - TOXIC AND NON-TOXIC
ORGANICS - TOXIC AND NON-TOXIC

INFECTIOUS AGENTS IN WATER

VIRUSES	- POLIO
	- ENTEROVIRUSES
BACTERIA	- CHOLERA
	- DY SENTARY
	- TYPHOID
PROTOZOA	- GIARDIA
	- AMEBIC DYSTENTARY
OTHERS	- FLUKES
	- WORMS

TABLE 2. PATHOGENIC MICRO-ORGANISMS IN DOMESTIC RAW SEWAGE

Organisms	Prevalence Rate (%) [a]	Sewage Concentration (organisms/l Typical	Sewage Concentration (organisms/l Maximum	Occurrence in Lower Animals
Bacteria				
-Escherichia Coli (Toxigenic/ invasive)	10	10^7	10^8	Yes
-Salmonella typhi				No
Salmonella paratyphi	1	10^5	10^7	No
Other Salmonella				Yes
-Shigella	1	10^4	10^6	No
-Nycobacterium Tuberculosis	15	10^2	10^2[b]	Yes
-Leptospira	<<1	low	-	Yes
Protozoans				
- Giardia Lamblia	10	10^5	10^6	No
- Entamoeba histolytica	10	10^4	10^5	No
- Balantidium Coli	<1	low	-	Yes
Helminths (Worms)				
-Ascaris Lumbricoides (roundworm)	20			No
Necator americanus (hookworm)				No
Ancyclostoma duodenale (hookworm)	3	10^2	10^3	No
Taenia saginata (tapeworm)	<1			No
Trichuris trichiura (whipworm)	10			
Viruses (100 different viruses	10	10^5	10^5[c]	few

a Prevalence rates for helminths are based upon populations in the rural south; prevalence rates in urban areas and in other geographic regions are lower than the tabulated rates.

b The prevalance rate is not likely to increase.

c An epidemic caused by one enteric virus would not greatly increase the virus concentration of sewage but would change the relative proportions of different virus types. The epidemic virus would become prevalent.

TABLE 4. WATERBORNE DISEASE OUTBREAKS BY TYPE OF ILLNESS - 1976-1977*

Total Outbreaks: 68
Total Cases: 7,775

Agent or Illness	% of Outbreaks	% of Cases
Gastroenteritis**	57	58
Chemical poisoning	12	3
Giardia	11	18
Shigella	9	14
Hepatitis A	7	1
Salmonella	2	3
Typhoid fever	2	<1
Toxigentic *E. coli*	<1	3
	100	100

* Data for 1977 are preliminary

** Norwalk-type virus is suspected etiologic agent in one outbreak.

- We control infectious agents by disinfection processes. Usually chlorination - HOCl effective species.

  1. Chlorination good disinfectant - more effective against bacteria than viruses or protozoan cysts.

  2. Can lead to other problems - trihalomethanes.

2. Chemical Nutrients

All forms of life require chemical nutrients, C,N,P. These nutrients are also required in the proper ratios $C_{106}\ N_{14}\ P_{1}$ Man's activities can generate and release nutrients into the environment.

Excess nutrients can cause problems - algal blooms. Under normal conditions growth in aquatic ecosystems is balanced and controlled by available nutrients, the one present in lowest concentration relative to need controls growth. When we add excess can get rapid growth of algae - algal bloom.

- Unsightly
- Taste and odor
- Clogging of water works
- Toxins generated by algae
- Oxygen demand

The whole process leads to eutrophication. Eutrophication is the natural aging of lakes - it will happen naturally but over long period of time. By adding nutrients man speeds up the aging process.

3. Oxygen Demanding Substances

- Oxygen in water is critically important for fish life.
- Many of the materials we add to water create an oxygen demand.
- All water has extensive microbial populations - microorganisms metabolically breakdown materials from sewage, industrial waste, agricultural run off and use O_2 in process.

INDICATOR ORGANISM

- MUST COME FROM SAME SOURCE AS PATHOGENS
- MUST OCCUR IN HIGHER NUMBERS
- EQUALLY SENSITIVE TO ENVIRONMENTAL FACTORS AND DISINFECTANTS
- EASILY QUANTIFIABLE

COLIFORMS MEET ALL THESE CRITERIA.

COLIFORM BACTERIA = ALL THOSE BACTERIA THAT CAN FERMENT LACTOSE WITH PRODUCTION OF GAS IN 48 HOURS AT 35°C.

DISINFECTION

$CL_2 + H_2O \rightarrow H^+ + CL^- + HOCL$

O_3

CLO_2

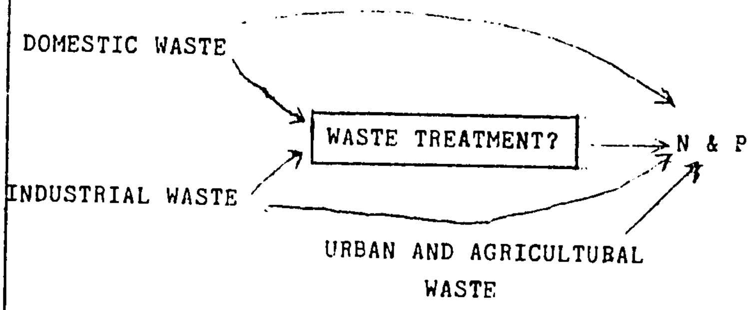
COMBINED CHLORINE

$HOCL + ORGANICS \rightarrow CL^- +$ CHLORINATED ORGANICS

CHEMICAL NUTRIENTS

LIVING MATTER = $C_{106} N_{14} P_1$

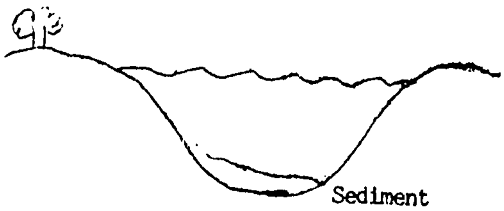
LIMITING NUTRIENT = THAT PRESENT IN LOWEST CONCENTRATION RELATIVE TO NEED



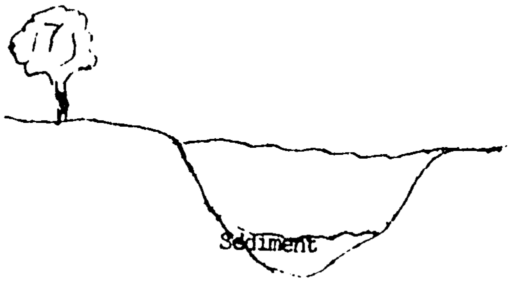
ALGAL BLOOMS

- UNSIGHTLY
- TASTE AND ODOR
- CLOGGING OF CANALS AND WATERWORKS
- TOXINS
- OXYGEN DEMAND
- EUTROPHICATION

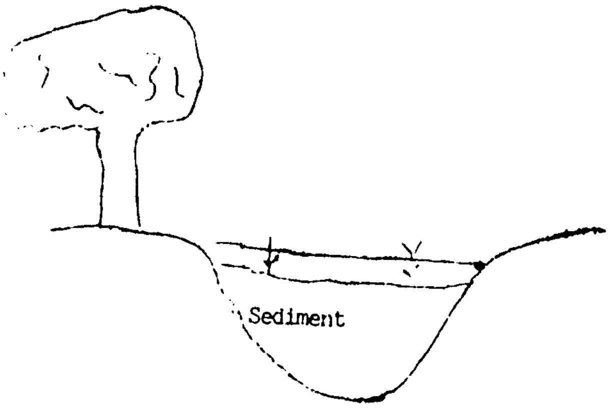
NATURAL AGING OF LAKES = EUTROPHICATION



YOUNG LAKE - OLIGOTROPHIC NUTRIENT POOR, LOW PRODUCTI ITY, CLEAR WATER



MIDDLE AGED LAKE - MESOTROPHIC - HIGHER NUTRIENT CONCENTRATION, HIGHER PRODUCTIVITY, MORE TURBID WATER



OLD LAKE - EUTROPHIC - SHALLOW, GREAT ACCUMULATION OF SEDIMENT - HIGH NUTRIENT, PRODUCTIVITY-VERY TURBID WATER

- If these materials are released into lake or river the O_2 in water will be decreased. We measure BOD - Biochemical Oxygen Demand as a way to assess how much oxygen a waste will consume.
- Can construct engineered systems so oxygen demand is satisfied in tank rather than natural water.

4. Sediment

Sediment load to water generated by erosion of soil man's activities in removing ground cover and soil disruption can accelerate soil losses.

5. Inorganic Pollutants

- all metals occur naturally - man's activities change concentration and distribution.
- Metals Hg, Pb, As,Fe,Cu,Zn, etc.
- Exposure from food, air, and other sources usually more important than water.

6. Organic Pollutants

- These are substances other than the readily oxidizable compounds that create BOD problem.
- We are really concerned with the persistent chemicals. Chemicals that breakdown rapidly are not major health problem - even if quite toxic.

SEDIMENT

- NOT HARMFUL EXCEPT AT VERY HIGH CONCENTRATION
- CAN HAVE 100,000 TO 200,000 MG/L
- 100,200 MG/L CAN HAVE EFFECT IF ALLOWED TO ACCUMULATE

    1. COVERS FISH FOOD AND HABITAT
    2. DECREASE WATER FLOW INTO SEDIMENT
    3. 90% MORTALITY TO TROUT EGGS BY 200 MG/L

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INORGANIC POLLUTANTS

METALS - MERCURY
LEAD
ARSENIC
IRON
COPPER
ZINC

MOST FROM INDUSTRY

WATER EXPOSURE USUALLY NOT MAJOR ROUTE FOR HUMANS.

ORGANIC POLLUTANTS

- PROBLEM WITH STABLE ORGANICS
- RECOGNITION OF PROBLEM THE RESULT OF ADVANCES IN ANALYTICAL CHEMISTRY
- THOUSANDS OF COMPOUNDS
- SOURCES: INDUSTRY - SOLVENTS, FEED STOCKS, WASTES
  AGRICULTURE - PESTICIDES
- QUESTION: WHAT ARE EFFECTS OF LONG TERM EXPOSURE TO VERY LOW CONCENTRATION?

∠ chemical

- This problem can be recognized as a result of development of new analytical ∠ techniques that allow measurement of very small amounts.

- Literally thousands of compounds.
- They come from industry - solvents, feed stocks, wastes
  agriculture - pesticides
  municipal - trichalomethanes
- These compounds are usually present at very low concentrations - parts per billion.
- We do not know what exposure to low concentrations means.
  1. Most data from toxicity studies using animals other than man.
  2. Toxicity studies usually done at high concentration.
  3. What is impact of consuming 1/10 gram over whole lifetime?
  4. Our ability to measure for outdistances our understanding.
  5. Toxicity not major problem - sublethal effects - carcinogens.

How do we control water pollutants - what are alternatives?

- Recovery - reuse
- Product modification
- Process modification
- Elimination
- Dilution
- Dispersion
- Diversion
- Environmental Treatment
- Waste Treatment

OXYGEN DEMANDING SUBSTANCES

CO_2 + $+H_2O$ → ORGANICS + O_2 AUTOTROPHS

ORGANICS + O_2 → CO_2 + H_2O + ENERGY – HETEROTROTROPHS

NH_4 + O_2 → NO_3 – N_2O + ENERGY

H_2S + O_2 → $SO_4^=$ + H_2O + ENERGY

BOD = BICHEMICAL OXYGEN DEMAND

WATER POLLUTION CONTROL ALTERNATIVES

- Recovery - Reuse
- Product Modification
- Process Modification
- Elimination
- Dilution
- Dispersion
- Diversion
- Environmental Treatment
- Wastewater Treatment

COMMENT ON
WATER AND ITS CONTAMINANTS

BY

F. PFAENDER

Water is H_2O, it has stable characteristics whatever the environment. It holds heat and therefore can serve as an insulator. It also influences tempeature and climate which is an influence on all other activities.

Water is a good solvent and dissolves most substances, to some extent. This raises the concern about its **quality.** Water quality is defined as the suitability of the water for a beneficial use. Pollution is defined as the introduction of anything that is deleterous to a given use. Thus pollution relates to the use. Therefore the extent and degree of pollution ought to be related to the intended purpose .

A lengthy discussion interupted the presentation when the participants intervened to say that a definition which focuses only on specific uses at a given point in time would cause serious long-term problems.

It was agreed that the element of planning must be introduced in the water use.

Water is found in different distribution. 97% in oceans, 2% in Ice Caps, and only ½ - 1% is available for ordinary usage.

also Water is constantly in motion: In oceans, in vapour form, as rain, on rivers and Lakes/Oceans.

The biggest user of water in U.S.A. is in cooling systems. It is not consumptive. At the same time there are smaller uses as irrigation and domestic consumption. All these uses add something to the water. These are called contaminants.

1. Infectious agents include bacteria, viruses and other disease causing micro-organisms (See Table 2 of Pfaender Lecture). The problem for man is through consumption. Oral - Anal path. The predominant diseases are on Table 4.

   Generally, however, it is difficult to detect presence of pathogenic micro-organisms. Very often we depend on indicator organisms. The indicator bacteria often used is the bacteria Escherichia coli developed by a German Scientist about 90 years ago. Since coliform bacteria are associated with human faecal matter their presence can be used as indication of the presence of sewage and by association, the presence of pathogens. In a laboratory test, the higher the concentration of the E-Coli the higher the concentration of the faecal contamination.

Procedures can be done for total of facal coliforms. Ordinarily the test done should correspond to the intended use, or what is perceived as acceptable level of purity of the water. Then the applicable or acceptable disinfectant such as chlorine is applied to the water. There are other disinfectants but chlorine is applied to the water. There are other disinfectants but chlorine is still the most dominant and perhaps most reliable and safest. Granted, there are possible chlorinated organics but there is still a highly doubtful effects on human beings.

2. The effect of chemical nutrients on water is to increase growth in the water. (see schematic presentation in Work Book (E). Depending on the composition of the nutrient added, the phosphorus or Nitrogen will control the nature of growth. Algal bloom for example will result from the addition of excess nutrients. These can cause taste, odor, asthetic and health problems as well as physical obstruction in water passage. At the same time when the bloom dies, oxygen is depleted and can kill water life. Essentially, the age of the Lake can be hastened by adding materials to water. The example in this regard is Lake Eirie and Lake Michigan.

3. Microbial metabolism which can be summarised as:
   - Organic material + O_2 — CO_2 + H_2O + Energy and is characterised as an oxygen demanding reaction.

- $NH_4 + O_2 - NO_3$ can also result in oxygen demand. This reaction can be measured by the measurement of BOD - Biochemical Oxygen Demand - That is the measure of the impact of the waste that may be dumped into the water, on the Oxygen and resource of the receiving water, and the factor depends on the effluent involved.

4. Sedimentation has problem in terms of its physical impact as well as hastening age of a water body.

5. Inorganic pollutants occur naturally. Most of us consume these through food rather than water. The main source is industries and of such effluents heavy metals (e.g. Mercury, copper) are the most dangerous. There are several chemical techniques for determining the presence as well as the concentration of the metals.

6. Organic substances are dangerous if they are persistent for long periods of time. An example is pesticides. Some pesticides are degradable and have short lives, (i.e. organophosphates) but there are many that are persistent in natural and polluted bodies of water. The concentration is often very small - often only a few parts per billion.

   The main origin is industries and pesticides from agriculture, among others. They can be detected fairly easily; the toxity study is often more difficult. The simple test of dipping an animal, e.g. rat, is often used to test the toxicity of specific chemical pollutants. These are elusive because we have, for instance, used water treated with chlorine which means that there is chloroform, a carcinogenic substance, in the water we drink. The problem is with determining the effect of that chloroform on human consumers.

that

The substances that are characterised as harmful are extremely large and they can be identified but it is an awesome task to determine their presence and toxity; and evaluate whether long term exposure to miniscale concentrations has a significant effect.

Water pollution control alternatives are manyfold. One can recover and reuse; modify the product or process; eliminate the production; dilution (is the solution to pollution)! upto a point - because we are exceeding the absorptive capacity of the water bodies; dispersion; diversion; environmental treatment; or wastewater treatment.

Even though these alternatives have scientific basis the mode chosen is essentially a policy matter.

EFFECTS OF POLLUTANTS ON
RECEIVING WATERS

BY

PHILIP C. SINGER

I. Rivers and Streams

A. Dissolved oxygen depletion due to biological oxidation of organic material (exertion of BOD)

e.g. $CH_2O + O_2 \rightarrow CO_2 + H_2O$.

1. Rate of O_2 utilization = $K_1(L-Y)$
   where
   k_1 = deoxygenation constant, $days^{-1}$
   L = initial BOD of wastewater
   (L-Y)= BOD remaining at any time

2. Rate of O_2 supply = k_2D
   where
   k_2 = reoxygenation or reaeration constant, $days^{-1}$
   D = dissolved oxygen deficit $(C_s - C)$at any tim

3. Oxygen sag curve

$$\frac{dD}{dt} = k_1 (L-Y) - k_2D$$

$$D = \frac{k_1L}{k_2-k_1} (e^{-k_1t} - e^{-k_2t}) + D_oe^{-k_2t}$$

   where D_o = initial deficit. See Figure 1.

4. k_1 is a function of the nature of the wastewater (a typical value is 0.23 day^{-1} at 20°C), while k_2 is a function of the stream characteristics, e.g. velocity (V), depth (H). A general relationship is:

$$k_2 = \frac{(D_L V)^{\frac{1}{2}}}{H^{3/2}}$$

   where D_L = $8x10^{-5}$ ft/hr at 20°, the diffusivity of oxygen. The ratio of k_2/k_1 is termed the oxygen recovery or self purification factor, f. See Table I.

5. Effect of temperature:
   a. Rate constants increase, C_s decreases as temperature increases.

b. Heated wastewater can significantly magnify the extent of DO sag.

c. Seasonal effects may be significant.

6. Effect of ammonia (nitrogenous oxygen demand)

a. Nitrification. See Figure II.

$$NH_4^+ + 2O_2 \rightarrow NO_3^- + H_2O + 2H^+$$

4.57 mg DO consumed per mg of ammonia-nitrogen oxidized.

7. Species diversity

a. Numbers of organisms increase but diversity of species decreases. See Figures III and]

8. Benthic deposits

a. Deposition of suspended organic material (settleable solids) in vicinity of discharge can lead to benthic oxygen demand, and unaesthetic conditions in vicinity of discharge.

b. Benthic demand is much slower and can have long-lasting effect. See Table II.

B. Aquatic Toxicity

1. Due to discharge of specific pollutants which are toxic to aquatic life, e.g. heavy metals, CN, pesticides, polynuclear aromatic hydrocarbons, chlorinated and nitro-phenols. See Tables III and IV.

2. Usually of industrial origin.

3. Generally non-biodegradable (refractory) species which persist in aquatic systems. In addition to their toxic impact on aquatic life, at lower concentrations these species can enter the food chain and accumulate to levels which may be harmful to man.

C. Die-Away of Enteric Organisms

1. Enteric organisms will die in natural waters due to lack of food and lack of ideal conditions for survival (as are found in the intestines of man). See Figure V.

2. Rate of die-away increases with increasing temperature and is more rapid in turbulent shallow streams than in deep, sluggish streams. It is also more rapid in industrially polluted streams than in clean streams.

II. Lakes and Impoundments

A. Lakes tend to stratify due to density differences brought about by temperature variations. See Figure VI.

1. Such thermal stratification will result in vertical gradients in water quality, especially dissolved oxygen.

2. Eutrophication due to inputs of nitrogen and phosphorus. See Figures VII and VIII.

   a. Stimulation of algal activity, photosythesis in surface waters, i.e. production:

$$106CO_2 + 16NO_3^- + HPO_4^{-2} + 122H_2O + 18H^+ \xrightarrow{light} \underset{\text{algal protoplasm}}{C_{106}H_{263}O_{110}N_{16}P_1} + 138O_2$$

   b. Leads to production of unsightly algal material in lakes.

   c. Leads to taste and odor problems if the water is used for drinking purposes.

3. Ultimately, dead algae die, settle to the bottom of the lake, and decay, exerting a significant oxygen demand.

$$\underset{\text{algae}}{C_{106}H_{263}O_{110}N_{16}P_1} + 138O_2 \rightarrow 106CO_2 + 16NO_3^- + HPO_4^{-2} + 122H_2O + 18H^+$$

   a. Bottom of lake can go anoxic, resulting in reduction of nitrate to ammonia, sulfate to sulfide, ferric to ferrous iron, carbon dioxide to methane.

   b. The nutrients which are released during the decomposition are returned to the surface waters during spring and fall overturn and can lead to additional algal production during the next summer season.

   c. Reduced substances from anoxic hypolimnion are released to overlying waters during overturn causing problems if the water is used as a source of drinking water.

   d. Sediment accumulates in lakes at a faster rate than under natural conditions.

B. Aquatic Toxicity and Die-Away of Enteric Organisms

1. Similar considerations as for rivers and streams (see above).

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EXPLANATORY COMMENTS

EFFECTS OF POLLUTANTS ON RECEIVING WATERS

BY

DR P.C. SINGER

Referred to the Workshop and explained the importance of dissolved oxygen and the nature of BOD - as a measure of the strength of a Waste Water. The concern is with the rate of oxygen consumption or the deoxygenation process. The reaeration process has a rate which depends on the degree of undersaturation of the water. The lower the oxygen concentration the higher the rate of reaeration - See Fig.1.

The general decrease in oxygen content of the water increases with the introduction of organic material into the water. At times, the water can become anaerobic at which point the water does not support any useful life at all. The process can be inhibited by reduction of the waste load or increased addition of oxygen.

Temperature changes have effect on the pollution process: Effect of ammonia - 4.57 mg DO consumed per mg of ammonia - nitrogen Oxidized. Organic materials as well as ammonia are two major consumers of oxygen from water. As a result of introduction of these substances in water organisms will rise in number, but the diversity of aquatic species will go down. Thus an adverse ecological environment will result. See Figure III and IV.

Downstream from organic (BOD) discharges, the water goes from clear fresh water, - turbidity and darkness, - septric noxious odors, sludge - improving - clear water.

Most of the suspended materials in the discharge (effluent settle to the bottom of the river or stream. Thus, they may cover sites such as spawning ground and increase oxygen demand.

With respect to the discharge if persistent (non-biodegradable) pollutants, the general concerns are the effects of any of the pollutants reach in the food chain, bioaccumulating, and ultimately being consumed by man.

In lakes and impoundments it is not only the deoxygenation due to the decay of organic material, but lakes also tend to stratify due to temperature differences between upper

and lower waters and due to quiscent conditions.
The deeper waters are cooler than the top water, and is therefore more dense. It is true however, that the temperature differences in the tropizal areas are small, usually an average of 3-5C^{o}? That is the case in Eastern Africa. However, lack of wind can restrict mixing of the upper and lower waters causing the stratification. These factors have an impact on the Eutrophication process, due to inputs of nitrogen and phosphorus, as well as organic material. In the first instance algal activity in the form of photosynthesis occurs in surface water. The unsightly algal growth in lakes can lead to taste and odors, inhibition

can of fish activity and interfere with water use. When these algae die and settle, they impose a significant oxygen demand as the bottom waters.

Dr Singer drew attention to the section of the workbook entitled Principles of Wastewater Treatment. Table I illustrates the characteristics of Wastewater.

Techniques to remove suspended solids as well as BOD. BOD is a measure of the strength of a wastewater. The measurement of BOD requires 5 days. However, the Chemical Oxygen Demand (COD) test might be faster and can serve as an indication of the strength of the waste-water. The objective of sedimentation is to remove grease and oil and/or to remove settleable solids from water. Solids settle to the bottom, oil rises to top. This primary sedimentation can provide removal of most suspended solids within 2 - 4 hours.

Disolved or colloidal organic material (BOD) can be removed by biological processes - see Figure II of the Singer Section of the Workbook.)

Secondary Treatment is largely biological with Aerobic processes which use stabilization ponds, trickling filters and activated sludge. In pretreatment, PH neutralization and equalization may be required.

The principles involved are to remove the settleable portion of the suspended solids, where the efficiency of removal is a function of the density and site of the solid particles and solution density and viscosity.

In the process, the overflow rate of a sedimentation basin governs the effectiveness of the basin in removing the suspended solids.

Secondary settling tanks are required to remove the suspended micro-organisms in the trickling filter and activated sludge effluents. Rectangular and circular horizontal flow basins are typically used. The settled solids (sludge) from the primary and secondary settling tanks must be disposed of.

Drew attention to Figure IV in the Workbook. It shows that organisms require energy for synthesis of biomass, i.e.

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new cells. The energy required for synthesis of the biomass can come from sunlight, oxidation of organic compounds, and oxidation of inorganic materials - such as ammonia. These reactions require and consume oxygen. In general, aerobic reactions are faster than anaerobic reactions.

In order for the reactions to occur the wastewater must be nutritionally balanced. This may require phosphorus or nitrogen supplementation for certain industrial wastes.
A biological treatment process often used is waste stabilization ponds (see Table II in (Singer Workbook)
There are four reactive phases involved in waste stabliza-tion ponds. Aerobic Oxidization of organic material by bacteria; Photosynthetic oxygenation by algae; acid formation by an aerobic bacteria; and Methane fermentation by anaerobic bacteria. Ponds are known by different names in different countries:

(a) Oxidation Ponds - (unaerated aerobic) shallow (3-4 ft) with complete sunlight penetration throughout the entire depth. Thus, they depend entirely on photosyenthetic production of O_2 by algae.

(b) Facultative ponds as in Figure 4 and 6 are among the most common stabilization ponds. These are deeper - ranging 3 to 8 feet in depth. In here, aerobic conditions exist only in the upper layer where algal photosythesis and aerobic oxidization of organics occurs. In the deeper layers, anaerobic decomposition of dead algae and bacterial solids occurs.

(c) Aerated ponds where oxygen is supplied by a mechanical device. It may be completely aerobic if mixing process occurs throughout, or they may be facultative if they are only partially mixed.

(d) Anaerobic ponds are primarily used for treating strong industrial wastes for very heavily loaded COD. They are used for pretreatment only and are usually followed by faciliative ponds.

(e) Maturation ponds provide detention to allow for death of coliform bacteria and for settling of suspended solids from earlier biological treatment ponds.

Other biological treatment processes are:

(i) Trickling Filters - Relatively shallow 3 to 8 ft, circular or rectangular bed of rocks over which primary clarified waste water is sprayed intermittently as shown in Figure VII. There are several kinds of trickling filters depending on how they are loaded. Design is based on hydraulic loading and organic loading. They may make use of recirculation to equalise wastewaters of variable flow and quality. They must be followed by settling tanks to capture the bacteria which sloughs off the rocks.

(ii) Acticated sludge system has three main components. The primary clarifier which removes suspended solids on aeration tank to which concentrated bacteria sludge is returned. The water then moves to a secondary clarifier where bacterial solids are removed and either disposed of or returned to the aeration basin.

It is advisable that if the wastewater contains sanitary waste and therefore carries fecal material and possibly pathogens, then the water should be disinfected e.g. chlorination, to kill pathogens. Chlorination is the dominant mode of treatment, but as an alternative, detention in maturation ponds can be used. In this case, the detention time in the maturation ponds may have to be extended.

Therefore, all urban and industrial centres should have, as a requirement, treatment plants, with standards of performance. Plant performance must be monitored and standards enforced to ensure that the system works effectively. Proper plant maintenance is also required to ensure satisfactory performance.

PRINCIPLES OF WASTEWATER TREATMENT

BY

DR P C SINGER

CHAPTER II - BASES OF WATER POLLUTION PROBLEM

EXPLANATORY COMMENTS

ON

PRINCIPLES OF INDUSTRIAL WASTEWATER MANAGEMENT

BY

DR O'ROURKE

Pollution problems created by industries depend on the industry and the processes involved. No such thing as a typical industrial waste. Two different factories within the same industry will have different wastes.

What are the wasteloads involved - and these depend on the input to the industry.

It is important to consider the surrounding environment, and the general ecology of the area in which the treatment facility is situated. Consider also the population and settlement of the area to guard against offensive odors and nuisance problems.

Ask the question if it is possible and/or ideal to separate the various process streams for separate treatment. Check also to see what use could be made of the final "Wastes". Can some be recycled or put to other uses?

If the industry has a unique effluent for which there is no experience in treatment and for which no literature is available treatability or pilot studies may be conducted. Remember again that no two industries have identical effluents.

Are there any by-product recoveries possible in the "Waste" system?

Ascertain the working mode of the factory. Is a one, two a three shift system in operation at the industry: How many hours per day does it work and with what end produce?

Ascertain the plans for expansion of the industry, then determine the capacity to be developed for treatment.

Further specifics of industrial waste survey are easy if the factory is under plan. Then it is easy to review experience of other industries. In such circumstances the experience is only a guide not blue print. Clues can also be gleaned from products and materials envisaged.

Diversion of storm water in a municipal setting is simple. But in a factory it may be complex because of the wastes that may be in that large amount of water.

Decide what mechaniems should be adopted in the industry to reduce the total effluents. Can reuse be arranged for some of the water or wastes? Wherever possible perform some treatability studies. Organic wastes from the same industry can differ every different day.

Determine what product might come out of the industry every day and sample the output over an extended period of time. Remember that the duration of study would depend on the specific industry. Sugar industry may take different sampling during from textile dye or pharmaceutical industry.

Question: It is fine to talk about factory input. But most industries will not reveal the input into their production systems considered "Industrial Secrets".

Answer: At times it is possible to design treatment without full knowledge of the substances involved. Otherwise it may be a policy matter to be settled in the"Industrial Effluent Agreement". Or handle it through legislations requiring disclosure. In the U.S.A. the EPA has gone to court to secure disclosure; then the government must guarantee confidentiality.

Comment: In some instances the company may not delibera-tely refuse but they may not know as a matter of fact. One might ask the industries to discharge upstream and accept to reuse. But this is a policy matter.

The US National Pollution Discharge System requires any one who intends to discharge to reveal the contents of the materials to be discharged and their origin.

EFFECTS OF CHANGING AGRICULTURAL PRACTICES AND INDUSTRIAL EFFLUENTS ON RIVERINE AND LACUSTRINE FISHERIES IN THE NYANZA GULF

BY

OCHIENG E.O. AND
GETABU A.M.

ITRODUCTION

In areas drained by rivers which enter Lake Victoria, there has been a recent increase in population. This has resulted into the utilization of more land to produce enough crops to support the ever expanding population. Coupled with the population increase, there has been the recent introduction of cash crops like coffee, tea, pyrethrum, sugar cane and cotton and the breeding of varieties of cattle. These have resulted into increased usage of agricultural chemicals in controlling their pests and disease vectors. The once forested areas particularly in the densely populated districts of Kisii (438 people km^{-2}) and Kakamega (324 people km^{-2}) have been cleared and land is cultivated upto the river banks. In such districts land has become scarce and the same piéce of ground is cultivated year after year so that the soil has lost its natural fertility. Where the population density is very high, people have shifted from the mixed type of farming into the cultivation of both subsistence and cash crops. Deforestation and cultivation of land upto the river banks has resulted into severe erosion especially in steep sloped areas resulting into silting of rivers whose effects are transmitted into the lake.

Along with the changes in the agricultural practices mentioned above, there has also been a recent expansion of urbanization and industrial sector in the Lake Basin. In the last two decades, many industries and factories have been established. To name some of them, these are the Coffee factories, the textile factory (Kicomi) at Kisumu, Pan African Paper Mills at Webuye, the sugar factories in the Sugar Belt and at Awendo and Mumias and the Molasses factory at Muhoroni. Presently, the Kenya Breweries and the Molasses factories are being constructed at Kisumu. One characteristic feature is that these factories have been established with very little knowledge on their environmental impact on water quality which is very important for domestic use, aquatic life and the fishes in the Lake Basin. Some of them like Kicomi discharge untreated effluent which finds its way into the Lake through river Kasat. There is very little aquatic life in this river.

As the agricultural, industrial and urban sectors have kept expanding, there has been an associated decline of riverine fishery done inland by line fishing and it has generally been claimed that the water levels in the rivers are lower than before. Clearing of forests and intensive cultivation especially in the intensively cultivated and densely populated districts of the Lake Basin, has left the ground and the rivers exposed to sunlight resulting into the loss of a lot of water through evaporation. Another consequence of this is that the bare soil has been left loose resulting into erosion of large loads of silt containing agrochemicals into the rivers. These factors probably affected the habitats where anadromous and other riverine fishes feed and breed. Examples of rivers which have been found to contain discharges of both agricultural and industrial origin are the Kuja and the Nzoia. The silt together with the substance based agro-chemicals are deposited at the river mouth. The effects of agricultural, industrial and urban effluents on riverine and lacustrine fishes in the Lake Basin are largely un-assessed.

METHODS

The data and information presented in this paper was collected between February and July 1982. The study area was around Kisumu town and covered the golf beach, the river Kasat and the boat jetty. More manual methods were adopted in water analysis. Titrimetric methods were used in estimating the concentrations of dissolved oxygen in ppm; the DR-2 spectrophotometer was used in the measurement of turbidity and water colour. PH was measured using the PH metre and the visual comparator in some cases. Turbidity was measured using the Turbidometer and water samples were collected using Nansen bottles. Other physi-cochemical - parameters not presented in this paper were also measured.

RESULTS

The PH of river Kasat was found to be higher than that of the boat jetty and golf beach and ranged from 7.9. - 9.6 The ones for golf beach and boat jetty ranged from 7.6 - 8.1 and 7.1 - 8.1 respectively; Table I. It can be deduced that the PH of the Kasat was more variable and alkaline than that of the other two stations. That data are presented in Table I and the annexed figures.

This shows the presence of both hydroxide and carbonate in the water of the Kasat. The two rarely exist together under conditions at PH more acidic than 8.2.

The water colour of the Kasat was found to be very high and more variable than that of the two other stations. It ranged from 667.4 - 1096.9 $mgl^{-1}pt$ as compared to 81.7 - 181.3 and 55.7 - 103.1 $mgl^{-1}pt$ for the golf beach and boat jetty respectively. This suggests the discharge of highly coloured industrial effluent into the river which ultimately finds its way into the lake.

The dissolved oxygen of the Kasat was found to be very low and more variable than that of the other two stations. Such very low and variable oxygen suggests discharge of compounds into the river of very high BOD.

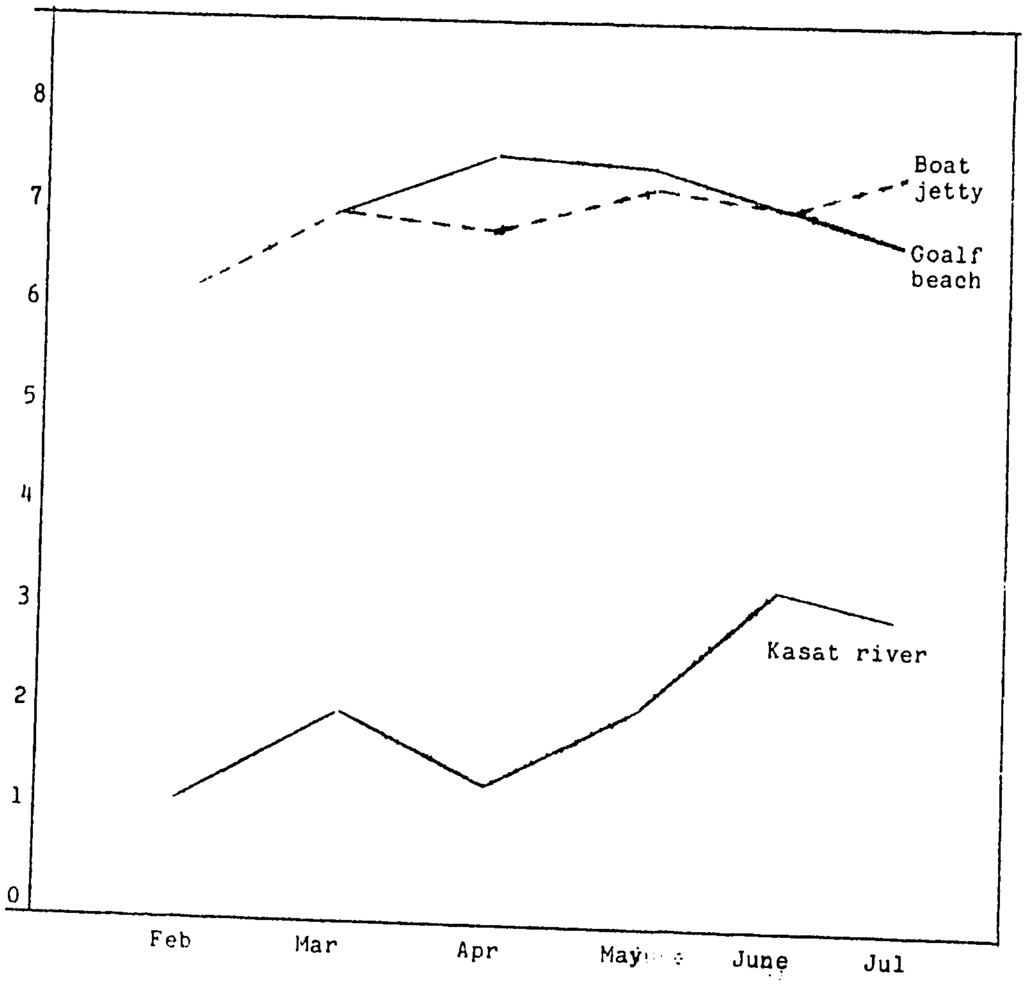
The Kasat was found to have a very high turbidity which was also more variable than that of the other two stations. It ranged from 223.0 - 385.6 (FTU) while that one of the golf beach and the boat jetty ranged from 19.0 - 26.8 and 19.0 - 32.9 respectively. This for the Kasat is a reflection of the presence of a high concentration of suspended solids which cannot only affect the gills of the fishes but also reduce the penetration of radiant energy with an ultimate reduction in the productivity of the water.

Mainga (1981) working at the mouths of rivers Sondu and Kuja collected data on some important physicochemical parameters; Table II.

Table I. Physicochemical characteristics of two stations in the Lake and on the Kasat river

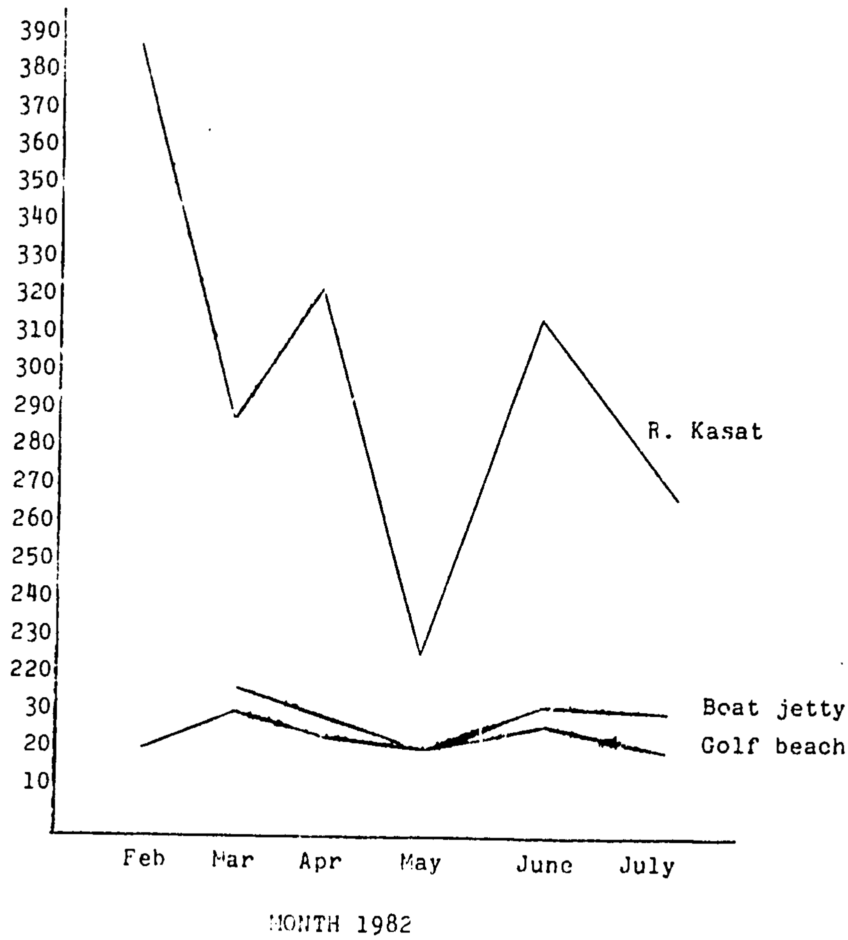
Parameter	KASAT RIVER						GOLF BEACH						BOAT JETTY					
	Feb.	Mar.	Apr.	May.	Jun.	Jul	Feb.	Mar	Apr.	May	Jun.	Jul.	Feb	Mar.	Apr.	May	Jun	Jul.
PH	9.5	9.4	9.4	9.6	8.1	7.6	-	8.0	8.1	8.1	7.82	7.6	7.72	7.6	8.0	7.1	7.8	7.6
Colour $mgl^{-1}pt$	1013.1	919.6	1041	721.3	1096.9	667.4	-	100.1	181.3	81.7	102.8	94.9	55.7	92.6	98.3	75.7	103	107.2
Dissolved oxygen (ppm)	1.1	1.7	1.1	1.3	2.6	2.2	-	6.8	7.08	6.7	6.4	5.99	6.0	6.9	6.4	6.5	6.4	6.6
Turbidity (FTU)	385.5	286.3	322.9	223.6	312.6	261.5	19.3	26.6	21.0	19.0	26.4	19.7	-	32.9	26.5	19	26.4	26.8

The data on dissolved oxygen and Turbidity of the Kasat has been presented graphically in the next two pages.



Graph showing the concentration of oxygen in ppm at three different locations in the lake within Kisumu municipality.

Note: The relatively low dissolved oxygen in the Kasat river



Graph showing the turbidity values of three places within the Kisumu Municipality.

Note: The relatively high turbidity of the river Kasat.

Table II: Values of some important physicochemical characteristics at the Kuja and Sondu river mouths.

Parameter	Kuja		Sondu	
	Range	Mean	Range	Mean
Water turbidity (FTU)	13.5-96	36.6	4.5-9.5	7.0
Water dissolved oxygen (ppm)	5.5-7.2	6.3	4.3-8.2	5.8
Water PH	6.9-7.7	7.4	6.9-8.1	7.5
Sediment Ca^{++}(ppm)	6.4-8.7	7.6	3.2-6.9	4.9
Sediment PH	6.4-7.2	6.8	4.6-6.7	5.8
Phosphorus (ppm)	0.07-0.1	0.1	0.07-0.1	0.1

Most of the variables showed slight differences at the river mouths but values of water turbidity and sediment calcium showed some significant differences at both river mouths. This may be a reflection of the geological nature of the areas which the two rivers drain. The high turbidity of the river Kuja may be attributed to the presence of a large mud observed at the river mouth (Mainga op cit). It measured 300 m by 50 m and was a half a metre deep. River Kuja drains the most densely populated and the most intensively cultivated region in the Lake Basin, the Kisii highlands. Since most of these highlands are very steep and are cultivated for planting crops (almost everywhere) just before the heavy rains, one can attribute the high turbidity at the Kuja due to the presence of a lot of suspended organic and inorganic material brought down into the lake as silt.

Some information was also gathered on some of the agricultural chemicals and pesticides used in the Lake Basin. Most of them fall under the organochlorine and organosphate groups which are very toxic to fish and aquatic fauna in very low concentrations as can be seen below. Stelladone (300 ec) is used as an acaricide on livestock. It is both an organophosphate and an organochlorine. Greenzit is a pesticide applied on vegetables. It is an organophosphate compound which contains phosphorus as P_2O (30 gl^{-1}), potassium as K_2O (70 gl^{-1}), nitrogen (70 gl^{-1}) as macroelements and iron, copper, Boron, Nickel, Zinc, Manganese, Molybdenum and Magnesium as microelements. Delnav is an organophosphate insecticide which has a tropine as the active ingredient. It is used on livestock as an acaricide. Other agricultural compounds used in the Lake Basin are nitrogeneous fertilizers for example the sulphate of ammonia and the NPK fertilizers. As it can be deduced, the utilization of Greenzit as a vegetable pesticide will have limited use for extensive growing of vegetable in swamps and along the rivers since the heavy metals in it are toxic to fish and other aquatic life. The nitrogeneous fertilizers have high BOD.

At Ahero irrigation scheme, DDT is sometimes used by local farmers to eradicate rice stock borers. This is because it is cheaper to buy than chemicals recommended. Other chemicals used in the scheme are Cabaryl, Diazinon Carbofuran, BHC and Mathion. Molluscides are used for the control of snails but we were not able to get the name of the chemical used. It is important to note that Ahero is an area which is very suitable for aquaculture and has good grounds to construct fish ponds. On the other hand, it may be possible in future to grow rice and fish on the same paddy. But the fish are likely to be threatened with the pesticides sprayed on the rice. Effects on the pesticides already in use at the scheme on the fishes in the paddy canals and in the rivers around the scheme are unassessed. However, the process of integrating fish with rice is a practice which has been carried out in South East Asia for a long time. There is very little reason why it cannot be possible at Ahero.

DISCUSSION

The effects of the effluents

The effects of the effluents on the fish are either direct or indirect. They may cause a reduction in fish food by reducing the productivity of the water in which the fish are found; they may get assimilated by fish food and get concentrated up the food chain so that the fish get them by feeding on their prey. The fish may get them directly from the water, for example silt swallowed with water effects gills of the fishes. When the pollutants are extremely high, they can kill both the fishes and the general aquatic life on which they depend. In this case the fish stages which suffer the greater consequence are the eggs and larval fishes and this results into high mortalities. The pollutants can also alter the habitat (the breeding and the feeding grounds) of the fishes by changing their chemistry.

A limited number of cases have been reported in Lake Victoria where the fishes have been found to have concentrated pesticides in their tissues. Koeman et al (1970) found that Tilapia, Alestes and Clarias tissues carried levels ranging from 0.014 - 0.068 mg kg^{-1} of dieldrine levels ranging from 0.014 - 0.068 mg kg^{-1} of DDE in Lake Victoria. Corbet (1958) found that 0.4 mgl^{-1} of dieldrine used to eliminate Simulium damnosum larvae applied for 30 minutes daily for over two and half weeks also eliminated all the natural populations of ephemeropterans and trichopterans in the Victoria Nile. Elsewhere in the tropics, several examples can be cited where insecticides used in concentrations thought to be very low and therefore not lethal, have had adverse effects on fish and the aquatic life on which they depend. Greichus et al (1977 and 1978) has shown that water sediments, plankton, aquatic insects, some fish and aquatic birds can concentrate heavy metals such as arsenic, cadmium, copper, manganese, lead, zinc and mercury in Lakes Mcllwaine in Zimbabwe and Nakuru in Kenya. This can probably be a case where the chemicals have been transmitted up the food chain. Experiments using chlorphoxim were carried out for six months in Ivory Coast on a river. Successive concentrations of 0.025 and 0.05 gl^{-1} applied for 10 minutes exterminated 75% of the major aquatic invertebrate fauna (Statzner 1979). Another example can be cited on attempts aimed at controlling Glossina using two insecticides, endosulfan and decamethrine on the Niger. Application of 900 gha^{-1} of endosulfan killed all fish species 12 hours after spraying. Treatment using the same product on the Comoe river in Upper Volta at a concentration of between 100 and 200 gha^{-1} caused a high death rate of fish and shrimps (Evert). Application of aerial pyrethroid treatments resulted into a high death rate of shrimps and aquatic insects.

The very low dissolved oxygen concentrations in the Kasat reflect the presence of pollutants with a very high biological oxygen demand but also which are lethal to the survival of the fishes. This can contribute to poor benthnic productivity of the water and conditions which both fish and other aquatic life cannot tolerate.

It has been established above that the water turbidity and colour of the Kasat and that at the mouth of river Kuja are reasonably high. The effects of these are obvious from simple ecological principles. High turbidity and water colour reduce the penetration of radiant energy into the water. The result is that the amount of energy available for algae and other primary producers in water is limited and therefore less food is available for the aquatic animals from the photosynthetic process (the sole source of food manufacture in aquatic environments). The Kasat is known to obtain its industrial and urban effluent from Kicomi textile mills and Municipal sewage treatment plants. The effluents from these two sources have been found to be inadequately treated. The lesser the food, the fewer the fish in the rivers and the lake. Fogg (1980) has noted that pollution also makes it difficult to estimate primary productivity.

It has already been noted that the effects of the agrochemicals, industrial and urban effluents on the fishes in the Lake Basin are largely known. For conservation purposes, it will be of great interest to investigate the environmental impact of these products.

Another source of pollutants for the fishes and other aquatic life is the bottom deposits. Silt being deposited at some river mouths contains some of the pesticides and industrial effluents. Many fish species of Lake Victoria are known to feed on bottom deposits like Labeo victorianus, the Mormyridae, some Tilapia spp. and Haplochromis. Thus any agrochemical or industrial waste in the bottom deposits is ingested by the fish and these eventually find their way into man when he eats the fish. Some of the pesticides in the bottom deposits are carcinogenic.

CONCLUSION

In order to sustain optimum yields of fish from the lake and its affluent rivers, it is very necessary to conserve the aquatic habitats. This not only involves prevention of discharges from large towns like Kisumu into the lake but also the taking of necessary measures on the prevention of the usage of any agrochemical which is dangerous to the existence of the fishes. In this respect it is very important to look at the entire area drained into Lake Victoria and assess the environmental impact of especially the densely populated districts like Kisii, Kakamega and South Nyanza on the fishes and aquatic lifes. There is need to foresee the future effects of any industries or factories being set up since the existing ones have been found to pose a threat to fish life. Better systems should be devised in handling urban wastes like sewage, runoff and industrial effluents. Lastly, studies on the effects of the agricultural chemicals in current use on fish are very necessary.

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SEWERAGE OPERATION AND MAINTENANCE IN ELDORET

BY

P.O. SEWE
ELDORET MUNICIPAL COUNCIL

The Municipal Council of Eldoret draws and returns Water to Sosiani River through a conventional treatment system (Trickling filters) and waste stabilization ponds.

The waste consists of municipal and industrial effluents with a higher percentage being industrial waste. Both the wastes contributes organic and inorganic into the works. Due to fluctuations in the activities of the industries, the characteristics of the effluent received into the Municipal treatment facilities keeps on fluctuating and this affects the uniformity of the sewage or renders it nonuniform.

The effluent from the industries have been preliminarily checked and found to have a wide variation in pH ranging from 4.5 to 12. Below are a few examples according to the Eldoret-based industries:

- C.P.C. - pH 4.5 starch factory
- West Kenya Bottlers - 11.3 Soft drinks
- Coca-cola - 11.25
- Rayments - 8 Textiles
- Rivatex - 7.2 Textiles.

Observation of the final effluent from the ponds showed a pH of 8.5. But following through the whole works (ponds) it has been observed to show very little activity both at the primary ponds which are unaerobic, and much action is expected; the secondary ponds which are aerobic show signs of unaerobic action occuring in them to a small extent. Further to the maturation smell of ammonia gas can be felt which shows that some action is occuring here too. This shows that treatment works is not doing what it is intended for.

Due to lack of monitoring facilities and personnel it would be difficult to point out the exact cause of the failure in the system but to attribute it to general known parameters.

1. The BOD and COD loading might have exceeded the amount to which this facility can operate efficiently under the prevailing conditions.

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2. The pH value being so high and non-uniform must have slowed down the bacterial activity in the ponds.

3. Dye staff from industries discharged into the ponds must have cut down the sunlight penetration which is used for the photosythesis in the alga.

4. Continual expansion of the existing industries which varies the flow and content of their effluent.

5. The inability of the authority to develop the infra-structure (sewage treatment works) to cope with expansion of the town.

PROBLEMS WITH THE CONVENTIONAL SYSTEM

The conventional treatment of sewage is highly affected by operation. Due to lack of trained operators who can operate the works with a relation of flow to the functions of the treatment works elements or structure in mind. The works fails to carry out its required functions. Just to mention a few of the existing problems:

1. Screening and grit removal : Improper grit removal allows the grit to flow into the moving parts of the works wearing it down. This is critical in a situation where procurement of new parts is difficult. Most parts of the works are rendered non-functional.

2. Withdrawal of sludge from the tanks: Improper withdrawal of the sludge from the tanks have been observed to render the tanks septic and frequent withdrawal deprives the tanks of the required micro-organisms needed for treatment.

3. Lack of paper work: This has made it very difficult to study and follow up the history of the works, thus making it difficult to suggest improvements.

SUGGESTIONS TO IMPROVE THE WORKS

i. Since the ponds are the cheapest to construct and maintain a system to aid in reduction of BOD and COD should be introduced.

ii. Local Authorities should enter into discharge agreements with the industries and the agreements should be specific in standards required.

iii. Provide facilities and trained personnel are adhered to.

iv. Force the industries to pre-treat their sewage before discharge into the Municipal Sewage treatment system.

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THE EFFECTS OF AGRICULTURAL
CHEMICALS ON ENVIRONMENT

BY

P J M[illegible]ATI
A MOSHI
I M KILONZO
AND J GAUDET

BY KILONZO

Agricultural chemicals have deleterious effects on drinking water and sewerage. Upto a decade ago agro-chemicals were insignificant in Africa because the use was still minimal. Elsewhere, the use had been high. More recently, increased use of agricultural technology to increase production has increased the chemical inputs. The use of chemicals has also been directed at disease control as well as control of plant pests.

At the same time the chemicals have been found in aggregate to have more harm than good. The chemicals are washed to other habitats; food chains and into human body. Because the life and cumulative effects vary the bioaccumulation of the chemicals into human body have only recently been found.

Research has been directed to finding chemicals that have short-life.

Herbicides have been in recent use to replace weeding. Chemicals like 2,4,D selective for broad-leaved plants such as PISTIA STOIDES (of the same family salvinia in Lake Naivasha). This chemical is bad for sewerage treatment because of its high BOD.

The view in Africa is that the impact has still been low in Africa but there are more industries producing variety chemicals in Kenya, for example Welcome Trust of Kenya.

This view might be misplaced because chemicals exert pressure and change ecosystems because one harm to one plant or animal might have serious chain reaction. For instance from Njoro to the nearest Lake Nakuru about 30km and wastes discharged in Njoro should, by the time they reach Lake Nakuru have been drastically reduced. But the effect of the wastes have been conspicuous as evidenced by the migration of flamingoes from the Lake.

Use of Chromium compounds around Thika has caused immense impact on riverine fisheries and this has been verified.

The use of chlorinated hydrocarbons in agriculture has also increased the chloride content of water. Spray used in fruit farms to increase nutrients for the plants. But the effects have not been ascertained. Foliq fertilization for sukuma wiki may also have doubtful effect.

In spraying of turberous plants the chemicals may end up into the roots of plants such as cassava. Mercury may find its way into roots and it may accummulate into human body through the chain.

The policy machinery should not remain oblivious to these actual and possible deleterious effects on man and his environment.

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BY MADATI

By and large the most important chemicals are pesticides which include a whole range of chemicals to control insects, ticks, snails, worms, fundi, herbs, rodents, etc. Fertilizers have taken a prominent position as water pollutants. Then there is a third category of potentially toxic chemicals such as plant regulators, insect repellents.

The important point is that these chemicals are directed at targets but very often they also end up on non-target organisms including man, to whom they are equally toxic.

The necessity for use of the chemicals such as pesticides is not questionable because we lose big fractions of crops every year and the losses would be greater if we didn't. Similarly we use the chemicals for control of vector diseases.

The chemicals find their way into water bodies by direct application e.g. to kill snails, or by being blown by winds, or washed by rain or even by seepage or by abuse and abuse eg. by washing chemicals containers. The dangers are quite real, warranting urgent remedial measures.

Persistance, non biogradibility and toxity are the crucial properties to consider before deciding on using any pesticide or environmental chemical. So also is resistance by the targets where they are misused.

We know that the deleterious effect of organochlorines are largely on the central nervous system; but of late, some of these have been found to have carcinogenic properties. Other effects are on egg shells of some birds. Large doses of organochlorines are cumulative and lethal. The organophosphorus pesticides are acutely toxic by virtue of their interference of the enzyme cholinesterase which causes vomiting, diarroheа, convulsions and even coma or death within hours of ingestion. Carbonate pesticides are also anticholinesterase in their acute toxicity. just like organophosphates.

Rodenticides find way to water and kill man at the same speed as kill the rodents and through similar mechanisms e.g. anti-coagulating effects on blood. The analytical methods of detecting and quantifying pesticides are fairly simple and instruments are inexpensive and speedy; such as gas and liquid infrared and ultraviolet spectrophotometry, atomic absorption spectrophometry. The unfamiliar pesticides require the use of more expensive instruments like mass spectrometers in addition to the above mentioned instruments. One can select chromatography, polarography, and potentiometry.

Control of potentially toxic chemical inputs has been rather lax and sporadic in this region. There is a need for someone in each of the countries to formally register all the pesticides coming into the country after being satisfied that they are efficacious and safe. Their toxic effects should be ascertained. It is important that we should know exactly what pesticides are used in the Lake Basin Area, for example, and screen for them in all waters in the basin all the time. Register of such chemicals should be kept and a tracer, analysis established to find out on a steady and continuing basis what their effects are. Consequently, the dangerous ones can be withdrawn the moment any harzadous effects are ascertained; or quantities of them be closely controlled in order to minimise injury to health.

It is clear we cannot do without the chemicals. Public Health and Agriculture, especially food production need the use of pesticides chemicals. It is only necessary to register, control, including monitoring in aquatic and other environments and prevent mishandling so that only the right chemicals are used. Armed with all the efficacy and toxicological data as well as other socio-economic factor by all means, let us ban what policy makers agree we can afford to do without.

Fertilizers vary in kinds and provide plant nutrients such as P,K,N,S,Ca and Mg. These are known as macro nutrients or M_o,E,Mu,Zn,Fe and Cu and are referred to as macronutrients. These are derived from organic manures but more readily from inorganic fertilizers.

Pesticides: among the earlier ones were inorganic, (namely, Hg,Cu,Pb,S compounds). Towards the beginning of the present century it was found that many insects were developing resistance to these inorganic pesticides. This gave rise to the synthesis of organic fertilizer such as DDT and the related chlorinated insecticides.

In the early 1940s at the Geigy laboratories in Switzerland, biological potency of DDT was first established and its use has increased dramatically since then.

Studies have revealed the presence of pesticides in contaminated waters and their accumulation in Plankton as well as anthropods and birds. The concentration increases from water fish to birds and the DDT effect on some of the birds was so high that some types of birds are now extinct in parts of North America. Significant DDT concentrations have been found in the fat tissues of Eskimos (who are not agriculturalists anyway) and even higher concentration found in people living in both developed and developing countries.
This is one of the reasons that led to synthesis of the less persistent pesticides such as organophosphates and carbonates. Insecticides like parathion biodegrade quickly so as to allow crop harvests any time after two to three weeks.

Studies of pesticide residues in foods and waters especially organochlorins are carried out at the Tropical Pesticides Res. Just. Arusha and a few other laboratories. East Africans should intensify studies on monitoring of heavy metals in our water systems. Water which flows nearby garrages and industrial centres is sometimes used for irrigation, pollution of the irrigated food crop by heavy metals such as Pb and may lead to ill health following consumption of the contaminated crop.

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Pesticide control and registration was recently introduced in Tanzania, with the purpose of controlling/distribution use and production of pesticides in the country. It has been observed that sometimes pesticide dealers tend to cheat; such as change of trade names or selling fake formulations. The only remedy, as Mr Madati said, is to strictly maintain a register and analyse the formulations for their content of active ingredients.

Question: Impact of fertilizers on soils has not been emphasised. We may be putting in excessive acidity or alkalinity into the soil.

Answer: It may be true in East Africa, as perhaps anywhere. Super phosphates and sulfate of ammonia, for example increase soil acidity.

Comment: Could we come up with a recommendation here to urge for high level training and to have professionals who could monitor specific chemicals to ascertain not just accumulation but also the effect.

Question: What has been the decision in US where certain chemicals are banned and then the industries allow for their manufacture and export, mostly to the Third World Countries?

Answer: Most companies probably are busy depleting stocks of already made chemicals, and governments of these countries should help by restricting these industrial firms from exporting chemicals banned in their countries.

Comment: Tighter import controls should begin in the Third World Countries themselves. In the U.S. it is difficult to ascertain production and direction of trade in chemicals such as pesticides.

Comment: Any country is a system and all systems must agree to work together, formulate standards, and agree that the whole system maintains health. This is what applies to monitoring of agro-chemicals including pesticides and fertilizers and natural or indigenous pesticides.

Comment: We should try to use the most natural and cheap organic fertilizers.

Comment: Over four years ago it was decided that we should monitor fertilizer inputs in this area. The goal is to see methods of control and see if they can be synchronized.

When Ahero scheme came up it was not certain that they would need pesticides in pest control. DDT is still cheap and effective but it has a long residual effect. For those who want effective pest control DDT is still the best. Its effect on man and other animals are confirmed.

A new pesticides control Act has been gazetted in Kenya, and it requires that for each pesticide released for use the conditions for its application should be stipulated.

Use of DDT has been changed. Some of the pests in Kenya have become resistant to DDT and this has necessitated use of Organo phosphates. The latter is a contact poison.

A third generation of pesticides include carbonates and these are predominant in Kenya.

KILONZO

Biological control of pests would be excellent if it worked 100%. Unfortunately the predator eradicates the target pest then it becomes a pest in its own right. An example of cactus in Australia is in point here. In Kenya's Lambwe Valley steralization mechanisms for specific pests has been used to eradicate certain pests.

Pyrethrum is a widely used natural pesticide. Strangely enough, however, this is exported abroad when we remain to use synthetic pesticides. The Board should consider preparation of pyrethrum formulations in Kenya.

MADATI

Biological control in Tanzania has been tried for bilharzia, malaria vectors by using organisms that predate on their eggs or the snails themselves. Studies are also being conducted for plants that have pesticidal effects. Agronomists should also continue the efforts to produce hybrids which are more pest resistant. Also steralization of male vectors of some diseases should continue, as alternatives to chemical pest control. Pesticide and fertilizer run off to the water system is prevalent, legislations should be targeted also at control of procedures for application and there must be inspectors that ensure that the standards guidelines and laws are adhered to.

Our countries should be determined enough to adopt legislations that prohibit import chemicals proved to have deleterious effects elsewhere and enforce the regulation rigorously.

There is a theory that Eskimos eat seals which eat fish which had been contaminated with DDT in warmer waters further south. Thus the Eskimos are found to have DDT in their systems although DDT is never used in their part of the world. This is why we say some of these pesticides are very ubiquitous.

Fertilizers should be used only after soil analysis have divulged the nutrient defficiency, or else we would be wasting our fertilizer and even damage the crops.

MOSHI

The problem with organic fertilizers is that one usually requires to use them in large quantities sometimes several tons per hectare. However, to achieve the same effect normal agricultural crops require only a few kg. per ha. of inorganic fertilizers.

NATURE OF THE LOAD DISCHARGED THROUGH RIVERS FLOWING INTO LAKE VICTORIA

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JOHN GAUDET

The diagram below shows a rough estimate of data synthesized from a variety of sources, especially Okidi, "Natural Resources and the Development of the Lake Victoria Basin of Kenya" IDS/OP 34 (1980). The figures actually suggest the annual discharge estimate.

SOME HYDROLOGICAL DATA

RIVER	DISCHARGE $M^3 \times 10^6$ ANNUALLY	SEDIMENT t/y	Potential BOD t/y		
			SMALL INDUSTRY	DOMESTIC	LARGE INDUSTRY
SIO	287	86	543	4,706	-
NZOIA	1,777	400	7,593	22,199	36,600
YALA	1,114	166	6,336	9,165	-
KIBOS	68	20	4,875	2,928	3,900
NYANDO	247	82	825	1,630	10,170
SONDU	845	-	2,267	6,531	-
AWACH	180	-	215	2,922	-
KUJA	952	78	768	15,515	20,727
MARA	1,038	165	1,422	2,617	-
TOTALS	6,500	1,000	24,800	68,000	75,000

Much more accurate readings are required to allow meaningful development programming and planning.

An accurate information of flows and load is vital for a seminar of this kind, and accurate data should be consolidated and analysed.

In relative terms, the largest BOD seem to come from industries but the figures need to be coroborated with research.

The complete Lake Area is 68,000 square kilometres. The Kenyan past is about 3,755 sq.km. The Lake Victoria Basin portion of Kenya is about 50,000 sq. km. The figure is still controversial because they have not been systemarised.

Comment: There is a project on river profile by the Lake Basin Development Authority. That project should give a reasoned and rationalised data on the contribution of the respective rivers into the Lake. So far the data prepared are controversial.

Comment: There should be a recommendation of this Seminar for ar East African Water Magazine.

PROJECTED AGRICULTURAL AND INDUSTRIAL DEVELOPMENT
IN THE LAKE BASIN REGION
IN THE YEAR 2005 AD

BY

J N BONUKE

BONUKE

1. INTRODUCTION

1.1. INCEPTION OF THE AUTHORITY

The Lake Basin Development Authority is a Statutory Organization which was created by an Act of Parliament of the Republic of Kenya in August 1979. The Authority itself was inaugurated in May 1981, but before the official inauguration, steps had been taken to appoint the Chairman and the Managing Director, and to gather a nucleus of professional and administrative staff. It is headquartered in Kisumu, the very centre of the Lake Basin. In accordance with the present Kenya Government Organizational structure, the Lake Basin Development Authority falls under the Ministry of Regional Development, Science and Technology.

1.2. AREA COVERED

The Authority is charged with the cardinal responsibilities for planning and coordination of the socio-economic development of the Lake Basin Region and initiating programmes and project activities identified from such planning. The area under its jurisdiction consists of Nyanza and Western Provinces and the catchment areas lying in the districts of Kericho, Nandi, Trans-Nzoia and Uasin Gishu; as well as parts of West Pokot and Elgeyo Marakwet. The area, as defined by the Act of Parliament has some 7 million inhabitants which is about 40% of the Kenyan total population. The Act also defined a smaller area known as Development Area and confined to Nyanza and Western Provinces with a total population of some 5.5 million inhabitants or a third of Kenyan population. For purposes of overall planning the total catchment area has to be taken account of.

1.3. MAIN FEATURES OF THE REGION

In many respects, the Lake Basin Development Area has special if not unique position within the whole of Kenya. A few facts are given as illustrative.

- the development area occupies a mere 4.3% of Kenyan territory, yet it houses a third of its population;

- population density is high nearly everywhere and averages over 200 people per square kilometer. Local densities are extremely high in some areas e.g. Kisii district with an average density over 400 per Km^2 and Kakamega district with over 500 per Km^2; Birth rate range from a low 2.2% in Siaya District to high birth rates of 5.4% in Kisii District;

- Over 90% of the people are rural based, and depend for their livelihood on agriculture;

- rainfall is relatively favourable and more reliable. Yet drought spells occur, while on the other hand hailstorms and floods constitute frequent harzards;

- the area has 10% of the waters of the Lake Victoria and has six major rivers, namely, Sio, Nzoia, Yala, Kuja, Sondu and Sondu/Miriu;

- many densily settled parts of the basin are classified as "Medium potential" land, which produce only one crop of maize and other annual foodcrops per year.

- in many places poverty is extrene; the average farm size in the densily populated parts of the region is too small to feed the family adequately and alternative sources of income are often non-existent;

- as a result of this poverty, modern farming techniques which promise higher yields, but require cash for inputs like hybrid maize seed and artificial fertilizers are often not, or only very partially applied;

- in many places a process of rural involution and marginalization can be observed which inter alia leads to rising criminality (including robbery and theft of crops) despite concerted efforts to reverse the process;

- despite a relatively high rate of out-migration the population continued to increase at a rapid rate, which further compounds the developmental problems and increases the pressure on the available resources.

2.0. STRATEGY FOR AGRICULTURAL AND INDUSTRIAL DEVELOPMENT IN THE LAKE BASIN REGION

The Kenya national policy on industrial development basically centres on the decentralization of industries. This means that future industries will have to be located outside the traditional major metropolitan areas of Nairobi, Mombasa and Kisumu. This policy lays emphasis on locating industries in the rural areas of the country.

The Authority lays emphasis on industrial development of the region in order to enhance the following broad objectives:-

(i) To provide for the farm surplus output through various forms of industries and thus increase the farmers' incomes and employment.

(ii) The need to provide non-farm employment in the region due to population pressure on the land and thus curb outmigration of young people to urban centres of the country.

(iii) The utilization of the natural resources available in the region in order to raise the standard of living of the people of the region and to earn the country foreign exchange where necessary.

3.0. PRESENT STATE OF AGRICULTURAL AND INDUSTRIAL DEVELOPMENT AND FUTURE TRENDS IN THE REGION

Since the region is basically an agricultural producing region, most of the industries that have been established in the region are mainly agro-industries. Therefore, the agricultural sector may be considered "a carrier of industrial development" in the region. Broadly speaking, one may put the type of industries that have been established in the region or that are likely to be set up in the region as follows:-

1) Agro-industries
2) Livestock based industries
3) Forestry based industries
4) Fisheries and Boat Building
5) Mineral based industries
6) Tourist industries
7) Informal sector and service industries

3.1. AGRO-INDUSTRIES

3.1.1. SUGAR AND ALLIED INDUSTRIES

The region produces the bulk of the country's white sugar output. These are Miwani, Chemelil and Muhoroni in the Nyanza Sugar Belt, Nzoia and Mumias in Western Province and Awendo in South Nyanza District.

At present there is a mini sugar factory at Yala and two mini sugar factories are proposed for Kabras area in Kakamega District and South Mugirango in Kisii District. There is also a number of small scale jaggeries operating all over the region.

Most of these sugar factories are experiencing decline in production due to shortage in cane deliveries due to a number of problems related mainly to the outgrowers not having sufficient incentives to produce adequate cane for the factories.

Utilizing the molasses generated from white sugar manufacture, two power alcohol plants are planned for the region. These are Muhoroni and Kisumu power alcohol plants. It is envisaged that another plant to produce ethanol fuel is likely to be established in South Nyanza District. The future trends would indicate that it is highly unlikely that more white sugar manufacturing enterprises will be established in the region due to problems of balancing cash crops versus food crops production. What is likely to develop in future is that the present sugar manufacturing enterprises will be expanded rather than establishment of new factories. It is also envisaged that depending on financial and economic viability of mini sugar factories, more of this type of sugar factories are likely to develop in order to cater for cane farmers who may not have access to the main sugar industries in the region.

3.1.2. EDIBLE OIL

The region has great potential in producing inputs for the manufacture of edible oil. The region is endowed with suitable conditions for the production of groundnuts, sunflower, sesame, cotton seed, among others, that are the basic materials for the edible oil manufacture. Production of these crops has experienced notable decline in the region. However, the Lake Basin Development Authority in conjunction with the Government Ministries and other agencies are embarking on major rehabilitation of the growing of these crops. It is hoped that if these efforts succeed, there will be adequate output of these crops to warrant the establishment of edible oil processing facilities in the region. The region, especially Kitale area has established facilities to produce certified cereal and vegetable seeds.

3.1.3. MILING

The area has a number of enterprises of varrying capacities that are engaged in milling mainly of cereal crops. They are mainly engaged in milling maize flour, wheat flour and to some extent rice.

This sector is likely to expand in future particularly in the area of increased maize milling facilities that will range from posho mills to large scale milling enterprises. It is envisaged also that with the expanded production of rice both from Small Holder Irrigation Rice Schemes and the proposed large scale Rice Irrigation Schemes, and the stepped up expansion of the upland rice that is being carried out under the auspices of the LBDA. The tonnage of this crop is likely to rise significantly in the next couple of years to warrant the establishment of one or two rice milling plants in the area.

3.1.4. FOOD PROCESSING

The region is endowed with production of horticultural crops, such as passion fruit and pineapples, and vegetables. It is likely that with expanded production of these crops, processing enterprises are likely to be established in the region.

The area also, especially in the highlands, has a number of coffee and tea factories. These factories carry out primary processing of cherry coffee and tea leaves. In most cases, these enterprises are located around the rivers or streams. It is envisaged that both coffee and tea factories will increase in the next couple of years.

The region has also a number of enterprises engaged in the manufacture of both soft drinks and beer. At the moment, there are facilities to process soft drinks in Eldoret and Kisumu. Currently, the Kenya Breweries is constructing a beer brewing plant in Kisumu which should be operational in the next couple of months. This sector is likely to expand in regard to more soft drinks plants being established.

3.1.5. TEXTILES

There are three major textiles manufacturing plants in the region. These are Kisumu Cotton Mills in Kisumu, Rift Valley Textiles in Eldoret, and Raymond Woolen Mills in Eldoret. One does not envisage more plants of this nature being established in the region but rather one can foresee the expansion of the existing plants.

3.2. LIVESTOCK SECTOR

The region has the largest population of cattle in the country. The cattle are both dairy breeds mainly in the highlands and concentration of beef animals in the lowlands especially in South Nyanza District. This sector will expand with the improvement of animal husbandry especially in regard to disease and pest control and the improvement of stock through importation into the region of improved grade stock and through artificial insemination. Therefore, there is reason to foresee the establishment of most packing plants in the region and subsequent development of allied industries.

3.2.2. MILK PROCESSING

At present, there are two mild creameries located at Eldoret and Sotik. These facilities do not cater adequately for the dairy farmers in the region. It is therefore envisaged that with improvement of dairy industry, some milk processing facilities will be established in the future.

3.2.3. LEATHER PROCESSING

As mentioned earlier on, the region has the largest population of cattle in the country. The region therefore, generates large quantities of hides and skins which are exported in raw form to other parts of the country and to the overseas market. At the moment, there is no single tannery in the region. Attempts to establish a small tannery in Kisumu failed due to the entrepreneur being unable to satisfy the municipal authorities regarding adequate effluent treatment facilities. However, it is envisaged that leather tanning plants will be established in the region to process leather to wet blue stage. After the establishment of this facility, one would foresee the growth of the manufacture of leather products.

The region is suitable for growing of wattle trees. The wattle tree provides tanning extract which is used in the leather industry and this offers opportunity for linkages.

3.2.4. BEE INDUSTRY

The area has very suitable environment for bee-keeping. This sector at the moment is not being exploited fully. The Lake Basin Development Authority in conjunction with the Ministry of Livestock Development has programmes to promote bee-keeping and honey refining to produce natural honey and been wax. These refineries will be on the basis of cottage industries and will be scattered all over the rural areas of the region.

3.2.5. POULTRY

The region has no poultry hatcheries and consequently, poultry farmers have to import day-old chicks into the region which leads to heavy loses. Similarly, the region does not have facilities to process broilers for table use. At the moment broilers are sent to Tigoni near Nairobi to be processed and this leads to the substantial loss of the carcasses weight. To rectify the above situation, it is foreseen that there will be need to establish a number of hatcheries at strategic points in the region and the establishment of facilities to process broilers.

3.3. FORESTRY SECTOR

There is a large scale plant manufacture paper and pulp at Webuye. This is the Pan African Paper Mills. It utilizes pines and eucalyptus trees. There are also in the region a number of saw mills that produce sawed timber. This sector is not likely to expand unless stepped-up afforestation will be affected in the region. The region also has substantial potential for the manufacture of inter alia wall boards and ceiling boards using saw dust and bagasse.

The region has potential of establishing cottage industry based on the use of papyrus in the region. This enterprise involves unique technology and possibilities are being explored of utilizing the enormous quantities of papyrus available in the region to manufacture a special type of paper that can be used for tourists' art'facts, art paper etc.

3.4. FISHERIES AND BOAT BUILDING

There has been plans to establish fish meal plants in Kisumu utilizing haplochromis fish species. However, it appears as though the whole eco-system of the fish species in the Lake Victoria has drastically changed with the disappearance of large quantities of non-hyplochromis population and the emergence of nile pearch as the dominant species.. The current thinking is that any proposed fish meal plant may have to be based on the utilization of the nile pearch either from waste arising out of filleting or from the fish itself. The realization of the fish meal processing facilities will also be an important input to the enterprises that will produce animal feeds such as poultry feeds.

In order to modernise the fishing methods in the lake, the improvement of fishing boats is an important element. At the moment, the region has no modern boat building facility. In order to improve on the fishing industry, one will foresee the possibility of the establishment of boat building facilities in the Winam Gulf area of the region.

3.5. MINERAL BASED INDUSTRY

One may observe that the region is one of the areas of the country with heavy concentration of mineral deposits. These are mainly limestone deposits in Koru, Wire hills, Homa Hills and Cherangani. It is therefore foreseen that in the future, there is likelihood of the establishment of a cement factory in the region. This will have great advantages as it will serve the cement needs of the region and the surrounding countries such as Uganda, Tanzania and Sudan. If this project is realised, the enterprise will have to be on a large scale basis.

There are also mineral deposits such as copper, zinc, and gold that are known to exist in the southern part of the region. The commercial exploitation of these minerals will depend very much on the establishment of their present qualities and quantities.

The region has very suitable clays. These clays are being investigated with the possibility of establishing brick and roof tile manufacturing industry in the region. One may foresee the establishment of a couple of plants located in various parts of the region. There are also a number of quarries that produce ballast and building stones for the building and road construction. The potential of this sector has not been fully exploited and one would foresee more activities in this sector.

The Tabaka area in the Kisii District has significant amount of soapstone deposits. This rare mineral deposit will in future be exploited to manufacture such items as school chalk, electric insulators and possibly china-ware.

3.6. TOURIST INDUSTRY

The Lake Basin region has the necessary prerequisites for the tourist industry. These include scenery, flora, fauna and the cultural heritage that can attract tourists in the region. This region falls under what is known as the "Western Tourist Circuit". A number of tourist class hotels established to tap this tourist potential. These are at Homa Bay, Kisumu, Kakamega, Eldoret and Kabarnet. To tap the tourist potential basic infrastructure is being established such as the establishment and improvement of road and air transport, communication and other facilities, the eradication of tsetse flies in the Lambwe Valley. With the above facilities, one will foresee increased tourist traffic coming into the region. With the increased tourist traffic, a number of cottage industries to produce artifacts will naturally be increased.

3.7. INFORMAL SECTOR

In the large and small towns in the region, there are a lot of activities in the informal sector. Repairs and the manufacture of household items are catered for in the open air garages known in this country as "Jua Kali" workshops. This is an important sector in that it provides employment to a number of craftsmen and artisans in the region. Although this sector is often not given the necessary support by the authorities, it has significant contribution to make in the development of the region. Given the necessary infrastructural support, credit, and know-how, this sector will expand in the future.

In the rural areas, one observes that the presence of cottage industries mainly dealing with pottery, basketry, textiles etc. is part of the industrial programme. The cottage industries should be encouraged to produce semi-finished products as inputs to the major industries in the region and the country as a whole. This will be in the area such as edible oil processing and textiles industries.

4. CONSTRAINTS FACING AGRICULTURAL AND INDUSTRIAL DEVELOPMENT

The problems facing expanded agricultural and animal production are indeed many. They centre mainly on inadequate extension services, timely farm credit and other farm inputs. The whole of the farming system will have to be improved in order to get farmers out of a vicious circle. The farmers are in a vicious circle whose basis arises from producing just enough food for the family to lacking incentives to produce cash crops due to insufficient inputs, insufficient c seed at the right time, low crop pricing causing low incentives and so on. A development strategy of improving this sector will have to be placed on breaking this vicious circle that faces the farmers in the region.

Regarding industrial development in the region, one may foresee a number of constraints which may be outlined as follows:-

4.1. RAW MATERIALS

As mentioned earlier on, the farmers are faced with a vicious circle in production and consequently they may not be able to produce enough surplus to feed the agro-industries. Already this shortage of raw materials are being experienced in regard to cane deliveries to the major factories mentioned earlier on.

4.2. POWER SUPPLY

The supply of electric power is likely to remain a major constraint that is likely to hamper the growth of industries in the region. The likely victim of this situation will be the cottage industries and rural based small scale to medium size industries. The stepping down of power from the main supply lines is often far beyond the financial means of rural communities and individual entrepreneurs.

The cost for example of installing a transformer is often prohibitive. Furthermore, electric tariff charges are also so high that the rural communities and enterprises cannot afford this essential input for industrial activities. In order to rectify the problem, the LBDA in conjunction with the Government will have to explore possibilities of utilizing the hydro-power potential in the region. This will be either the installation of a major hydro-power stations or the exploitation of the mini hydro-power potential that has been identified in the region. Some of the power potential need not be fed into the national grid but can cater for specific rural areas, communities as well as industries.

4.3. WATER SUPPLY AND SEWERAGE FACILITIES

Most of the Municipal and Town authorities do not have sufficient quantities and quality of water for industrial use. The case of Kisumu water supply is a typical example that face many towns in the region. The sewerage facilities are also inadequate to cope with the industrial effluent arising from the industries in the region. A great deal of assistance will be needed to the Municipal and Town Authorities if they have to cater for future increased industrial activities.

4.4. LACK OF LAND AND ACQUISITION OF LAND FOR INDUSTRIAL USE

Most of the towns in the region are located in densily populated areas. This is true in regard to towns such as Kakamega, Kisii, Kericho, Kapsabet etc. These towns hardly have any land for industrial use.

The acquisition of land for industrial use will not be an easy task. Kisumu Municipality appears to be an exception in this regard in that it has acquired enough land for most of its development in the very near future.

Towns such as Kericho, Eldoret, Kitale are in the midst of commercial farmlands and acquiring this land for industrial use is likely to be difficult.

Furthermore, the administrative and legal machinery to acquire land for use such as for industrial enterprises is often prolonged and cumbersome process. This often discourages enterpreneurs who may have options elsewhere outside the region.

4.5. TOWN PLANNING AGENCIES

Most townships in the region do not have adequate machinery to plan their municipalities and towns. Consequently, development has taken place in a haphazard manner. For instance, construction of buildings would make the installation of social amenities such as power lines, telecommunications cables, water and sewerage installations quite expensive.

There is great need and urgency to assist these towns to improve their planning capabilities in order to facilitate industrial growth of the region.

4.6. LACK OF INCENTIVES

Most of the local authorities in the region have literally no incentives to offer to potential investors. For example, they do not have adequate water supply and sewerage; they may not have land that they could offer tax rebate on industrial sites as incentives.

Local authorities do not have the machinery to advertise and publicise industrial potential of their municipalities and towns to potential investors in the country and abroad.

4.7. LACK OF CAPITAL

Domestic financial institutions have not shown keen interest in assisting individual entrepreneurs and institutions that would like to set up enterprises in the region. This problem is aggravated by the fact that most of the financial institutions are highly centralised and located in Nairobi and it is often difficult for small scale entrepreneurs to travel back and forth in persuit of their loan applications. In this process, the entrepreneurs in this country are often discouraged.

There is no adequate financial intermediaries to marshall the savings potential of the region and to channel the savings into use within the region. Most of the savings are utilised outside the region. With regard to foreign private capital, the Government will have to take measures to implement its national policy of Decentralising of Industries. To attract more industries into the region, the Central Government has leverage of using the financial and administrative instruments to direct potential overseas investors into the region.

4.8. The presence of endemic diseases contribute to high mortality and morbidity of the population in the region. Waterborne and Vector diseases are common in this region. Consequently, many man-days of farm and non-farm labour is lost. This contributes to low productivity of labour in the region.

5. RECOMMENDATIONS AND CONCLUSIONS

In the context of the Seminar, one can observe that most of the agricultural and industrial activities are located near or alongside the major river systems and the Lake in the region. For example, Nzoia river runs through a major farming area that uses agricultural chemicals that are likely to be washed into the streams.

In view of the location of industries and farm activities with this important drainage system of Lake Victoria, the seminar will have to consider measures of conserving the environment arising out of both agricultural and industrial activities in the region. In this context, I would like to make the following conclusions and recommendation:-

(i) In the context of the seminar, focus need to be made on the need for coordinating planning to ensure competent handling of industrial wastes and chemical pollution of the environment arising from the domant carrier of industrial development sector i.e. agriculture in our region.

(ii) Ensuring safe and adequate amounts of water for both domestic use and for the industrial use and thus need for effective monitoring and control of the quality of water and effluents.

(iii) The importance of ensuring that the Lake Victoria water are not polluted from the streams and industrial effluent as this would destabilize the aquatic life that plays a significant role in the fish industries and natural requirements of the population of the region and the country.

(iv) Cooperation is required among the nations that share the Lake Victoria to take common measures to locate industries at a reasonable distance away from the Lake shores and rivers that drain into the Lake Victoria as a way of reducing possibilities of accidental pollution of the lake waters. In this regard, there is urgent need to collect baseline data on the rivers of the region and the Lake Victoria.

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Comment: The main environmental problem in the Lake Basin Development Area is that of poverty and under- development. Mr Bonuke has indicated the range of constraints which show that the area needs to develop in order to overcome its deficiencies in public health, and malnutrition.

Accordingly, the Authority's programme is to select a crop a year for promotion. For instance upland rice is current. The second year is edible oils and so on. That will go on steadily according to selected crops. After five years the Authority will phase out the first crop, expecting it to have become viable and self-sustaining.

There is going to be increased cultivation, use of water and siltation. Similarly social services such as sewerage must develop correspondingly with industrialization, agriculture and urbanization.

It is that development which will stabilize the population, reverse rural - urban migration.

Question: What is the role of Lake Basin Development Authority in helping establish industries? Do these go beyond the regular governmental practice?

Answer: The Authority is presently looking for approaches for doing just that. It has the mandate to promote development in the Authority area and it is in the process of liaising with respective ministries.

With Agricultural Ministry the Authority has established procedure for farm inputs, especially seed bank.

The Authority, where it is convinced about the value of a given project to the area, can actually invest. Right now the Authority is examining the bricks and tiles industries. The Authority will spearhead entrepreneural work in the industries of value.

The Authority will also establish food - industry balance, vis a vis cash crop industries.

Comment: (i) It seems that the key to development of crops in the area will depend on water resources management in the area. Could Mr Bonuke comment on irrigation policy and strategies for water resources use.

(ii) Use of fish, especially Nile Parch in industrial sense, may be trecherous in fish meal. At one time it was haplochromis, now that is not there. Nile Parch is new and might not be viable.

Answer: (i) Irrigation is expensive; because of that we have not considered pumping from the lake. We have a focus on gravity system. The proposed Kano Rice programme is irrigational and we may expand damming.

The present land tenure system where farmers are simply tenants in perpetuity is inequitous and the future will examine options for ownership of the land.

We also want to link fish and rice farming as practised in the Far East.

(ii) The ecosystem of the lake has changed over the past few years. That is the reason for dropping haphochromis. But we have also secured funds from the World Bank and FAO for fish farming. The idea may indeed, need reappraisal.

Comment: Remember too that Lake Victoria has an international character and we are cautious to draw on it for irrigation. We use the water while it is in the rivers as far as possible.

Comment: On the Tanzanian side Lake Zone Physical Development Plan for 1980-2000 for Mara, Mwanza, Shinyanga and Kagera Regions.

- integrated development of sectors
- to minimize competition and conflict in land use between forestry, agriculture, livestock, game, urban and rural areas.
- urban master plans for important centres.

Comment: Mr Bonuke did not stress the need to collect baseline data as to the quality of the environment before industries are established. Baseline data for the rivers should be collected.

Comment: It seems that the LBDA is largely coordinating body; yet I have also heard from presentations especially comments of Dr Olindo that LBDA is also for implementation.

Comment: The role of the LBDA is coordinating but we are also required to catalyse and catalystic role must overlap with implementation. The Authority can also supply the seed efforts as well as initiate. We are not confrontational and we recognize our limits. We have no manpower to assume full role of plan implementation.

Comment: Problems of deforestation is critical. Has the Authority looked at it?

Comment: UNDP Programme is underway on catchment rehabilitation and river profile studies. It was effective from July 1st 1982 for three years and that project should provide a basis for dealing with problems of deforestation.

Comment: Is there a need for a future coordination of conservation of the catchment of Lake Victoria basin. A recommendation to that effect should be produced by this seminar. The solution will have to be in the cooperation among all basin states.

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PROJECTED AGRICULTURAL AND INDUSTRIAL DEVELOPMENT
IN THE LAKE BASIN AREA BY 2005

BY

PEREZ M OLINDO

PEREZ M OLINDO

The view that the Lake Victoria Catchment of Kenya, is a sparcely populated rural area where subsistence farming is the major occupation of its people, is outdated. This status has changed rapidly over the last three or four decades. There are high population concentrations in districts like Kisii, Kakamega, Kericho and threatening trends in this regard manifest themselves in Siaya, South Nyanza, Nandi and Bungoma districts.

The recent rapid rise in population has led to increased demands for food, clothing, providing employment, health services and accommodation. Land as the basic resource remains the same in area but continues to decline in its capacity to support larger populations. Whether one considers the provision of food and shelter or the containment of the wastes produced by these populations, it is quickly realized that a problem exists. The resultant strain to existing systems, if not addressed and resolved, will surely destroy the natural and self renewing mechanisms within the aquatic and general environment in the foreseeable future.

The agricultural sector has continued to progress in the recent past. However, sustained observation of the public sector tends to reveal some resistance to scientific farming techniques which promise consistent high returns. The exacting demands this approach places on all those concerned is the apparent deterrent.

The order of priority in the expenditure of farm incomes does not include reinvestment in the farm itself and thus, leaves farms to feature as the exploited weeping boy. This trend has led to the realization of diminishing returns which of necessity breeds discontent, and at the worst, desparation in the farming communities. Having become an unstable entity, the farmer has tended to develop tendencies of trial and error by drifting from crop to crop hoping for some chancy good luck to come to him along the way.

Fluctuations in Farm Produce Prices

The single most destabilizing factor in the production of any crops, whether they are staple or cash crops is the fluctuating price structure. To a large extent, this must have an adverse logical relationship to the cost of farm inputs. The truth of the matter is that the consequent unstable rate of production cannot be expected to sustain agro-based industries. Actually, a set of conditions which promote public confidence is needed to guarantee a sure basis for the rapid development of a thriving agro-based industrialization programme. With proper agricultural policy inputs, the public confidence helps the sector to ensure the continuing production of larger and better qualities of selected crops to the level of sustaining stable industries. The components of the system suggested would include pricing structures that take into account the cost of farm inputs and provide for a small margin of profit for the farmer. Other requisite considerations include a secure market, even if this means the Government becoming the main buyer of the farm produce and storing the same in the form of reserve food stocks for the purpose of guaranteeing raw materials availability for industrial activity in the selected areas all the year round. The current vacillation between periods of plenty at harvest time and long periods of shortages can never really provide a good foundation for establishing an agro-industrial base for any part of the country including the Lake Basin Area.

Industrialization

Supposing that some criteria was agreed upon to select a given number of crops for large scale promotion, how and when would such a decision have a physical and economic impact to the Basin Area?

One could take for instance, Robusta Coffee, Passion Fruit, Cotton, Pyrethrum, Pineapple, Sugar-cane, Cassava, Bananas, Rice, Oil Seeds, Beans and Peas as crops with high potential in the Lake Basin Area.

The effort would not be as formidable as it looks at a glance, yet it would not be as easy as to dismiss it at a glance either. A careful look shows that specific Authorities have been established in Kenya to promote and market the following crops:

Cotton	Sugarcane
Coffee	Rice
Pyrethrum	Horticultural crops

Whether these Authorities are transacting their business in a manner that is commercially acceptable or not is not the subject under discussion here. However, the strategy to promote and market these crops at a level that may sustain agro-based industries would require the intervention of the Lake Basin Development Authority at the co-ordination level, between the existing Statutory Boards, the Ministry of Agriculture and the farming community at the production level, while the KIE, ICDC and the appropriate Parastatals undertake the marketing and possibly processing the raw materials to finished products.

The crops around which no Parastatals have been established would involve the Ministry of Agriculture and the farming community at the production level with LBDA taking the role of promoter and possibly special institutional arrangements being made which may very well include the establishment of subsidiaries of the LBDA to handle the marketing and manufacturing aspects. For the crops around which Statutory Boards have been established. commodity pricing is controlled and in many cases the farmers have no other markets.

However, an alternative to controlled pricing exists. This alternative involves the lifting of all controls and allowing the marketing of farm produce within the country as may be dictated by the forces of supply and demand. If the country opted for the latter alternative, the

Besides, it is used industrially for the manufacture of starch, cornflakes, bread and for oil extraction.

Maize grows well at altitudes of upto 2200 metres; responds well to medium conditions of temperatures, altitude and rainfall but it does not do well under high temperatures. It can be grown well in most parts of Kakamega, Bungoma and parts of Busia of Western Province, and Kisii, Siaya, Kisumu and South Nyanza districts of Nyanza Province; and in Nandi, Kericho and Trans-Nzoia districts which also lie within the Lake Victoria Catchment. Maize is one of those crops which have attained the self sustaining status due to community needs and commercial productions subject to good prices. Efforts are being made to increase the yields and quality by the introduction of hybrid seed and application of fertilizers.

Rice (Oryza Sativa)

Rice was previously regarded as a luxury. It has now become a staple food for most Kenyans. Rainfed rice is now grown in various parts of Busia, Bungoma, Kakamega and South Nyanza Districts of Western Kenya. Potential land for growing rainfed rice in the area exceeds 19000 hectares and the Lake Basin Development Authority has definite plans to assist small scale farmers to put this land into active rice production. During the 1983 growing season, it is planned to plant 6-7,000 hectares of rainfed rice in the above mentioned districts and an estimated harvest of some 16,000 tons of paddy is expected. Rainfed rice is grown in swampy areas, which, for many years had remained furlow and only provided rough grazing for native cattle sheep and goats . It is hoped that farmers in these areas will adopt zero grazing and keep grade animals for their dairy and beef requirements. With the introduction of A.F.C. loans to rice farmers, the purchase of more tractors by the LBDA, the early commencement of land preparation should lead to the achievement of the target of 7,000 hectares during the 1983 growing season.

Millet

This crop has the capacity to withstand hotter conditions and grows under less rainfall (around 500-6mm per year) than maize. This crop is well suited to medium/light sandy soils but will produce a good crop on the poorest soils in the area. Thus it is most suitable for the marginal zones of the Lake Basin Area and should be encouraged as a buffer food crop, but under normal circumstances, it should be grown specially for animal feeds.

Millet is a staple food for most families in the Lake Basin area. The aim is to find and propagate varieties that can be high yielding and more palatable than the conventional types found in the region.

Cassava

Cassava is a staple food crop in many areas of Kenya. It has considerable potential for starch production and may be used for the preparation of animal feeds, both nationally and for export. Cassava is capable of producing high yields under conditions of poor fertility and low rainfall. Its foliage on the other hand contains about 17% protein and there are varieties which have been developed in some countries for other uses. There is a large and rapidly growing world trade in dried cassava notably from Thailand to European and American markets. The main cassava growing areas of Kenya are situated in the Lake Basin and Eastern Province. Cassava grows in warm drier areas at elevations of below 1500 m.

Oil Seeds

Groundnuts, sunflower, soya beans, green grams, simsim and cotton can be planted on a large scale within the Lake Basin Area. Land preparation is done during the dry weather and seed planted soon after the first rains.

These crops require sandy soils with adequate rainfall at flowering stage. Clean weeding is essential. Some fields might require fertilizer, but this is not critical for good growth.

Most of the Lake Basin Area can be utilized for growing oil seeds notably in North and South Kabras, Nambale Division, South Teso, Bunyala and Samia. The entire coastline of Lake Victoria and most of South Nyanza district are suitable for these crops.

Most of the oil seed crops take between 90 - 150 days to be harvested. The crops are susceptible to various insect pests and disease but these can be controlled. Care should be taken using chemicals in agriculture because some insecticide have adverse side effects to the environment and the insects which are useful to the farmer. The bye-products of oil seed crops after extracting the oil are useful as animal feeds, and will be in high demand especially by the small scale farmers who are now going in for zero grazing.

Simsim

This is an oil seed with a high oil content (45 - 55%). It grows well in most parts of the low lands of the Lake Basin Area. Simsim is fairly drought resistant and will grow well under 400 - 500 mm of rainfall and a warm climate. The crop matures in 120 - 140 days.

Sunflower

This crop is grown on large scale farms in Trans-Nzoia and many parts of Bungoma and Busia districts by small scale farmers. Sunflower of the best variety in Kenya has an oil content of 28%. The cake that remains after oil extraction is a feed for livestock for which demand will increase as the concept of zero grazing takes hold.

Groundnuts

Groundnuts are used for margarine and cooking oil manufacture. The best quality are used in the confectionery trade. This crop constitutes an important source of human protein in Western and Nyanza Provinces. The groundnut cake is very rich as animal feed and may usefully be mixed with cassava in the zero grazing programme of livestock development in the area. Most parts of low lands of the

Lake Basin Area are suitable for groundnuts growing. Two varieties thrive, the Uganda Red and Uyoma type - both of which can be grown during short and long rains. The LBDA is encouraging the farmers to orient themselves for a two crop year in order to build up the stocks for industrial development. Selected seeds, which give the highest yield free from diseases are being sought and propagated.

Cotton

Cotton is a perennial crop which is grown as an annual, mainly because, if left for more than a year in the field, the pest problems become too great. Cotton grows well in most low lands of the Lake Basin Area and efforts are being made to improve the quality of the crop by proper crop husbandry. Kenya's requirement is 14,000 tons per annum, but at present Kenya produces under 8,000 tons per annum. This is one crop on which a full feasibility study has been completed with LBDA Funding.

Education

Farmers should be trained in all aspects of crop and animal husbandry through any one or a combination of the following procedures:-

(a) Farmers Training Centres - There are four institutions in the Lake Basin Area namely Mabanga in Bungoma, Homa Bay F.T.C., Maseno F.T.C., and Lugari F.T.C. These can be revived and/or expanded at low cost to cater for intensive courses of the nature suggested above. The Institutes of Technology should also be used to further farmers' education of this nature whenever possible.

(b) Field Demonstrations - either on individual farms or at Farmer's Training Centres should be intensified and diversified to cover all target crops. Whenever field demonstrations are organized, they should be widely advertised to attract maximum attendance.

(c) Tours and visits should be organized for selected farmers to facilitate maximum exchange of knowledge with other developed farmers or those with similar problems.

(d) Personal contacts by Field Officers should be encouraged - this will require well trained and dedicated personnel at all levels, if maximum returns are to be realised.

(e) Leaflets and Newsletters:

Farmers do not like lengthy letters, short and to the point leaflets in a language they can read and understand constitutes a useful medium of communication.

Field officers must also be trained from time to time through well organized refresher courses. They should be prepared to adjust according to the needs of the area of their posting. Research stations should work on farmers' problems and be able to communicate their findings through prescribed media as well as through the field officers. Arrangements should be made to make the necessary farm inputs accessible to the farmers, and if necessary at subsidized prices.

Cash Crops

Coffee

Robusta Coffee is for low altitude places, suitable for most parts of Bukhayo, Marachi, South Teso, Samia, Bunyala and large portions of Siaya District. The seed is planted in the seed-bed and transplanted after 18 months. The crop matures after 2-3 years. Treatment of disease and insect pests is necessary. he bean is harvested, dried and crushed after roasting. Yearly prunning is essential if high yields are to be assured.

Arabica Coffee is for higher altitudes. Treatment is the same as with robusta but this variety of coffee requires pulping before drying. The factories use plenty of water during the processing period and Arabica Coffee factories are amongst the biggest and worst polluters of water resources wherever appropriate waste disposal measures are not taken.

Pyrethrum

Pyrethrum is for higher altitudes, suitable for some areas in Kisii and to a lesser extent up the Elgon mountains. Pyrethrum requires deep loam soil and adequate rainfall. It is marketed through the Pyrethrum Board of Kenya who process it and distribute it all over the world.

Macadamia Nuts

Suitable for all areas along the lake shores. Very important fruit for domestic consumption and export and yet, little has been done about its cultivation in the area.

Avocados

Avocado pears contain plenty of food value and oils for soap manufacture and for beauty skin care but so far those farmers who have planted this crop find the fruit to be a continuing embarrassment when they do not find market for it and it has to rot year in and year out.

Sorghum - (Finger Millet)

Suitable to grow in many parts of the Lake Basin Area. Research should continue with the object of finding high yielding varieties which are resistant to disease. The crop is suitable for human consumption and as cattle feed. Its common disease is smut but may be contained by the use of chemicals.

Possible Industries for the Mentioned Crops

Robusta Coffee: is directly connected to the Instant Coffee Industry. Kenya is a net importer of Instant Coffee and allowing 18 months for the growth of seedlings, and 3 years for the coffee trees to grow, production of instant coffee should be realised within 5 years from the time the project is launched.

Pyrethrum is well catered for and the LBDA would only need to bring the farmers' representatives and the Pyrethrum Board together to ensure the full utilization of suitable lands in the area and the creation of incentives to encourage the farmers to strive for greater heights of production. Arrangements should be made to pay farmers adequately and in time to strengthen their confidence in their own industry.

Sugar-cane : The problem of sugar-cane growing lies in the pricing structure. It is the general view that, if a realistic pricing structure is not arrived at soon enough, the decline in sugar-cane production may continue to the point of endangering the heavy investment that has gone into the sugar mills in the country long before 2005 A.D, which is only 23 years hence. The formula of considering the inputs to determine the price for sugar-cane per ton should be used in the maintenance of farmer confidence.

Cotton: The two textile mills located in the Lake Victoria Catchment area of Kenya are net importers of cotton, while it is true that in 1980, the Lake Basin Development Authority completed a feasibility study on cotton and proved that, given the necessary promotion and marketing outlets, the crop should be self sustaining and also generate a series of other industries around cotton. Among such possible industries are edible oil industries, animal feed industries, cloth making industries etc. Developments of this nature would ensure the full and profitable utilization of the full and profitable utilization of the already established textile industries and the farmers would get more for their labours. The cotton farmers continue to complain that the cotton Act is defective, in that, it automatically transfers ownership of their cotton to the Cotton Board and must be amended to recognize the farmers' right to the crop before he decides to sell it to the Board. The Lake Basin Development Authority supports this view and should get the ball rolling towards the realization of legislative change to meet the farmers' aspirations.

Rice: One may consider that the National Irrigation Board is the logical promoter of irrigated rice. This crop has been adopted by many communities in Kenya as a staple food. When one looks at the numbers of rice eaters who go around but cannot get the commodity, trotting around the country looking for rice and yet returning home empty handed, one concludes that rice growing and milling has a definitely bright future in the Lake Basin Area and elsewhere in the country but further, that the industry must come under the full public control to ensure that, at least, those who grow the crop can eat some of it after it is processed. A combination of rice husks and pineapple peals is known to produce a very nutritious breakfast supplement. This possibility should be investigated further, and the results acted upon for the benefit of the country.

Bananas: It has been proved in Kisii and Kakamega Districts that large quantities of bananas can be grown. But there is no steady bananas market. Banana crisps are an excellent alcohol with the wastes serving as animal feeds. Pilot plants should be considered for Kisii and Kakamega districts where raw materials are already in plenty supply and further research on other uses of this crop should be continued.

Passion Fruit· has a ready market for its juice, both at home and overseas and passion seed can provide excellent cooking oil for an area currently inhabited by well over 7 million people, a majority of whom cannot afford to buy other brands of cooking oil imported into the area.

Cassava: is a human as well as an animal food and from it industrial and clinical starch may be manufactured. Most of the areas in Lake Basin Area are suitable for cassava growing and the crop takes two years to mature.

General: The judicious development of the various activities touched upon in this paper should be able to create jobs at the farm, manufacturing, distribution and retail levels and must be given serious consideration within the context of employment creation and the overall development strategy of the Lake Basin Area. While projecting agricultural development, it is safe to expect a problem rate of 25% of the entire programme, thereby, calling for intensified research to resolve these problems as and when they crop up.

Gestation Period For Building an Industry in the Agricultural Sector

The concerted effort of mobilizing rural communities to accept selected crops and break away from their tradition subsistance practices will necessitate virtually a crusade if any meaningful developmental impact in the agricultural sector is to be realised in the Lake Basin Area. First and foremost, the co-ordinating body has to accurately determine what the ground status of the target crop is. This is established by extensive ground surveys, making reference to background research and past experiences at the farm level of the target crop and finding out why it did not take off in the first instance. The psychological state of the community to be mobilized is an aspect of critical importance to the success of any community oriented mobilization. The second step is securing the commitment of the community in question to adopt the project as its own.

The co-ordinating body, cooperating with the Ministry of Agriculture will move further and train field extention officers selected from the Ministry of Agriculture to be versed in all aspects of the crop in question; including land preparation, planting time, diseases to which the crop is susceptible, how such diseases should be avoided and what remedies are available if there is an attack. The officers should be capable of advising the farmers involved as to the appropriate fertilizers, and such other information as the length of time the crop takes from planting to harvesting etc. The process described above takes about 18 to 24 months.

It is risky to embark on field demonstrations and field days with a bunch of ignorant extention officers, because, when they fail to answer the questions of the farmers or when they give incorrect information to the target community, that would undermine the intended goal of building up public confidence in the projects. Some of the activities mentioned above may be carried out simultaneously with much advantage. The project organizers are always the best judges of the projects' progress in relation to what degree of success they set for themselves. It is advisable that specialised units of researchers be alarted to observe and be ready to tackle any pathological problems, as and when they arise. By the end of the demonstration season, arrangements to widely launch the growing of the crop should be made and implemented in good time and with plenty of supervision. Other indications show that the yield results are better when the farmer is assisted to have easy access to the basic farm inputs such as certified seed, land preparation machines and fertilizers.

Consultations

In order to mobilize any community successfully, that community has to identify itself directly with the objectives of the mobilization exercise and actually adopt them as their own. This requires detailed consultations at all levels of that community to enhance widespread involvement in the project.

Special Extention Services Training

It has been proved under the Upland Rice Project sponsored by the Lake Basin Development Authority and the Ministry of Agriculture that specialized training is best directed to those already trained technical extention officers who have the grasp of the functional aspects of agriculture and have worked closely with the rural farming communities. Such extention officers could be the additional training in the growing of a wide range of selected crops. Such a step would minimize the strain to have on the limited trained manpower and meagre financial resources in the country. But at the same time, training of additional manpower for these projects provides the opportunity for job creation and therefore the possibility of reducing the high incidence of unemployment which presently exists in the Republic.

Crop Demonstration Plots & Field Days

The next stage of promoting the growing of selected crops is through the organizing of field days and making it possible for large numbers of farmers within a given area to interact and exchange information. They would also receive practical instruction in the proper husbandry of selected crops and the likely problems the farmers may encounter in the field when growing the crops. The approach which has been adopted by the LBDA is to support selected farmers in areas where the Ministry of Agriculture considers appropriate for the growing of the selected crops. The selected farmers are given certified seed, fertilizers, if necessary; research findings of the crop in question is placed at their disposal, and they are guaranteed the necessary protection against any pest or disease that may attack the crop. The supported plots are then supervised by extention officers from the Ministry of Agriculture and it is around such plots that field days are organized to effectively transfer the needed knowhow to a wider section of the target farming communities.

Project Implementation

The season following the demonstrations and field days is usually the best for getting the farmers to implement the programme. Early and proper land preparation is important. Assisting the farmers to secure short term credit facilities and other appropriate inputs, like certified seed and then organizing seminars for the farmers is an important initial strategy. Thereafter, use these seminars as the forum for identifying possible bottlenecks and doing everything possible to eliminate the problems. The seminars have been seen to have a positive psychological impact on the farmers because it enables the farmers to perceive themselves as a group striving for the same objectives. Therefore, it is recommended that this form of effective communication should be sustained, and intensified. Past experience in many parts of Kenya, including the Lake Basin Area, shows that the rural farming communities usually respond positively through all the stages described above until after implementation when problems arise.

Crop Selection Criteria

The most critical consideration in selecting which crop to promote for mass production is that of finding out which crop will sell fastest with attractive returns to the farmers in sufficient amounts to encourage them to repeat, expand and intensify their efforts in subsequent years. It would appear from the face of things that, staple foodstuffs have no serious problems because staple food markets have been established and levels of demand from time to time can be predicted from year to year. In such cases therefore, public confidence has been achieved and the crops may be described as self sustaining. In cases where ready markets do not exist, the promoters, the LBDA and/or the Ministry of Agriculture, and any third party interested in utilizing the raw materials so produced for commerce or industrial activity, must have a pre-determined commodity flow chat, so that the produce is purchased from the farmers as soon as possible after harvest. This enables the farmers to honour their obligations with the creditors and therefore, establish credit worthiness that will ensure their success as farmers on a continuing basis.

It is the considered view of the writer that, wherever this ideal level of farmer confidence is broadly achieved, a basis will have been established for industrial development for the crops concerned. However, once achieved, the promoters will have to look for ways and means of developing dedication and commitment to continuity of the industry. When one considers the stages described above, it quickly becomes evident that a lot of time is required to promote a crop from any point to the level of mass production. Whether or not any given crop attains the level of self sustenance depends on a number of factors including the commitment of the promoters, the farmers' enthusiasm and the sensitivity of the pricing structure to the cost of the wide range of inputs which are constantly required to make any farming effort a success. With the high priority that the Kenya Government has attached to food production in the country, there is need for clear mechanisms through which suitable farm inputs can be guaranteed to the farmers at prices which have a direct bearing to the cost of their farm produce at any given time. Indeed, there may be a need for a Standing Public Watchdog whose sole function will be that of ensuring the existance of a constant balance between farm inputs and farm produce prices. If it were possible to observe this sensitive relationship continuously, the adverse production fluctuations which have plagued the farming industry in Kenya for decades may be aliminated all together. Otherwise, these regretable experiences may still be realized in the future. In fact, a price produce balancing mechanism could create the problem of surpluses, which at the National level, may be viewed as preferable than its obverse. In point of fact, this should be the deliberate quest of the LBDA in close co-operation with other departments of the Government. When this goal becomes the reality, a basis will exist in which a stable and meaningful prediction may be formulated for the promotion of the agro-industrial development in the Lake Basin Area for the future.

If one were to base a prediction on prevailing trends and past experiences, the Lake Basin people would have no option but to prepare themselves for recurring rude shocks and developmental stagnation, or at the very worst, developmental retardation.

The thrust of this discussion points to the fact that, as the co-ordinator of the developmental process in the Lake Basin Area, the policies and resolute determination of the LBDA will decide whether Agro-based industries will take root and subsequently thrive in the area.

CROP PROMOTION - A CHRONOLOGY OF ACTIVITIES

Stage	Activity	Responsibility
1.	General Surveys to determine existing status of the selected crop	LBDA & MOA
2.	Locate trained crops extention officers. Stage 1 & 2 may be undertaken simulteneously to greater advantage.	MOA
3.	Mobilize target farming communities and launch crop demonstration centres detailing the farmers role and other inputs for making the effort successful.	LBDA, MOA Administration, Cooperative Dept. & Community Development Department.
4.	Organize special short courses for the crops extention officers see 2 above.	LBDA, MOA
5.	Mobilize the movement of certified seeds and other farm inputs to the target areas and assist farmers to arrange credit facilities	LBDA, MOA AFC, NC, PB & KFA.
6.	Mobilize ana strategically locate farm machinery teams, prepare the land and plant the crop.	LBDA, MOA & the farmers.
7.	Mobilize researchers with the knowledge of the crop under promotion.	LBDA & MOA
8.	Carry out surveys related to produce storage and marketing	LBDA, Ministry of Commerce & Parastatals.
9.	Carry out surveys for processing and manufacture	Ministry of Industry and Private Sector.
10.	Undertake large scale planting and purchases	LBDA & MOA
11.	Repeat the exercise yearly	

A Reserve Food Fund

It is tempting to suggest a possible dialogue between the LBDA and the Government aimed at establishing a Reserve Food Fund to facilitate the prompt purchase of selected farm produce from Kenyan farmers, even at preferential prices, and store the same in National Reserve Food Stores.

The realization of this strategy would convert the public sector into the largest and most stable marketing outlet for the farmers of the selected crops. The issues in question surround what actual expenditures the country incurs in curbing food deficits by buying from external sources, as compared to incentive pricing and preferential purchases by the State. The present proposal has the added incidence of job creation and the saving of foreign exchange, having national food reserves, and possibly generating surpluses for export. This raises wide open issues for discussion and resolution.

Assumptions on which Projection May be Made

It is assumed that the LBDA will adopt a reasonably aggressive agricultural policy and will make every effort to open dialogue after dialogue with the Government to streamline farm production systems in order to ensure the establishment of thriving Agro-based industries in the Area. It is further assumed that a Standing National Farm Produce Pricing Mechanism will be created to constantly review the relationships between farm inputs and farm produce, their actual and relative costs, and create a favourable outcome to the farmer on a continuing basis. This would be a practical incentive for farmers to produce more and more in Kenya. It is also assumed that the sprouting institutes of Science and Technology will bear fruit in the form of producing serious and well trained technicians, who will have the requisite technical discipline to adapt to changing conditions in a dynamic industry aimed at industrializing the Lake Basin Area of Kenya.

Another critical assumption surrounds the need for the modification of emphasis in the investment policies of a majority of the private and public Finance Companies in Kenya. A casual observation reveals the fact that finance companies in the country tend to shy away from financing ventures located too far away from the major commercial centres of Nairobi and Mombasa. One of the consequences is the depressed economic situation in the

Lake Basin Area. It is therefore further assumed that, in order to promote the rapid development of such economically depressed areas, the development Authroties will have to open discussions with the Government with a view to creating a series of preferential incentives to industrial concerns to locate their activities in areas that are manifestly suffering from industrial depression. The incentives may take the shape of tax relief, the provision of site and services free to industrial sites, ensuring the expeditious allocation of industrial plots, the waiver of Rates, Land Rent and Stand Premium. The list of incentives is almost unlimited. The intention here is not to deny the central Treasury sources of revenue, but rather, to underscore the Government's determination to promote a policy of equitable industrial development all over the country. In any event, this will expand new sources of revenue for the government if the expansion of the economic activities occur.

Projection

With the foregoing considerations in mind, and further assuming the active promotion of an atmosphere of public confidence in the agricultural and industrial sectors, it is not too remote to entertain a vision of widespread developments of agro-based industries and other allied activities all over the Lake Basin Area before the turn of the century. Anyone imagining that such a vision will be easy to come by is totally on the wrong track. The mammoth tasks of co-ordination and commitment are so extensive that it is not easy to quantify tnem nor accurately describe them in words. To successfully establish thriving agro-based industries in the Lake Basin Area, it is envisaged that there will be sacrifices, disappointments and casualties along the line, but if it is resolved to modernize agriculture and manufacture the raw materials arising from this expanded agricultural production to finished products, the possibility of industrializing the Lake Basin Area by the year 2005 AD is within our grasp.

Environmental Implications of the Projection

Water Demands

If the increased crop production reflected in this paper is realized, substantial water usage will occur. In the entire Kano Plains, the Yala Swamp and most areas near the lakeshore where two regimes of water supply are possible, farming systems based on rain and irrigation development present themselves as alternatives available to the Lake Basin people, the LBDA, the relevant Parastatals and the Ministry of Agriculture for the extensive diversification of the agricultural sector. This approach if adopted, will in turn call for the utilization of larger quantities of water, especially through irrigation to sustain the crops. However, as far as irrigated systems are concerned, major decisions will have to be made relating to how Kenya wishes to make use of her water resources to be found within her sovereign borders and also what portion of the waters of Lake Victoria which will have to be used regulated by some form of regionally negotiated water apportionment protocal. Kenyan needs will inevitably have to be related directly to two basic factors i.e. (i) her net contribution to the total water mass in the lake and (ii) her cost of safe-guarding the Lake Victoria catchment areas located within her borders, without which the stability of the lake level would not be guaranteed. This would take into account the value of the other alternative land uses to which the land within the catchment areas could be put. At the present time, the public may feel that, while 3/4 of Kenya's surface land is marginal, arid or semi-arid, water is a basic limiting factor. There is therefore the view that this important factor to national development should not be left pending any longer and that firm and binding decisions should be made.

Increased Siltation

With the expansion of arable land, the incidence of siltation will proportionately increase. This increase is bound to cause biological stress to the aquatic environments and the productive biological systems of the Lake Basin waters. The active soil conservation programme which Kenya is putting into effect should, in due time, reduce the silt load in the rivers all over the country and to an extent, rehabilitate a situation that is currently totally out of hand.

Agricultural Chemicals

The modern approach to agriculture calls for the use of a range of chemical inputs to increase the productive capacity of the land. Fertilizers and pesticides are deemed to be essential in agriculture, and a series of other chemicals are considered desirable for proper farming. This projection inevitably reflects a picture of intensive use of a wide range of these chemicals with the real possibility of increased deliterious effects to the environment. Considering the current public concern for the well being of the environment, and the growing trend towards the use of biological means to fertilize land and fight pests; it may be confidently hoped that the threat towards total destruction of the environment will be prevented or controlled.

Expected Discharge & Pollution

Considering the high rate of population growth, which is currently estimated at 3.9 and the fact that a majority of that population is under the age of 20 years, the prospect of doubling the Lake Basin Area population before 2005 A.D. is quite real. One may therefore expect a large quantity of domestic effluent discharge with the incident of pollution greatly increased, unless checks and balances are built into the system to be adopted for the development of the area between now and the year 2005 A.D.

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CHAPTER III

CASE STUDIES FROM LOCAL AUTHORITIES

BY

P.O. SEWE
R.I. KATAMBANI
ASHIBILA
W.O. ORWEYO

BY R.I. KATAMBANI.

The problems of urban sewage treatment and disposal are fundamentally the same for the small urban centres in Kenya. In this regard the discussions of Eldoret are illustrative of our problems, with only a few unique exceptions. But before I make a general presentation on Webuye I want to emphasize that there are two special problems that must be considered in every case: First, that manpower training for the task is a prerequisite. No local authority will be able to assess and deal with its problems on a continuing basis unless it has its own trained manpower to an adequate number. Secondly, land is getting increasingly scarce in this country. Therefore, it is already quite difficult to get land set aside for placement of lagoons. In Webuye, the paper industry is a unique feature. The problem here is that very often the treatment ponds of the paper industry do not work. Thus, most of the effluents from the industry are discharged into the river and other water systems. Thus I must point out to the organizing committee that the local Authorities are in need of a master plan for waste disposal, and stormwater drainage. They also need assistance for relevant organizational, financial, legal and administrative aspects to adopt and effectively enforce efficient treatment programmes.

We require a study with phased plans and recommendations to be represented, which will be avaluable planning tool in the hands of the local Authorities. That will enable them to stage municipal developments in the most National and economic manner. The reports should represent an essential contribution to the pollution control of the natural water in the Lake Basin.

Among the pre-requisites for the orderly functioning of a Town are adequate water, sewage disposal, stormwater drainage and refuse collection. There are problems that are encountered within these services such as pollution of water and air.

In addition to the significance of these problems from the stand point of public health, it is clearly recognised that they involve such matters as individual safety and comfort, recreational activity, industrial productivity and value of land and property.

In the Lake Basin area severe difficulties might arise within a few years and pose a major obstacle to the continued development of the communities if the present sanitary and drainage services are not improved. Up to date control of water pollution and air pollution should be properly planned in the urban areas.

Recommendations:

(a) As noted above the present conditions of sewage services, drainage systems and water disposal indicate a need for a comprehensive development pl This should also include what is mentioned before, namely, organizational, administrative, financial and Legal aspects of the múnicipal services.

(b) To make proposals for immediate requirements of the sewerage systems, sewage disposal, stormwater drainage, solid waste disposals and water pollution control systems as well as air pollution.

The latter proposals should provide adequate solutions until such time as the first phase of implementing a comprehensive water pollution control and solid waste proposal systems become operational.

The requirements may be in the form of urgent development needs, operational, maintenance and administrative changes and any service that may be deemed advisable.

COMMENT: The MOWD monitor the effluent from Webuye. It is confirmed that most of the time their factory which produces some highly toxic substances - sulphides, and are discharging into the river. The effects on the biota downstream, including humans, goats etc in Siaya are drastic either in the short-term or long range perspectives.

A small portion of the waste water is used for irrigation but only a small quantity. The rest goes to the river raw.

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The second unique problem is the air pollution. This is from hydrogen sulphide which is emitted from the factory. This can be invitigated by capture and removal of the sulphide and the technology is available.

Q.1. Has the Ministry of Health looked at the impact of this effluent on Man ?

Q.2. How about the colour noticeable in the water ?

COMMENT: The Ministry has actually checked and confirmed that the trickling filters were not working and the effluent was being drained into the river. In other instances the overflow from the ponds led to the river directly. The Ministry has warned that Company to take action within the shortest time possible. This was about 20th July, 1982. The air pollution is yet to be tackled.

COMMENT: The Fisheries Officials had, by 1979 noticed a decline in the fisheries on Nzoia River. This can be attributable to the impact of the raw effluents discharged from the paper factory. No court action has been taken against the company for discharge of the raw waste in the river.

COMMENT: The Webuye pollution is not new. It was raised within the East African Community's research Institutes in 1977. So they have actually been discharging for that long. A report prepared by Balirwa and Bugenyi on the subject was published on Biological Conservation of 1980 at pages 53 - 58.

COMMENT: But which Ministry is concerned with the enforcement ?

A. Ministry of Water Development under the Water Act has power to ensure that any water user treats the effluents before waste water is discharged into the water system, such as Nzoia. The problem is the evidence required to prove liability. The process itself is long and complex including securing consent of the AG. to prosecute. One of the problems the session should consider, is to recommend effective legislative mechanisms.

Q. Does the LBDA have power to regulate the quality of the water use ?

A. Authority has the advisory power to let the Government know. Part of the reason for Workshop is to get a set of recommendations to the Government on such an issue and the Authority will ensure that the recommendations reach the right persons.

COMMENT: The Lake Basin Development Authority should get to the baseline data and seek enforcement through the right channels.

COMMENT: There is a lacuna in the capacity in the existing agencies and not in law. Under Public Health Act there are powers and Public Health officers have used it in a number of instances in the country.

The Nzoia situation is a critical one because of its impact of man through food chain. The Authority is urged to act because its goal of promoting development is seriously undermined by pollution endanger ing the food chain.

The matter is critical because the paper mill of Webuye is owned by IBRD, Kenya Government and an Indian Company. This means that public institutions are doing the damage.

In the Sosios River instance the case was taken to court and the company was fined Shs 2,000/= for the Pollution.

The evidence was clear from the beginning when fish had died in the river. Therefore, this was a ridiculously low penalty for the damage caused.

COMMENT:

Municipalities are registered as water undertakers but without the Government ensuring the capability to ensure proper monitoring.

There are difficulties in dealing with Webuye Paper Mill, the fines have been minimal. At present the Ministry of Health is enquiring with the AG's chambers because the Principal Medical Officer is drawing up a charge against the factory for the offence and intend to file an injunction to stop their operation. The Public Health Act requires that a proper notice is served and beyond which the case can be taken to court for request fo an injunction or penalty.

BY C.ASHIBILA (PUBLIC HEALTH OFFICER)

(1) Type of sewage:

The main sewage is mainly domestic as there are very few industries in Kitale. The only industrial sewage is from the Kenya Cooperative Creameries (KCC) and very little from the new Kenya Utensils Ltd., a company located in the municipal area.

When the K.C.C. factory was commissioned, there were no arrangements to pretreating the sewage from the factory. This caused a major breakdown at the then conventional sewage works. This forced the Municipal Authority to force the K.C.C. to pretreat their sewage before discharging it to the sewer. As a result, a small activated sludge treatment plant was installed at the K.C.C. since there has never been a problem of the K.C.C. effluent from lack of monitoring its standard. The only other industry of importance is the Tannery which is presently under construction.

(2) TYPE OF TREATMENT PLANTS

FACILITIES:

(a) A combined conventional and oxidation pond.

(b) Oxidation ponds - Not Commission yet.

About four years ago, the then conventional sewage works was found to be overloaded. The system could produce an effluent of improved quality if additional extensions were constructed. It was therefore decided that an extension of oxidation ponds be made, so two ponds were added to give further treatment to the conventional works effluent.

The B.O.D. of the effluent from the oxidation ponds came down to 18 mg/L but due to lack of monitoring and constant data taking, it is doubtful whether the B.O.D. is still this low. It is also doubtful since the manpower running the sewage works lack adequate training and apparatus for proper measuring of the B.O.D.

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(3) MAIN POLLUTION PROBLEMS

(a) Sewage Pumping Station:

There are two old pumps which are part of the sewage system. These pumps are old and spare parts are not easily available. As a result when the pumps break down, it takes months before the spares are available and the pumps repaired. It becomes inevitable that untreated sewage is discharged direct to the rivers below the pumps. The resulting heavy pollution has therefore, adversely affected the flora and fauna of the rivers.

(b) Petrol Station and Garages:

There seems to be no control over the discharge of waste oils in the storm water drains from petrol stations and garage. As a result, when it rains all these oils are washed to the rivers which are already heavily polluted as pointed out above.

(4) MANPOWER AND TRAINING

The problems stated above are aggrevated by lack of sufficient trained manpower to maintain and repair the machinery to avoid mechanical break-downs. The manpower also lack the basic knowledge of monitoring the effluent and the apparatus required to carry out the tests. What therefore it ultimately amounts to, is the maintenance of the sewage work without knowing the end result of the effluent therefrom. No one knows exactly how efficient or inefficient the treatment system is, and this is a very unfortunate situation.

(5) FINANCE

Although a sewage works is supposed to be a self-supporting undertaking most local authorities including Kitale Municipal Council divert these funds to other purposes. Very little attention is paid to what is known as Renewal Funds for the purchase of new machinery and their spares. Further more, the staff running the sewage works are never sent for technical courses to efficiently equip them with the necessary knowhow. The end result of both these shortage is lack of proper maintenance of the sewage works and deterioration of the final effluent.

(6) CONCLUSION

Kitale sewage works need constant data collection on B.O.D., C.O.D., Chemical Contents, organic and inorganic matter so as to enable one to come to reasonably accurate conclusion.

COMMENT: The problem of operation and maintenance of the sewerage works for local authorities can be ameliorated by use of Ministry of Water Development which can second their technicians to any local authority which makes the request.

The Ministry of Water Development can also train operators from the local authorities and train them in the field. The capabilities of the local authorities can enhanced by this exchange and training. Very few local authorities have ever availed themselves of that service.

BY W.O. ORWENYO (TOWN ENGINEER)

Kisii has rudimentary sewerage treatment. This was constructed in 1975 as a sedimentation tank with single stabilization pond to cater for the commercial centre of Kisii, plus very few residential limits close by now called phase I.

In 1978 M.O.W.D. commissioned consultants desinged a new framework called phase II which is now in its final design.

The problem is therefore rather serious because the existing system is over leaded and now depends only on the dilution due to the heavy rains.

Agreed, we have a sewerage technician but there are no equipments like a loading equipment and exhaustor for desludging septic tanks. Kisii has a problem of storm water because the drainage system is poor and inadequate. When it rains the town is like a large river. The stormwater washes all wastes including oil from the garages to nearby streams.

Most of the sewage is domestic - Minimal industries to date but with the advent of industries the town faces catastrophe. That is what the new Mwalimu hotel in Kisii faced. Kisii would like to request cooperation from the Lake Basin Development Authority in this regard.

Kisii local authority has cooperated with the central government officials well in dealing with matters related to enviroment. What is true is that there is a great deal of intervention by the politicians in the operation of the local authorities, and in this regard we need help and cooperation,, from statutory bodies like Lake Basin Development Authority and other local authorities in similar situations.

COMMENT: Consider seriously the role of urban planning in environmental matters. Most urban centres are not planned and the sporadic growth defeats environmental objectives. Initial planning should also include long term sewerage systems.

Q. Are the facilities of the Ministry of Water Development decentralized or Nairobi based ?

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A. Facilities in Nairobi but can be moved to the local authority. In general, the local authorities are encouraged to purchase their own equipments. Thika has bought some of its own and so has Mombasa. Kisumu has some, even though limited.

COMMENT: The municipalities should have their own equipments manpower and monitoring system. With that principle in mind they can seek cooperation from the central government and statutory bodies like the Lake Basin Development Authority.

COMMENT: There is no requirement for environmental impact assessment but that is anticipated in the bill being prepared for parliament. Perhaps with adoption of that concept growth of urban centres and establishment of industries at those centres can be closely checked to prevent wild development.

BY N.V. DAGAYE AND J.M. OKELLO

1. INTRODUCTION

Kisumu Municipality is situated at the shores of one of the largest fresh water lakes in the world, Lake Victoria, where it derives almost all its drinking water. The lake also serves as a discharge point for industrial effluent, stormwater and sewage treatment plant effluent. Presently, continued discharge of the above without pre-treatment will result into a worsening state of the purity of quality of the lake water which is still wholesome and abundant and which is essential for human, animal and plant life. Unlike city of Nairobi, Mombasa and other towns in the Republic which obtain their water supplies from up-lands, uninhabited or populated and protected areas, Kisumu gets its supply from the low lying Winam Gulf which continually receives all types of wastes.

This municipality lake water is therefore faced with a considerable amount of pollution. The problem is growing and unless corrective measures are taken immediately there is potential damage to the lake and in turn to the Municipality's water supply. That would mean an adoption of a more complicated and expensive water treatment plant. To avoid this eventuality, the council is presently studying the pollution with a view to minimissing its effect on the lake. Those of us who have been to Nairobi know just too well, that Nairobi River is dying and it is no longer able to support life even that of lowest flora and fauna. This is because of untreated wastes which discharges into it. It will be a sad moment for this to happen to the lake.

With this in mind, the council had initiated some action on the matter. In 1979 the council wrote letters to operators of all possible sources of pollution to provide facilities for pre-treatment and to avoid discharging oils and industrial wastes into the existing stormwater drains and sewers. This was followed up with property inspection. Little result was achieved, apparently because of lack of a task force to see action through. In 1981, the Roanoke City Public Works Manager, from Virginia, U.S.A. visited our town on a Sister-city exchange programme and made a study of the possible sources of pollution, and reported his findings to the council.

Early 1982, a Nairobi Firm started the re-use of used oil and has been buying the used oil from the town. An appreciable decrease in the

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quantity of oil (the major source of pollution) has been noticed. However, some more practical action is still needed to completely eliminate the pollution threat to the lake.

<u>OBJECTIVES</u> - The purpose of this paper therefore is:-

1. To enlighten ourselves on the dangers we are faced with, create awareness to the public, and on a collective basis work out ways and means to try and solve the problem;

2. To abolish formerly accepted notion that the body of water is large and any amount of pollution will be adequately diluted; and,

3. To learn from the experience of developed countries e.g. U.S.A. which has to resuscitate either dead or dying fresh water lakes, too costly a venture for a developing country such as ours.

2. <u>SOURCES OF POLLUTION:</u>

Thorough investigations have identified several sources of pollution to the lake and a list is attached to this paper as an Appendix. However, some of the salient ones are mentioned below:-

(a) Railway mantenance shed:- This is the most known source. The railways do not have oil interceptors. Thus spilled oil flows freely into the lake.

(b) East African Power & Lighting Company ltd. - the power station at the lake shore on Power House Road releases constant flow of oil into the lake.

(c) Petrol Stations:- A study made of the petrol stations in the town revealed that the majority do not have functioning oil interceptors. Oil therefore, is discharged into the sewer lines and flows into the sewage treatment works. As most of the petrol stations are connected to the conventional sewage treatment works. It is this works that is most affected. This system discharges finally to the lake.

3. <u>MOTOR VEHICLE REPAIRS</u>

(a) Built up garages are not provided with oil interceptors and the used oil is usually dumped either into sewer manholes, or into stormwater drains. Oil finds its way directly into the Sewerage Treatment Works or directly into the lake.

(b) Open Air Garages - oil spillage from defective motor vehicles under repair in the open air garages find their way into the lake directly without any treatment.

(c) Motor vehicle washing in the lake water

(d) Large transport lorries, bus firms, and tankers repair/wash their vehicles on pavements of street and roads and surface washings drain oil into the lake.

4. OTHER SOURCES OF POLLUTION:

(a) Effluent From Industries - The majority of industries in the town do not have effluents which are objectionable in quality. However, M/s. Kisumu Cotton Mills discharge dyes which are received at the Municipal Conventional Treatment system in the plant.

Other industries that may contribute will be the Brewery and Kenya Chemicals and Food Corporation which have allowed for pre-treatment of their wastes but unless strict surveillance conducted they are likely to discharge wastes of objectionable standards.

(b) Effluent from Sewage Works

The discharge of the above effluent into the lake has effects on the quality of Lake Water. The quality of the effluent from the sewage treatment works has been considerably affected by oil and tests in 1979 showed that unless the discharges are controlled and improvements made to the works, the effluent from the works will become a major pollutant to the lake.

(c) Slaughterhouse Effluent

The present slaughterhouse next to the lake is old and unhygienic and has been condemned. Wastes discharge into the lake causing pollution comprise: Blood, Wash water, stomach guts and solid wastes such as hooves, horns and skulls.

5. RECOMMENDATIONS FOR CONTROL OF POLLUTIONS

To control pollution effectively, it is recommended that the following steps be taken. A long term study should be made with a view to establishing a research station with a well equipped laboratory and qualified personnel which will establish a programme and action plan for dealing with the situation.

(b) Would-be investors to be stringently scrutinisbd to show the nature of their effluents, the quantity, quality and method of treatment.

(c) There is need for replanning of built up areas of the town so that possible sources of industrial pollution, can be sited away from the lake to allow adequate distance for effective treatment before discharge into lake water.

(d) The council should ask the parent companies of all petrol stations, industrial firms, Kenya Railways, E. A. P. & Lighting Company Ltd., to effectively take adequate measures to control oil pollution, within their premises. This should be backed with rigorous monitoring and enforcement by the council officials.

(e) The Council should encourage garages and all users of oil to keep the used oil and sell it to the Nairobi firm, which re-uses the oil. They should be asked to provide proper storage facilities for the oil if wates before the proper mode of disposal.

(f) Discharge Agreement - The Council should enter into a discharge agreement with all factories in the town, which agreement will enable monitoring of the effluent from all the firms. The draft agreement is ready and will soon be presented for adoption.

(g) The Council should control the establishemnt of open air garages to facilitate proper disposal of the wastes they generate.

(h) Present companies of petrol stations should be asked to re-design and resuscitate oil interceptors and train proprietors of petrol stations and their petrol attendants for effective control of oil pollution.

(i) The Council should set up a small task force to make checks on possible sources of pollution and also to publicise the dangers of pollution.

(j) The Council should ask all petrol stations, depots to provide kerbs around all storage tanks to contain oil spills.

(k) The Council's conventional sewage works should be improved for effective exclusion of oil. Sewage Lagoon should be properly maintained and effluent monitored to attain, in a consistent way, acceptable standard of quality allowed for discharge into a water course.

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(l) Vehicle washing in the lake should be abolished and construction of a new site to be pursued.

(m) The Council should liase with the Lake Basin Development Authority for Control of inland pollution sources.

(n) The Council should fight the floating island menance more vigorously, with the assistance of the Lake Basin Development Authority.

(o) The Council should pursue the question of the physical development Master Plan for Kisumu to enable future possible sources of pollution to be identified early and remedial measures taken suitably.

(p) The Kisumu Municipality (General) by-laws to be up-dated with provision for severe penalty to any person who pours oil on the surface, or gutter or repairs vehicles in residential areas.

(q) The existing provision under Cap. 242 of the Public Health Act, Sections 118, 129 and Public Health (Drainage and Latrine) Rules, Building Code and the Municipality (General) by-laws are not severe enough to deter

(r) For a joint responsibility of the residents to control oil pollution, the public to be continually educated, by being made aware of the seriousness of lake pollution. Such education should emphasize the value of clean water and safe fisheries resources on which the people depend for food.

(s) The Council should pursue the question of controlling oil entry into the Sewage Treatment Works by provision of suitable safeguards.

(t) Health Department should continue to inspect major sources under provisions of the existing law and take appropriate action wherever necessary.

(u) Periodical consultations be held between the Council and all involved in the matter to discuss or review the situation from time to time.

THE VISIT TO KISUMU TREATMENT WORKS

This is one of the most modern treatment works in the Republic. Its 1st Phase was built in 1957 and 2nd Phase was completed in 1967. According to the visiting experts the layout is generally good and the treatment systems are working well. The final tank was overloaded and sedimentation was inadequate.

The problems faced by the works staff is that they are only able to carry out 4 tests namely BOD, pH, Temperature and Permenganate activity. Because of lack of equipment the treament works staff cannot test for COD, Ammonia Nitrates, Nututes and Phosphates, which are all tests vital for industrial effluent monitoring.

The other problem faced by the Municipality is that of dicotomy of responsibility when it come to certifying the adequacy of treatment works of the industrial set ups before licensing.

In Kenya for instance, the Ministry of Industry and the Ministry of Water Development are responsible together or singularly for the inspection and certifying the satisfactory completion of individual industrial set ups - then the Municipalities just connect these treatment works to their main sewer. This therefore, puts the Municipalities into dilema when an industrial set up does not comply adequately with the regulations on its treatment works.

The third problem is that of administrative/technician misunderstanding and inability to agree on priorities and urgency affecting sewage and industrial waste disposal.

APPENDIX I

	PLOT NO.	NAME	ADDRESS	ROAD
1.	518 Block 6	M/s Roadways (N) Ltd	Box 70 KSM	Makasembo
2.	520 - 521 Block 6	M/s Kisumu M. Works	Box 164 KSM	Obote
3.	514 - 515 Block 6	M/s Rainbow G. Ltd.	Box 291 KSM	Makasembo
4.	334 Block 6	M/s New Best A. Works	Box 1826 KSM	Makasembo
5.	513 Block 6	M/s Doughty Ltd	Box 115 KSM	Makasembo
6.	510 Block 6	M/s Ifran Motors	Box 56 KSM	Makasembo
7.	506 Block 6	M/s Rehmatkhan & Sons	Box 218 KSM	Makasembo
8.	504 Block 6	M/s Bhamra Motors	Box 1212 KSM	Makasembo
9.	1329 & 1330	M/s Lakeland M. Ltd.	Box 450 KSM	Makasembo
10.	502 Block 6	M/s Makasembo R. Motors	Box 1754 KSM	Makasembo
11.	601 Block 6	M/s Spares & Reports Motors Limited	Box 984 KSM	Makasembo
12.	535 Block 6	M/s T J Cottington & Partners Ltd.	Box 1692 KSM	Obote
13.	534 Block 6	M/s Western Tractors & Motors Ltd	Box 890 KSM	Obote
14.	579 Block 6	M/s Farmtec	Box 1588 KSM	Obote
15.	580 Block 6	M/s Roadside Motors	Box 546 KSM	Obote
16.	582&583 Block 6	M/s Yasmin Motors Ltd	Box 1012 KSM	Obote
17.	928 Block 3	M/s Kenya Motors Co.	Box 1950	Obote
18.	1318 Block6	M/s Sembi P. Beaters	Box 1720 KSM	Makasembo

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PLOT NO.	NAME	ADDRESS	ROAD
19. 517 Block 6	M/s Garage Simlac	Box 888 KSM	Makasembo
20. 21 Block 3	M/s Barwanji Motors	Box 483 KSM	Obote
21. 21 Block 3	M/s Shaker Motors	Box 30 KSM	Obote
22. 13 Block 39	M/s Kenya Motors Co.	Box 1950 KSM	O Odinga
23. 44, 81, 10 Block 15	Manager Eastern Motors (Hughes Company ltd.)	Box 106 KSM	O Odinga
24. 37 Block 68	Manager Friends AutorG	Box 489 KSM	Makasembo
25. 1421 Block61	E A Road Service	Box 1254 KSM	Nkrumah
26. 8 Block 69	Manager Tower Services	Box 970 KSM	Ogada Str.
27. 541 Block 68	Manager Lake Service Petrol Station	Box 910 KSM	Obote
28. 2 Block 38	Manager Mijele Esso	Box 1400 KSM	P Mbuya
29. 519 Sec.36	Manager Caltex	Box 621 KSM	Obote
30. 2 Sec. 28	Manager Minara P Dist.	Box 618 KSM	Kenyatta
31.	Manager Family Agip	Box 1648 KSM	Kenyatta
32. 56 Sec. 63	Manager Tosheka Total	Box 690 KSM	Kakamega
33. 854 Sec.63	Manager Wayside S.S.	Box 1314	Kakamega
34. 1017 Sec.22	Manager Esso Standard	Box 694 KSM	Gumbi
35. 519 Bolck 6	M/s Musee S Station	Box 792 KSM	O Oyoo
36. 445 Block 6	M/s Kenol Oil Co. Ltd	Box 621 KSM	Obote
37. 986 Block 6	M/s New Sila S Station	Box 1629 KSM	O Oyoo
38.	Nairobi Deluxe Service	Box 1007 KSM	Otuoma
39. 68 Block 5	Nyakach Bus Service	Box 407 KSM	Owuor
40.	Karim Bus Service	Box 1395 KSM	B/Station

CHAPTER IV

CASE STUDIES ON SELECTED INDUSTRIES

BY

J O'ROURKE

SUMMARY OBSERVATIONS FROM FIELD TRIPS

BY

P.C. SINGER

BY J O'ROURKE

INTRODUCTION:

There is a small number of officials of the Ministry of Water Development whose duty is to visit the industries in the country and to ascertain if their wastewater treatment systems are functioning properly. But these officials, including Mr. Kiai, can make the visits only once in a long while.

During the visits out of which the following reports arose, I was accompanied by Mr. Kiai. At every one of the places visited something, if not everything, had broken down. Very often, the explanation of the industry was that "it had broken down only the day before, and would be repaired the following day". Unfortunately, there was very little or no follow up in supervision and enforcement. Therefore, the inefficiency of the system was evident.

The wastewater, in form of effluent, from the plants is generally frothy, with very high BOD. This was true of RIVATEX at Eldoret as with the other factories visited.

SOURCES OF POLLUTION FROM COTTON AND SYNTHETIC FIBER AND FABRIC FINISHING OPERATIONS

Slashing is the first process in which liquid treatment is involved. In this process, the warp yarns are coated with "sizing" in order to give them tensile strength to withstand the pressures exerted on them during the weaving operation. Such substances as starch, starch substitutes, polyvinyl alcohol, carboxy methyl cellulose, gelatin glue and gums have been used as size agents. The source of pollution in this process results from the cleaning of slasher boxes, rolls, and make up kettles. The volume is therefore usually low; however, the BOD can be quite high, especially if starch is used.

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The operation of desizing removes the substance applied to the yarns in the slashing operation, by hydrolyzing the size into a soluble form. There are two methods of desizing - acid desizing and enzyme desizing. In acid desizing, the fabric is soaked in a solution of sulphuric acid, at room temperature, for 4 to 12 hours, and then washed out. In enzyme desizing, complex organic compounds produced from natural products or malt extracts are used to solubilize the size. The bath is maintained at a temperature of 130^{o} - 180^{o}F. and a pH of 6-7.7, for a period of 4-8 hours. Due to the unstable nature of these organic compounds, the whole bath must be discarded after each batch. After the size has been solubilized, the fabric is rinsed clean. Desizing contributes the largest BOD of all cotton finishing processes - about 45 percent.

Scouring follows desizing. In this process, the cotton wax and other non-cellulosic components of the cotton are removed by hot alkaline detergents or soap solutions. In most modern plants, scouring is done in conjunction with desizing rather than as a separate operation. Caustic soda and soda ash along with soaps and synthetic detergents and inorganic reagents are used to remove the non-cellulose impurities. The bath is characterized by a pH of 10 to 13 and temperatures of up to 212^{o}F. Although the strength of alkali in the beginning of the operation is between 1 percent and 5 percent, the waste liquor will have a 0.3 percent, alkaline concentration, the rest being taken out of solution by the cotton fibers. In a few mills, the scouring process is a batch operation requiring the fabric to remain in the kier for a period of from 2 - 12 hours. Scouring is the second largest BOD contributing process in the finishing of cotton textiles - about 31 percent. Following the "boil-off," the goods are rinsed clean with hot and cold water to remove residual alkali.

Bleaching, the next process, removes the natural yellowish coloring of the cotton fiber and renders it white. The two bleaches most commonly used for cotton are sodium

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hypochlorite and hydrogen peroxide. In hypochlorite bleaching the fabric, after scouring, is impregnated with an alkaline solution of hypochlorite and allowed to stand at room temperature for 4 to 12 hours. It is then washed, saturated with a weak solution of hydrochloric or sulfuric acid for neutralization and then again washed.

About 80% of the cotton containing fabrics which are bleached white are done on continuous ranges using hydrogen peroxide. The fabric, after desizing, is impregnated with a 2-3% solution of caustic soda and stored in a "J" box at 200°F for 1 hour. This operation replaces the kier scouring of the batch method. After the caustic scour, the fabrics are washed. All of the above are syncronized so as to give a continuous output of 50 to 200 yearns per minute depending on the weight of the fabric and size of the equipment.

The mercerization process was originally developed to give increased luster to cotton fabrics. Today it is still used for that purpose, but more importantly to impart increased dye affinity and tensile strength to the fabric. It is estimated that only 30 percent of all cotton fabrics are now mercerized, and with the increasing use of cotton-polyster blend, less will probably be done in the future. The process uses a 15 to 24 percent solution of sodium hydroxide at room temperature for ½ to 3 minutes. The fabric is then rinsed in an acid wash to neutralize the fabric, washed in water and then dried. The effluent from this process is alkaline and high in dissolved solids, but low in BOD.

After mercerizing, the goods are sent to the dye house or color shop. In the dye house they are dyed either in small volumes in batch process machines, or on continuosly dyeing ranges in large volumes. There are five important classes of dyes used on cotton fabrics: developed, sulphur, direct and fiber reactive.

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The dyeing process is carried out in an aqueous bath with pH variations. Cotton fabrics are printed with primarily three classes of colors: pigments, vats, and fiber reactives. The most important methods of printing are roller printing and rotary and flat bed screen printing. The color in the former method of printing is delivered to the fabric by way of a print paste from an engraved roll. The latter method required the print paste to be pushed through a perforated screen to the fabric. The print paste contains color, thickener, Varsol (pigment systems only), hygroscopic substances, resins (pigment system only), and water. With fiber reactive dyes, the pH of the print paste is adjusted to 8.5. The pH of the print paste for vat dye is neutral, but the print is treated with caustic soda and hydrosulfitite prior to flash aging.

The pollutional load from the color shop comes mainly from the wash-down rinses used to clean the equipment in the shop and the cloth rinsings. The pollutional load is rather low in volume and BOD. When a mill does both printing and dyeing, the BOD contribution of the combined processes is 17 percent, and the total BOD load comes from the process chemicals used.

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RIVATEX at ELDORET
KICOMI at KISUMU

During our/of industries, Mr. Kiai and I visited three /tour textile mills. The two on which I will present case studies today and the third, which handles only synthetic fiber and discharges only limited wastewaters.

The Rivatex mill at Eldoret processes raw cotton and synthetic fibre into woven cloth. They process the cloth by dying and printing. This mill produces a wastewater that appears to be typical of similar mills in the United States. The waste is highly colored (conducted), high and varible pH, (at times likely to exceed pH of 12), high BOD and suspended solids. No current analyses were available. However an analysis of the waste in June 1980 indicated the following:

pH...............	12,55
COD..............	1020 mg/L

Alkalinity: (as Ca CO^3)

Phenol...........	1840 mg/L
Hydroxide........	1636 mg/L
Sulphide.........	500 mg/L

(I would expect that the BoD was in the range of 500 to 600 mg/L) and a high concentration of dyes.

During our inspection of the pretreatment facility on Wednesday, 14/7/82 the waste appeared very dark in color and there was no reason to expect that the waste was of a quality much different as that found in the 1980 analyses given above. The pretreatment plant was not functioning during visit.

The pretreatment plant contained the following treatment elements:

Hand cleaned bar screen
Mixing tank with two mechanical mixers

Aeration/Cooling Tower
PH adjustment system with pH
recording

We were informed that the plant was out of service to make an electrical connection for a new water storage tank that had been recently installed. This statement however, was not collaborated by the Assistant Town Engineer in Eldoret Mr. Sewe, who informed us that the system was not working due to "some electrical" problem when he visited the plant in May 1982.

The pretreatment system that has been installed at the Rivatex Mill appears capable of producing an effluent that should meet the limitation setforth in the "Trade Effluent Agreement" signed in May of 1976. No treatment facility, no matter how well conceived, designed and constructed can affect any treatment unless it is operated.

The impact of the lack of operation of this pretreatment plant is very evident by a tour of the Municipal Sewage ponds operated by the Town of Eldoret. The only effluent analyses available were from a sample taken in June 1980 at the same time as the mill effluent was analysed. The results were as follows:-

pH............... 9.2
BoD.............. 98 mg/L
CoD.............. 640 mg/L
Sulphide......... 300 mg/L

There appeared to be no doubt that the Rivatex effluent was having a deletorious effect on the sewage ponds. The influent to the ponds was highly colored and anaerobic. The effluent from the ponds did not appear much different from the influent although there was a very slight ting of green in the effluent indicating that there way have been some algal growth in the final pond. The final pond was producing a fair amount of gas indicating that anaerobic decomposition was taking place. It is interesting to note that, just a few hundred meters down stream of the discharge from the ponds, women were washing clothes and collecting water for other uses. The key to the correction of this situation is monitoring and enforcement.

On Friday, 16/7/82, we visited the Kisumu Cotton Mills (KICOMI) immediately following a tour of the Municipal Trickling Filter sewage treatment plant. It was noted that the color of the effluent from Kicomi was unlike that of the influent to the Kisumu STW (sewage treatment works).

The cotton mill has a pretreatment facility that consists two settling tanks (in parallel) that are designed to also remove floatable solids and oils. Each tank is divided into four compartments with a combined volume of $430m^3$ at a reported effluent flow rate of $1400m^3$/day the retention time in the settling tank is estimated at 6 to 7 hours. There are no provisions for pH adjustment. (Incidentally data from H. Humphreys (Kenya) Ltd. report dated June 1980, Ref. 76.039 indicates that the pH of the raw sewage at the Kisumu STW was reported as high as 9.7).

There was a very thick layer of oil/grease on all the settling compartments in the pretreatment plant. The outlet from each compartment is through a verticle "T" with one leg of the "T" submerged to prevent the escape of oil from that compartment.

It was reported to us that the compartments are cleaned at a frequency of one compartment each Sunday when there is no flow into the system. The cleaning is conducted by having the entire compartment contents pumped into a tank-wagon and hauled and dumped in the immediate neighbourhood. Other large floating objects and rags are removed from the tanks periodically.

There was no monitoring of the effluent from this pretreatment facility consequently no data were available. The effluent was highly colored but did not appear to contain

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large amounts of suspended solids. It is expected that the BoD of this discharge would be in the range of 400 to 600 mg/L and at times could be in excess of 1000 mg/L. Using the 400 to 600 mg/L BoD value and discharge of 1400 m^3/day, the waste BoD load from Kicomi is estimated to be about 700 kg/day. The estimated design capacity of the Kisumu STW is approximately 3400 kg/day of BoD. Consequently, it appears that the Kicomi mill is discharging waste waters that constitute about 20 percent of the design load of the Kisumu STW with respect to BoD loading. This industrial loading should not be excessive for the Kisumu STW if all the trickling filters were operating. On the day of our visit only two filters were operating which was the case during the H. Humphreys study in 1979 and 1980. Even with only two filters operating the plant is achieving in the range of 60 - 70% BoD removal (BoD of influent is 400-600 mg/L and effluent is about 150 mg/L).

Two immediate steps should be taken. First, get all the filters operating at the Kisumu and secondly, require Kicomi to adjust pH to range of 6 to 9.5. In addition, monitoring of the industries is an absolute necessity.

PANAFRICAN PAPER MILLS LTD
WEBUYE - KENYA

The mill at Webuye is an intergrated pulp and paper mill with a current (1982) capacity of 60,000 tons per year. The mill produces unbleached craft as well as bleached grades of writing and printing papers from plantation grown pines and also from Cypress and Eucalyptus.

The Mill is composed of the following processes:

A. Raw Material Preparation - This is the where the wood is stored debarked, chipped and where chips are stored.

B. Digesters - Chips are cocked in "digesters" in a liquor of alkali consisting of sodium hydroxide, sodium sulfide and other chemicals. The resulting brown pulp is washed to separate the fiber from the digester liquor ("black liquor"). Caustic soda is recovered from the black liquor. Then is washed and processed to remove dirt and grit from the fibers.

C. Bleach Plant - To produce white and light colored papers the pulp is bleech with chloride and then washed with caustic solution to extract lignin derivatives and to stop the action of the chlorine and finally is bleached white in two stages using calcium hypochlorite.

D. Stock Preparation - The pulp, both bleached and unbleached is refined and sent to the paper section where special materials are added depending on the final product. Additives include alum, resins, waxes, starches, clay and dyes.

E. Paper Machine - There are two paper machines at Webuye - one for unbleached and one for bleached and one for bleeched grade papers. The machines are high - speed fourdrinier machines consisting of a pressurized headbox, wire section, press section, dryer section and calenders. The stock (a suspension of pulp fibers in water) with any additives needed is fed continuously to the machine. The wet paper is formed on a moving wire screen and dried over drying cylinders.

The paper is then passed through a series of calenders (rollers) and finally is rolled on reelers. Some of the paper is cut into sheets for final marketing. There are also a number of auxillary or support processes that are carried out at Webuye.

These include:

A. Recovery Causticizers and Lime Reburning - Black liquor from the pulp mill is passed through evaporators and concentrated. Salt (sodium sulphate) is added to the concentrated liquor and the liquor is fired into a waste heat boiler (Recovery Furnace). As the sodium lignate burns, the molten salt flows into dilute caustic solution which is pumped to the Causticizers where lime is added. A chemical reaction takes place producing sodium hydroxide and calcium carbonate. The liquor is passed through a clarifier where lime sludge is recovered and the liquor is reused to cook chips in the digestors. The lime is recovered by burning in a rotary biln and is used again in the Causticizers.

B. Electrolytic Plant - The chlorine, Caustic Soda and calcium hypochlorite used to bleach the pulp are produced on-site in the Electrobytic Plant using salt brine.

C. Steam and Power Generation - One oil-fired boiler and one waste heat recovery boiler are used to generate the necessary process steam. Electric power is generated by a 12.5 MW Turbo generator. A bark boiler was recently installed.

D. Water Treatment - The mills' water treatment plant has capacity of 13.2 million gallons per day. About 12 million gallons per day is withdrawn from the Nzoia River.

The mill is equiped with a modern waste-water treatment plant and the mill practices acceptable fiber, chemical and wood (and bark) recovery methods to reduce its impact on the environment. The waste water treatment plant includes the following:

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Trash Screen
Primary Clarifier
Sludge Thickener
Belt Filter to dewater the sludge
Two aerated ponds
Two Maturation pond
Sludge Beds

The trash screen removes the large objects from the waste water. The primary objective of this process is to prevent mechanical damage to other treatment elements, such as clarifier mechanisms and pump impellers. The waste then flows into the clarifier where suspended solids are permitted to settle. The removal of these solids reduces the load on the boilogical processes to be carried out in the aerated ponds. The removal of solids also prevents the ponds from being filled with heavy inert solids thereby reducing their capacity.

From the clarifier the sludge (settled solids) are pumped to the sludge thickener to allow them to settle and thicken.

The overflow from the thickener goes back into the clarifier while the solids are dewatered on a belt filter. The dewatered solids fall into a lorrie-wagon and are hauled to a land fill area. The clarifier overflow (the liquid fraction) flows by gravity to the primary aerated pond, then to the secondary aerated pond and finally through two maturation ponds in series and then into the Nzoia River.

Biological activity in the primary and secondary ponds is the heart of this waste water treatment system. The biological organism (primarily bacteria and protosoa) utilize the celloidal and soluble organic materials in the waste for cell metabolism. This process converts soluble organic material into cell material that can be settled out in the maturation ponds. It is a well proven and accepted process for the treatment of pulp and paper mill waste.

The aerated and maturation ponds have a combined surface area of 67 acres and a liquid detention time at current flow of nearly one month. The two aerated ponds are equiped with 3 mechanical aerators, each. Their aerators transfer oxygen from the atmosphere to the liquid to support the aerobic biological activity in the ponds. Nutrients in the form of ammonium sulphate and superphosphate are added to provide the nitrogen and phorphores necessary for healthy biological growth.

Available data, from the mill, indicates that the treatment works have sufficient capacity to produce an effluent acceptable for discharge in accordance with government standards as can be seen in the following table (with respect to BoD and VSS):

Government		Treated Mill Effluent			
Standard		7/3/75	24/4/75	20/6/82*	30/6/82*
BoD mg/L	80	18	40	10	9
VSS mg/L	60	-	-	9	7

* Represent one week composites.

<u>However, on the day of our visit all waste water was by-passing the treatment works and flowing directly to the river</u>. No treatment works, no matter how well conceived, cleverly designed and beautifully constructed can prevent pollution of a stream unless it is used on a continuous basis. Proper operation and maintenance are absolutely essential. In addition, frequent inspection and monitoring by the MDW is a key element in successful pollution control program.

COFFEE INDUSTRY

Kisii Factory Visits

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The Ministry of Water Development report by Mr. W. Thitai entitled "Industrial Development in Rural Areas in Relation to relate supplies in Kenya" (dated June, 1979 - No. 79 - 4761) contains an excellent survey of the coffee industry in Kenya. The report discusses coffee processing, water use, quantity and characteristics of coffee waste waters, pollution effects, treatment and disposal of waste waters and methods of disposal of the solid wastes.

The processing of the coffee cherry includes a number of unit operations:

1. Pulping - removal of the pulp (the outer skin) in a mechanical pulper.
2. Pre-grading - to remove bad beans and grading.
3. Washing - to remove pulp.
4. Fermentation - degradation of the mucilage layer from the pulped coffee.
5. Drying - air dried to about 12% moisture.
6. Hulling - removal of the parchment (skin) by mechanicol means.

Water useage will amount to up to about 20,000 gallons per ton of clean coffee without recirculation and reuse. This can be reduced to about 5000 gallons per ton when complete recirculation is practiced.

The waste water has extremely high suspended solids (the pulp) up to about 5% by weight and very high BoD, as high as 9,000 to 10,000 mg/L. When pulp is removed from the waster water the character average characteristic have been report by Thitai, 1978 as follows:-

Parameter	Measurement
pH	4.4 - 4.5
BoD	3600 mg/L
Total Solids	10411 mg/L

The Water Act (Cap 372) requires that all coffee factories are legally required to install water recirculation systems and use about 5000 gallons to process one ton of clean coffee. None of the water used should be returned any water course. The final effluent may be disposed on land .

We visited two coffee factories in Kisii, one private factory when no recirculation was being used and the pulp was being discharged with the waste water to a "pit" where the pulp settled out and the water overflowed to the nearby steam. No treatment of any kind was being carried out. The operator report to us that the pulp was used by local farmers as fertilizer and soil conditioners. (Slides of coffee factory will be shown).

The second factory was the "Coffee Research Foundation" Kisii Sub-Station. This research factory employed complete recirculation of the waters. The pulp was removed by a screen and the water discharged to a sump where it was picked - up by the recirculation pump and returned to the process. Final disposal was through land application (irrigation). The pulp was well drained and then hauled away to be used as fertilizer and soil conditioner. (Slides of the Research Factory will be shown)

SUGAR INDUSTRY

During our survey of industries in the Lake Basin Area, Mr. Kiai and I visited the following sugar mills:

1. Nzoia Sugar at Bungoma - Tues. 13/7/82
2. Sony Sugar at Awendo - Thur. 15/7/82
3. EASI at Muhoron - Sat. 17/7/82

Both the Nzoia and Sony Mills have reasonably adequate waste water treatment facilities. Except for the general need for operator attention (and training) and the need to keep all equipment (especially aerators) operating, these facilities were being operated in an acceptable manner. The EASI Mill at Muhoroni, however, has only anaerobic ponds which do not appear to be altering the quality and/or appearance of the mill effluent, except allowing it to become septic. EASI effluent is currently being used for irrigation as a temporary measure to reduce the pollution load on the river.

The treatment plant at the Nzoia Mill consists of the following:

Bar Trash Screen
Grit Chamber with two Channels
Sedimentation Tank - rectangular
Two Aerated Ponds-Diesel Generator
Maturation Ponds.

During our visit the sludge was being removed from the sedimentation tank by hand with hoes. The tank is reportedly about 1.5 meters (4.5 feet) deep and the sludge appeared to be within about 0.3 meters (1 foot) from the surface. It was apparent that sludge should be removed from this tank more frequently. Due to some electrical problem it was necessary to supply power to the treatment plant using a diesel powered generator. This generator was capable of driving only one aerator at a time, therefore the aerators in the two ponds were operated on a 2 hour/on 2 hour off alternating basis. It was suggested that when electrical service is restored to the treatment plant the generator set be retained as a stand-by power supply for future use.

The maturation ponds had some floating solids but did have some green colour indicating the presence of some algal growth. There did not appear to be any offensive odours in the vacinity of the ponds. The effluent looked fairly good but had a BoD of about 150 mg/L. This should improve when electrical service is restored and both aerators are operated on a continuous basis.

A past pollution problem at the Nzoia Mill which appears to have been corrected was the practice of sending tank truck washing to a separate pond. The same trucks that are used to carry fuel oil are washed at the mill and then filled with molasses. The wash water contains significant quantities of oil. The pond to which this oily water was discharged was subject to flooding during heavy rainfall. The contents of the pond would on these occasions be flushed into the river. The tank

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truck washings are now passed through on oil trap at the mill and the oil is captured. The Sony (South Nyanza) Sugar Mill has biological treatment system consisting of the following unit processes:-

Anaerobic Pond	(1 day)
Oxidation Ditch	(1.5 days)
2-10 horsepower aerators	
Settling Tank	(.4 hours)
Return sludge pumps	
4 - Oxidation Ponds	(4.5 days each)
Sludge Drying Beds	
(Total flow-through time about 21 days)	

At the time of our visit the plant appeared too well maintained and operated. One of the aerators had been out of service for some time awaiting replacement parts for the gear box. There appeared to be a good, healthy growth of biomass in oxidation ditch which flocuted well upon standing. The return sludge appeared fresh and healthy.

There was some floating solids on the first oxidation pond but the appearance of the ponds progressively improved from number 1 to number 4. The effluent was reasonably clear with a sight green colour. The effluent appeared to have a quite low suspended solids contents and low turbidity.

The influent to this waste treatment system has, a BoD concentration of around 2300 mg/L and the effluent from pond number 4 had 80 mg/L of BoD. This represents about 96% removal. Although the plant is not meeting the discharge requirements of 25 mg/L of BoD and 20 mg/L of SS, the plant could be used as an excellent model of what can be accomplished with this type of waste water.

The Sony Sugar Mill also has to request permission from the Ministry of Water Development to use the treated effluent from the mill to irrigate their can fields. This of course would completely eliminate the discharge of effluents to the river. And this seemed to be a job well done. The East African Sugar Industries at Muhoroni should be required to install a proper treatment plant at the earliest possible date.

MOLASSES FERMENTATION INDUSTRY

The Agro - Chemical and Food Company Ltd., Molasses fermentation plant at Muhoroni went into operation in early June, 1982. This plant produces:

60,000 L/day	- Power Alcohol
4,000 Kg/day	- Active Dry Baker's Yeast
100 Ton/day	- Vinasses (Cattle Feed)

and by-product of fodder yeast from the power alcohol fermentation and small quantities of industrial and reagent grade alcohols. The plant use 200 tons per day of Molasses. Molasses is received as a 50% solution with a specific gravity of 1.6 which rrepresents about 25,000 litres per day.

The plant has a water treatment plant with a capacity of 100 tons per hour (100,000 Litres/Hour) and the current water use is averaging about 40 - 50 tons/hour or about 960 to 1200 m^3/day - (250,000 to 312,000 gals (US)/day).

The waste water treatment plant consists of: (VOGELGUSCH Data)

Single Pass Atmospheric Cooling Tower	
High - Load Aeration Tank	(12 hours)
Aeration Tank	(23 hours)
Clarifier (with Return Sludge Pumps)	(3 hours)
3 Unaerated Lagoons	(5 to 6 days each)
Anaerobic Sludge Stabilisation Lagoon	

At the time of our visit all elements of the waste water treatment plant were in operation.

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The mixed liquor (mixture of activated sludge organism and waste water) in the aeration tanks was light brown in colour and appeared to be healthy. The sludge flocculated on standing clarifier to the High-Load Aeration Tank.

There was some floating solids on the unaerated lagoons which appeared to be coming from the sludge stabilisation lagoon. A scum battle at the outlet and of the sludge lagoon could easily correct this situation. Infact a scum battle at the outlet of each pond would be adviseable to prevent floating solid from escaping from the lagoons.

The third lagoon was not yet full so there was no overflow, consequently no effluent was being discharged. The water in the final lagoon appeared low in solids and turbidity and had a slight green colour.

This treatment plant appears adequate to treat the waste water from the molasses fermentation plant. The plant personnel did not know if inorganic nutrients would be added to the treatment system. They did report that pH adjustment was being performed.

According to the design data (from VOGELBUSCH) the initial BoD loading of 2400 Kg/day is to be reduced to 10 Kg/day in the effluent from the final lagoon (99.6% removal).

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BY PHILIP SINGER

SUMMARY RECOMMENDATIONS ON FIELD TRIPS

1. KISUMU COTTON MILL (KICOMI)

Oil and grease should be removed prior to discharge. This requires holding basin and skimming device. pH should be neutralized to 6 - 9 prior to discharge. This may require an equalization basin to equalize variable quality of discharge. Kisumu should have a sewer use ordinance regulating industrial discharges.

2. KISUMU WASTEWATER TREATMENT PLANT (TRICKLING FILTERS)

PH should be relatively neutral (6.5 to 8.0) when waste enters plant.

Remaining trickling filters should be put back into operation (only 2 of 6 are working). Hydraulic loading to filters should be increased by recirculating effluent. This will also improve final effluent quality.

3. WEBUYE - PAN AFRICAN PAPER MILL

Plant should aerate continuously. Aerators should be repaired and be made operative. Nutrients (Nitrogen and Phosphorus) should be added after primary clarification.

Paper processing should be improved to decrease settleable solids load to primary clarifier. Too much sludge is being collected. Dewatered solids are very fibrous and could be re-used in some fashion. Waste (dewatered) solids should not be dumped in area adjoining ponds but should be landfilled properly.

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4. MIWANI SUGAR MILL

Stream(s) upstream and downstream of mill should be sampled for DO, BOD. If water quality is impaired by non-point source run-off from the mill, Miwani should be required to install waste treatment facilities.

5. CHEMELIL SUGAR MILL

Stabilization ponds are under-designed, (if they were designed at all). The ponds are overloaded, hence they are anoxic. Either ponds need to be enlarged, to provide longer retention for the high BOD of the waste water, or aeration facilities need to be provided to mechanically provide oxygen to meet BOD of the waste waters.

Nutrient (N,P) supplementation and pH control may be necessary.

6. MUHORONI SUGAR MILL

Activated sludge tanks may be underaigned (therefore overloaded with BOD). When O'Rourke visited, the plant was functioning well; the tanks were aerobic. When we visited two weeks later, the tanks were anaerobic, despite the diffused aeration system. The stabilization ponds are underdesigned (if they were designed at all). The ponds are overloaded, hence they are anoxic. Same recommendations apply as for Chemelil Ponds.

7. SONY SUGAR MILL

Line from anaerobic pre-treatment pond is plugged; anaerobic effluent is spilling out of manhole, and draining overland off the site. The line need to be cleaned and maintained.

The oxidation data needs to be kept operative, full-time, to provide treatment of the high BOD waste water. The stabilization ponds locked to be of adequate capacity. However, in order to treat the waste effectively, the ponds should be aerobic; they depend upon the operation of the oxidation ditch to pretreat the high BOD effluent. If the oxidation ditch does not operate, the ponds may go anaerobic, as two of them did the day we were visiting. (The third pond was aerobic, and did appear to have good algal activity). The effluent line carrying final effluent to the stream is plugged; final effluent was flowing out of the inwhole and overland to the stream. The line needs to be cleared and maintained.

DISCUSSIONS

COMMENT: Colour should be one of the items which should be reduced in any treatment system, and that goes particularly for KICOMI in Kisumu. Colour could impair the biological treatment processes and has an effect of reducing solar radiation as well as photosythesis. A recommendation on the improvement of treatment facilities should include it.

COMMENT: The colour question may not be important for a trickling plant but it might in biological stabilization plant.

COMMENT: Some of the trickling filters were not working but the recyclation was also incomplete. Some of the trickling filters were in fact blocked. But the point is that the whole system: recyclation and the trickling filter must be made to work all the time.

COMMENT: Domestic waste need to be disinfected before discharge into the municipal treatment system. Chlorine is an effective enough disinfectant even though chlorine has its possible effect via such substances as chloroform.

COMMENT: Mechanical aeration such as used at Webuye are bound to fail. Could they use cascade system or step aeration from the pond to the disposal site of the water?

COMMENT: Foaming at Webuye could have been caused by several factors: Continuous operation of a machine, ABS detergents can both cause foaming. ABS detergents are non-biodegradable and are banned from use in some countries such as the United States.

There are three procedures for controlling foaming. One is to add defoamers (antifoam chemicals). The second is to spray water over the foam - spray the water through spray thistle. Thirdly, you can shovel the foam mechanically.

COMMENT: There is serious basis for concern with the discharges into Nzoia River by Webuye Paper Factory. The dark and heavy effluents will have impact on the anadromous and catadromous species of fish in the river.

There is a need to require that action mandatorily, to save the natural resources of the river and the Lake from depletion. Depletion will arise because the fish species will not reach spawning areas. A barrier will have been created at Webuye and the river will be dead downstream.

COMMENT: Most of the dust in Webuye are very fine and they fly out from inside the factory. A closed convayor system is necessary to prevent that.

COMMENT: We should recommend to the Factory Inspector to check for the discharges especially gaseous discharges and particulates. The recommendation should also deal with the terrific noise which will easily affect the workers in the factory.

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COMMENT: There was a lot of pistia or water cabbage at Chemelil ponds. It seemed that it could inhibit photo-sythesis and cause anaerobic situation. The green colour suggested that there was an aerobic situation but then the oxygen probably went straight into the air; beneath that there would be no solar penetration.

It seemed that the pistia had actually been introduced into the pond.

COMMENT: This seminar should make a recommendation to Miwani and Muhoroni to construct proper treatment. Miwani did not have a direct discharge into a river but there might be subterranean flows to the river. One should take sample up and downstream and see the difference then to trace the source of organic discharge.

COMMENT: There will be a recommendation here that a regional short-term intensive training programme for waste water operators and workers from all the three countries of the basin. Financial requests should be sent to USAID, ETMA and UNEP, among others.

QUESTION: Why shouldn't the LABDA and other basin authorities employ a water quality expert to deal with the problem we have here. The LABDA which has a water resources man already did not even have the person here at the Workshop.

ANSWER: A water quality expert is indeed necessary and LABDA will consider it.

COMMENT: The TRDA is looking into water quality control by monitoring effluents from the municipal centres along the river.

CHAPTER V

AQUATIC LIVING RESOURCES AND POLLUTION

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FISHERIES IN LAKE BASIN

RIVERS AND WINAM BAY

BY

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ABSTRACT:

Although Kenya is a country not endowed with major inland drainage systems, it possesses less than 4000Km of permanent rivers, however, the basin area is favoured with a number of inland drainage systems compared to the rest of the country. There are about five major permanent rivers and other six small rivers not to mention the many intermittent streams that also drain into Winam Bay.

The water bodies have formed important fishery for the local population over the year, however, owing to the gradual change in both climate and ecology of the area the level of fishery continue to change with time, both in the Bay and the basin rivers. In this paper, I have tried to discuss the fishery in the region both in historical terms and have also highlighted the present situation. I have further tried to shed some light on changes influenced by the development patterns in the region. The emerging industries in the region and current agricultural practices that call for agro-chemical use such as pesticides, hebicides and mulliscides, are a attribute to such influence on water quality resulting into indirect effects on the basin fishery.

INTRODUCTION:

The surface water resources of a region are the result of the interaction between the physical relief and climate of the region. Past geological events create catchments and Lake Basins while differences in altitude influence rainfall and temperature. Rainfall in Kenya is characteristically low with uneven geographical and temporal distribution, hence, over 70 per cent of the country receives less than 500mm of rain per annum, the rest of the country receiving between 500mm and 750 mm. Kenyan lake basin area seem to be favoured by a number of inland drainage system compared to the neighbouring countries as may be seen in the number of rivers that drain into Winam Bay, (see fig.1). In Uganda there is only one main river Kagera which drain into Lake Victoria. Tanzania on the other hand has one major river, River Mara, which is very close to the Kenyan border and which is likely to influence part of the Kenyan waters and a few other minor ones such as Mosi, Gurumeti, Simiyu and Isanga rivers (Fig.11). The basin area is further favoured by such drainage system compared to the rest of the country(see table.1). These are the drainage systems that have formed important fishery in the region for many years. These drainage systems also do influence fish production in Winam Bay. Thus, Winam Bay fishery continues to be sustained inspite of heavy fishing that characterize the gulf area. It is a fishery which is now being affected by the changing trends in development patterns and agricultural practices in the region.

THE FISHERY IN THE BASIN AREA:

The Fishing in the region is recognized as an important fishery and it has had a long history of success. The Gulf area produces the bulk of the total national annual fish landing from freshwater and marine fishery put together. In the last few years the Lake yield has continued to rise, with catch for 1982 showing a record 40000m. tons. These catches are largely influenced by emergence of Lates niloticus (Mbuta) fishery, a species of fish introduced in the lake in the late fifties and early sixties on the Uganda side, the seedlings mostly being drawn from the Western Uganda Lakes where it is endemic,

(a) THE LAKE BASIN RIVERS:

Past records show that the river fishery in the Basin region formed very important fishery until about two decades ago. The fish taken from the Nyanza rivers, over the years, remained entirely of anadromous species that ascend the rivers from Lake Victoria at the onset of the rainy seasons, Usually in late March and October every year. Prior to the rains these fish which include Barbus, altianalis radcliffi, Labeo Victorianus, Schilbe mystus, Alestus nurse and other cat fishes congregated in the river mouths where they were often exposed to intensive fishing upsteam to their spawning grounds (Whitehead, 1959). Although the river fishery remained high over the years, changing trends in the development of the region has had remarkable influence on the fishery a part from the effect of fishing pressure and the methods of fishing practised by the local artisanal fishermen over the years. The wide variety of indigenous and ingenious fish traps used by the local fishermen removed significant proportion of the unspawned population ultimately leading to reduction in the standing stock of the riverine fish. The changes in water quality upstream may have also affected fish population in rivers as the young fry are more susceptable to pollutants. These changes in water quality come about because of the modern agricultural practices and the establishment of industries in the basin area whose wastes and runoffs spill into our rivers subsequently emptying into Winam Bay. Some of the developments also resulted into river impoundement thus interfering with the normal upstream immigration of the riverine fishes.

In general the relationship between river fishery and the development of the basin area and reported decline in yield of river fish production would be difficult to determine because of lack of sufficient data on fish yield from these water bodies and because of the many other factors that may be operating in the whole basin river system.

River Kuja which used to form a very important fishery South West of the gulf has since shown some decline in fish production a fact which may have been influenced by river impoundment for purposes of hydroelectricity. The other smaller rivers in the same region have also shown decline partly because of destruction of catchment areas and partly because of overfishing of the riverine species during spawning time. It may be not worthy to record that when river Kuja was dammed provision for fish ladder was incorporated but the structure broke down at a very early stage and hence never became operational, as to allow free migration of fish up and down stream.

Similar factors have also affected the fishery of major rivers North of the Gulf such as Yala and Nzoia. The former became affected in recent year by land reclamation programme initiated in the lower reaches of the river to facilitate agricultural activities in the area. This development had great impact on the immigration of the riverine species, and other resident fishes in this river, where some fish found themselves in shelved lagoons such as Lake Kanyaboli. Although Nzoia river still support significant fishery the trend is slowly being affected by creation of dikes to control flooding in the lower reaches and also by the establishment of Paper Mill on the upper reaches of the river at Webuye. In our monitoring system it has already been established that there is a reduction of fish population in this river which is progressive from the paper mill factory downstream, and there are indication that similar effects may extend down to the Lake shores.

Finally, to say the least, assessment of the impacts of basin development on river fisheries may be possible only when adequate long-term fisheries statistics are available. The collection of such data has been difficult because of the relative importance that Kenya attaches to this fishery. It has, however, been observed that during the period 1971-1977 the river catches amounted to about 5% of the total inland catches which covered about 27000m. tons. You will observe that this is a decline down to about 100 m. tons in 1977, (Litterick, 1981). It is difficult to attribute this decline to the actual river yield or to a reduction in intensity of data collection, it is however, clear that river fishery do affect the greater populace that consume the unmonitored, invisible yield from the many rivers, streams and tributaries in the basin region,(see fig. 11).

(b) WINAM BAY FISHERY:

Winam Bay fishery has a long history of exploitation by the fishing community around the gulf. Over the years, the records have continued to show the gulf fishery to be the major contributor to the national annual fish catch every year, (see table 11).

The gulf fishery in the past had generally been dominated by the cychlids e.g. Haplochromis spp. Tilapia spp and non-cychlids such as Bugrus spp, Clarias spp, Barbus spp, Labeo spp, Engraulicypris spp Protopterus spp and other catfishes. Other species formed smaller percentage of the total annual catch. At the present time Tilapia, Bagrus, Clarias and Protopterus seem to have been partly affected by over-exploitation and partly by the effect of predation by Lates niloticus (Mbuta). The Lates niloticus (Nile perch) has in recent times emerged as a major fishery in the gulf and remain under-exploited (Arunga, 1981). The trend on Haplochromis fishery tend to be influenced by a number of factors, in the gulf. The general decline in the inner gulf of the fishery may be attributed partly to pressure of fishing and heavy predation by the Nile perch which was introduced in the lake about three decades ago and other endemic predators such as the cat-fishes. The Haplochromis fishery, however continue to be dominant in the open parts of the gulf less infested by such predators. Engraulicypris fishery continues to be stable and may be considered to have been under-utilized in the past. It is a fishery which is likely to be affected by continued establishment of the perch and the apparent progressive decline of the Haplochromis that hitherto formed the main perch food. It is envisaged that the perch may revert wholly to Engraulicypris as its main food source thus threatening its very existance.

The riverine fishery as discussed earlier have been affected partly by current development on our river systems and also by the methods of fishing adopted by the artisanal fishermen in Winam Bay and in the basin rivers for many years. Consequently the Burbus spp, Labeo spp Schilbe spp, Alestes spp; etc, now show progressive decline and in other cases almost a total decline of the various species. At the time, a general fear prevail that in some cases total depletion is likely to take place among the species which still exist in the gulf.

Apart from the points considered earlier as having had direct influence on the gulf fishery, the development of secondary industries around the gulf and modern agricultural practices which utilize agro-chemicals for control of weeds and protection of agricultural produce have had indirect influence on the fishery because of their effects on both river and Winam Bay water quality. The fishery is also likely to suffer direct damage from contamination caused by the discharge of pollutants from the emerging Urban Centers all around the gulf, (Arunga, 1981) The aspect of management problem is discussed at length in the following paragraph.

AGRO-INDUSTRIAL EFFECTS ON THE LAKE BASIN FISHERY

Records show that there is general awareness of the existance of possible contamination of our river systems and Winam Bay with heavy metals, pesticides, molluscides, hebicides and other forms of pollutants. These pollutants originate from the use of chemicals for the control of tropical diseases e.g. (DDT for control of tsetse fly) and the treatment of agricultural crops such as sugar cane, rice, coffee and cotton. The discharge or effluents from industrial plants such as the Paper Mill at Webuye, the Textile Industries in Eldoret and Kisumu, the Sugar factories in Nyanza and Western Provinces are some of the important source of water pollution in the region. The discharge of effluents from such industries find their way into our river system which eventually empty into the

Lake especially in Winam Bay. It is therefore, likely that the basin rivers that drain into the Lake do experience pollution long before the entire Lake becomes affected. Accumulation of pesticides, such as DDT, have been detected in fish and birds in Lambwe area, (ICIPE, personal communication).

As indicated earlier the agro-industrial influence on our fishery is indirect in nature and its magnitude is not likely to be realized immediately. The trend therefore calls for continued pollution monitoring systems in rivers, streams, bays and lagoons as a first priority. This monitoring should be paralleled by a survey of agro-industrial activities and general urbanization around the Lake shores especially in Winam Bay.

It has already been established in Winam Bay that some of the chemicals such as Furadan, used in the spraying of rice farms have deleterious effects on fish fauna and wil will kill fish immediately. The use of Fescon, Dimecron (saw 50), for the same purpose is still considered safe.

In concluding, however, it would be important to mention here that pollution and enrichment (eutrophication) which are often associated, are indeed separate in concept as they may have totally different influence on fish stock. Pollution arises mainly from industrial activities and has received attention from diverse sources in the past giving rise to many publication on the subject (Hynes 1971). The effect of pollution on the aquatic life in the ecosystem may be summarized as:-

(i) Actual lethal toxicity which kills the fish at some stage of its life history,

(ii) Sublethal effect which may be difficult to detect or prove but which may have a notable effect on its biological development,

(iii) Cumulative effects which may render fish either unsafe or unpalatable for consumption.

Enrichment known as eutrophication, however, arises from domestic or agricultural wastes which sometimes add phosphorus, nitrogen and organic substances in water media. Thus, moderate enrichment is not necessarily harmful and may be beneficial and heavy enrichment results into pollution when it is sufficient to produce dioxygenated condition in a particular water body.

DISCUSSION AND CONCLUSION:

The maintainance of a fish stock in any body of water depends on a variety of factors, many of which are external to the fishery or even to the aquatic system. This is particularly so when one considers the increasing pressure on water for industrial, agricultural and domestic uses, and fishing for food and other purposes. The management of fish resources under these conditions therefore depends on two major policy levels: the importance of fisheries relative to other uses of the rivers or lake basin; and objectives for the management of the fishery itself.

Fishery managers have a variety of tools which they may apply for effective management of a fish resource. These may include legislation controlling direct fishing effort, control on gear type used in fishing activities, protection of physical structure of the environment, culturing of fish, and introduction of new species to a water body as was done with the Nile perch. Here again the success of any chosen strategy to flourish would largely depend on maintainance of physical environment at a premium or optimal levels.

From the foregoing one agrees that the negative impacts on fisheries in the basin rivers and Winam Bay resulting from both agro industrial development and many other diverse factors, appear to be well defined and the solutions tend to be hampered partly by technical difficulties and partly by adverse political and social forces. Secondly, the Management of the basin will continue to be geared towards water supply needs as a primary goal, while consideration of fisheries needs remain subordinate. Fisheries however, will continue to feature prominently when the development and management of Winam Bay is considered and the emergence and continued

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abundance of Nile perch fishery will economically continue to be an important factor in the region. It is suggested that maintainance or management of Winam Bay water quality should bear this point in mind.

As will be seen above, if river management in the basin concentrates on maintaining high standard of water quality then fishery management in the river basins and aquaculture techniques may successfully be developed for the betterment of the fishing industry in the region. A workshop on water quality management and pollution should clearly address itself to the points raised in this paper.

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TABLE I: The catchment area, mean annual rainfall and mean annual run-off of the drainage basins of Kenya

Drainage basin	Catchment Area 00Km^2 1%	Mean annual rainfall(mm)	Mean annual run-off $10^6 m^3$ (%)	Run--off as % or rainfall
I Lake Victoria	45 (8.4)	1 245	6705(46.9)	12
II Rift Valley	127 (21.8)	535	860 (6.0)	1
III Athi River	70 (12.0)	585	1294 (9.0)	3
IV Tana River	132 (22.7)	535	4700 (32.9)	7
V Ewaso Ngiro	205 (35.1)	255	740 (5.2)	2
Total Mean	579	631	14299	5

Source: Kenya 1972, Ongwenyi 1979.

TABLE 11: Comparative annual fish catch in Kenyan waters by regions (M. tonnes)

	Lake Victoria (Kenya Waters)	Marine (coast)	Other Lakes	Total
1977	19.332	4,066	23,398	36,625
1978	22,529	4,178	19.687	46,394
1979	30,592	2,858	16,963	50,413
1980	26,940	3,490	-	-
1981	46,667	-	-	-

DISCUSSIONS

COMMENT:

Nile perch was accidentally discovered in Lake Victoria in 1963/4, on the Uganda side, A debate followed as to whether it should indeed be introduced, but the point remains that, it had actually found its way into the Lake by chance.

The idea then was that the Nile perch would eat the haplochromis and convert to its great mass. Indeed the Nile perch has increased the annual catch statistics of Kenya, it might not be negative effect.

Perhaps, there are other bases of the change of species in the Gulf. In which case we should change, and accept the new species.

COMMENT:

It is true the Nile perch is doing well in Lake Kyoga; it is true, too, that other species in Kyoga have also been disappearing as is the case with species in Lake Victoria.

COMMENT:

The DDT has been used in the Lake Basin Area. It is ICIPE researchers who established the level of DDT in fish and birds. Since the LBDA became active there should be a change and a new study should be commenced to ascertain impact of DDT on ecosystem, other than that it has had positive effect on the public health.

QUESTION:

Can the Fisheries Department deploy control devices such as prohibiting fishing in certain areas by season and ecological zones ?

ANSWER:

The Department has used the device of control in the marine fisheries and Naivasha. The situation has been rather difficult in Victoria for some topographical reasons. We have tried to create protected areas for tilapia, for example, and the results have been positive.

We have discouraged people from eating fish from sewage lagoons because of the established mecury content. There is a need to ascertain the same factor in sewage ponds in the country.

COMMENT:

The Ministry of Health has ascertained that the mercury content in fish has been intermitent. Some of the mercury is from dissolved thermometers but the exact source of most of the mercury found in fish is not clear. The Municipality of Kisumu, we understand, has some of that information but the extent is limited and so there is a necessity for further research in this critical area.

FISHERIES RESEARCH FINDINGS IN WINAM GULF OF LAKE VICTORIA

BY

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ABSTRACT

The research findings of Nyanza Gulf are briefly described under the following headings :

1. The biology of both anadromous and Lacustrine species.
2. Stock assessment.
3. Water Chemistry.

Of the three major divisions of research, the studies on fish biology, classification and stock assessment have been given more time. The fishes of the rivers affluent to the Nyanza Gulf which have been studied, include: Labeo Victorianus, Schilbe mystus, and Synodontis spp. Most of the early research findings regarding Lacustrine species in Nyanza Gulf are based on the studies carried outside the Nyanza Gulf of Lake Victoria.

Comparison of mean stock densities (Kg ha^{-1}) from 19 hauls in 1969, 69 hauls in 1975, 167 hauls in 1977 and 194 hauls in 1981 from Nyanza Gulf showed the following :

1. A reduction in mean stock densities for: Bagrus, Clarias, Haplochromis, Labeo, Protopterus, Schilbe, Synodontis and Tilapia Zillii.
2. An increase of Lates niloticus and Sarotherodon niloticus.
3. A part from 1967 survey no S. Esculentus was caught in the 1977 and 1981 surveys.

River Kasat is polluted to a higher degree.

There is a need for a long-term research in Nyanza Gulf and its surrounding rivers on the following :

(a) Invertebrate ecology and biology;
(b) Ecology of aquatic vegetation;
(c) Biology and ecology of freshwater fishes;
(d) Water Chemistry.
(e) Restocking of fish and development of fish ponds.
(f) A co-ordinated, regional research effort into limnology of Lake Victoria and rivers in East Africa.

INTRODUCTION:

The need for research on problems connected with Lake Victoria was emphasized by the East African Common Services Organization after the 2nd World War. This led to the foundation of the East African Freshwater Fisheries Research Organization(EAFFRO) station at Jinja, Uganda in 1948. In 1972, two sub-stations were set-up in both Kisumu and Mwanza to cater for Kenya and Tanzania, respectively.

The fisheries research investigations carried out during that period included among others, the life history (Fryer & Whithead (1959), Taxonomy (Greenwood (1966), Ecology (Okedi (1960), stock assessment of various fish general (Bergstrand & Cordone(1971), and Kudhongania & Cordone(1974) and the productivity of the lake (Talling (1966). Most of the findings were compiled in EAFFRO Annual Reports (1951-1974). With the collapse of the East African Community in 1977, the Management of the laboratories were taken over by the respective states.

Lake Victoria has fish fauna dominated by the Cichlid fishes which include Haplochromis spp. tilapia (Sarotherodon niloticus, S. Variabilis, S. Leucostictus, S.Esculentus and T. Zillii), and the non-cichlids like, Barbus spp., Labeo sp., Synodontis spp., Clarias spp., Protopterus sp., Schilbe sp., Alestes spp., Engraulicypris sp., Mormyrus spp., etc. The introduction of gill-nets in 1905 and beach-seines in 1920's resulted in increase in fishing efficiency for the two endemic Tilapia spp. As a result of increased exploitation inshore, there was a decline in the catch of Tilapia spp. (Beauchamp 1956). In 1951 and 1953 four exotic tilapia species namely S. niloticus, S. leucostictus, and T.zillii, T. rendalli, were introduced into Lake Victoria. Competition between the endemic S. variabilis and the exotic T.zillii might have occurred (Fryer 1961). The predatory fish Lates niloticus (Nile Perch) was introduced into Lake Victoria in 1960, with an intention of feeding on the Haplochronis spp.

RESEARCH FINDINGS IN WINAM GULF

The findings in Winam Gulf can be classified under the following headings.

(a) The biology of both Anadromous and Lacustine species.
(b) Stock assessment.
(c) Water Chemistry.

Anadromous species:

The fisheries of the rivers affluent to the Winam Gulf are quite significant. The anadromous species include Barbus altianalis, Labeo victorianus, Schilbe mystus, and Alestes nurse.

There is scanty information provided in the literature available, regarding the anadromous species in Lake Victoria and especially the Nyanza Gulf. Whitehead (1959) described thirteen fish species as anadromous within the whole of Lake Victoria. Cadwalladr (1964) reported on the decline of Labeo victorianus in the Nzoia river and he attributed their decline to overfishing using gill-nets at the river mouths, a practice which removed potential spawners migrating upstream to spawn. Cadwalladr (1965) reported that during flooding season, Labeo victorianus could migrate from Jinja, Uganda to Nzoia river, Kenya for spawning purposes. Rinne (1975) studying Schilbe mystus found that the spawning period occurred in the months of December, January, May, June, and July.

Mainga O.M. (1982) accomplished studies on some aspects of the general biology and ecology of Synodontis spp. found at the mouths of both Miriu river and Kuja river. He found that Synodontis breeds during rainy season (March-May). Apart from that there are also some on going investigations on the breeding biology of both Labeo victorianus and Schilbe mystus. With the decline in catches of the anadromous species, the Kenya Marine and Fisheries Research Institute (K.M.F.R.I.) had decided to set-up two sub-stations on rivers Kuja - at Gogo Falls and Miriu at Sangoro with an aim of carrying out research on riverine species. The ultimate objective of these research sub-stations will be to produce fingerlings by artificial spawning for re-stocking the river-systems.

Lacustrine species:

Most of the early research findings regarding these species in Winam Gulf are based on the studies carried out mainly outside the Nyanza Gulf of Lake Victoria. Within less than half a decade some research findings carried out by research officers at the Kenya Marine and Fisheries Research Institute is beginning to bear fruit. Ochieng, I.J. (1981) completed studies on the breeding and feeding habits on Bagrus docmac in Nyanza Gulf. Ogari is analysing results on studies on the distribution, food and feeding habits of Lates niloticus in Nyanza Gulf.

STOCK ASSESSMENT

Though several species were threatened by overfishing, large stocks of Haplochromis spp were believed to abound in the lake. The paradox of the Lake Victoria fishery, therefore, called for a fishing regime and management strategy which would economically exploit the stocks according to their biological characteristics. This required knowledge of the distribution pattern, extent and magnitude of the lakewide available stocks which was still lacking in 1967.

Therefore, the East African Fresh Water Fisheries Organization and UNDP/Lake Victoria Fisheries Research Project (LVFRP) embarked on a lakewide bottom trawl exploratory survey to bridge this gap. The immediate aims were to derive preliminary estimates of the temporal and spatial distribution pattern, magnitude and relative abundance of the available stocks and to evaluate trawling as a fishing technique for the Lake Victoria fisheries. These aims were accomplished and reported by Kudhongania and Cordone, (1974).

Four bottom trawl surveys done in Winam Gulf by Bergstrand & Cordone (1971), Martel, et al (1976), Muller and Benda(1981), and Okemwa (1982(b)) are compared in Table 1. This comparison of mean stock d. aities (kg ha^{-1}) from 19 hauls in 1969, 69 hauls in 1975, 167 hauls in 1977 and 194 hauls in 1981 from Winam Gulf showed the following :

1. A reduction in mean stock densities for: Bagrus, Clarias, Haplochromis, Labeo, Protopterus, Schilbe, Synodontis and T. zillii.

2. An increase for Lates niloticus and S. niloticus.

3. A part from 1967 survey no S. esculentus was caught in the 1977 and 1981 surveys.

Earlier surveys carried out in Winam Gulf used 'Ibis' & "Comorant" trawlers. These trawlers had some limitation i.e they could not trawl in areas which were less than 5 metres in depth. This meant that over 50% of the surface area of Winam Gulf was not trawled.

Table (1) Mean stock densities (Kg ha^{-1}) from the Winam Gulf from UNDP, EAFFRO, FFRI and KMFRI, bottom trawling surveys.

Species	1969/70* 19 hauls Mean (kg ha^{-1})	1975** 69 hauls Mean (Kg ha^{-1})	1977*** 167 hauls Mean (Kg ha^{-1})	S.E.	1981**** Mean (Kg ha^{-1})	S.d.
Bagrus docmac	11.732	12.545	1.845	0.170	0.078	0.078
Clarias mossambicus	3.318	2.638	0.694	0.081	0.026	0.0496
Haplochromis spp	35.837	32.721	28.555	2.299	+	0
Labeo victorianus	0.066	0.130	0.070	0.10	+	0
Lates niloticus	+	0.827	2.808	0.446	39.791	12.768
Protopterus aethiopicus	3.743	10.923	0.252	0.081	0.026	0.078
Schilbe mystus	0.025	0.218	0.005	0.002	0+	0
Synodontis spp.	2.137	0.171	0.478	0.100	0.026	0.052
Sarotherodon niloticus	0.013	0.168	0.722	0.107	2.533	2.245
Sarotherodon variabilis	0.030	0.106	0.266	0.038	0.026	0.026
Tilapia zillii	+	+	0.27	0.2	0.01	0.1

* Bergstrand & Cordone (1971) UNDP Survey.

** Marten, Wanjala & Guluka (1976) EAFFRO Survey.

*** Muller & Benda (1981) FFRI Survey.

**** Okemwa (1982) KMFRI Survey.

The availability of a fibre-glass boat 34' long, enabled Okemwa to trawl in areas of about 3m deep. Despite the additional information from the inshore areas there is still evidence of alarming decline on S. variabilis, T. Zillii, Bagrus docmac, Clarias mossambicus, Labeo victorianus, Trotopterus ae thiopus and Haplochromis spp. among others, within the Winam Gulf.

At least 89% of the catchable demersal ichthyomass in Winam Gulf consists of Lates niloticus, whereas other predatory fishes like Bagrus, Clarias and Protopterus constitute less than 0.5% by weight.

Okemwa (1982) suggests that the existing inshore artisanal fishery should be protected. Mechanized water transport should be provided by the co-operatives to the fishermen to transport their catches to the beaches along the Lake shore so as to reach the consumer in good condition.

The data we have been getting has been inadequate to estimate catch effort and length frequency in Winam Gulf for commercially important fishes. Early in 1981, we recruited Field Recorders on all landing beaches around the Winam Gulf for that purpose. The data already collected is being analysed.

Fish population in models have been developed with knowledge from studies of biomass of both phytoplankton and zooplankton in some areas. This brings us to the studies on planktons in Winam Gulf. The taxonomy, biology and ecology of the aquatic stages of insects in the gulf for example are still unknown. Such studies are necessary in view of the importance of various plankton groups as fish-food.

POLLUTION:

At the present time, there are three principal areas that may act as pollution sources in the Nyanza Gulf. These are:

(1) Urban development projects.
(2) Industrial wastes.
(3) Use of farm chemicals, mainly pesticides, and soil erosion.

The Kisumu Municipality has effluent collection installations at Nyalenda (Lagoons) and Kisumu waste works, which cater for effluents from the town and Kicomi and other factories.

The Kenya Marine and Fisheries Research Institute has conducted a case study of the water chemistry of the River Kasat that received effluent from the sewage treatment plant near Kicomi. The river empties directly into the lake. The Kasat water is dark in colour and has a fawl odour. Water samples for analyses were collected on a daily basis from Monday to Saturday for three months, January to March, 1982. Samples were collected at the river mouth.

Table 2 shows the mean results of the water sampled.

Table 2 suggests that River Kasat is polluted to a higher degree. Conductivity of the water as high as $4250cm^{-1}$ and a pH as high as 11.8 have been recorded. These are far above the tolerance limits for fish.

It is of interest to note that the Kasat water gives both phenopthalein and methylorange (total) alkalinities. This indicates the presence of both hydroxide and carbonate, which rarely exist together under normal conditions at a pH higher than 8.2. The nitrate content of the river ($60.94mg\ l^{-1}NO_3$) is far higher than that permissible for drinking water.

CONCLUDING REMARKS

Much still needs to be done in fisheries research and training to cope with socio-economic and technological developments in Lake Basin Area.

There is a need for a long-term research in Nyanza Gulf and its surrounding rivers on the following :

(a) Invertebrate ecology and biology;
(b) Ecology of aquatic vegetation;
(c) Biology and ecology of freshwater fishes;
(d) Water chemistry;
(e) Restocking of fish and development of fish ponds.
(f) A co-ordinated, regional research effort into limnology of Lake Victoria and rivers in East Africa.

Table 2: Mean results for various parameters analysed for the Kasat River mouth and its surrounding areas.

Parameters	Sampling Areas		
	River Kasat	Golf Coast Beach	Boat Jetty
Temperature (^oC)	25.5	26.8	26.9
Alkalinity ($mgl^{-1}CaCO_3$)	654 (T.A.) 180 (P.A.)	P.A. NIL	P.A. NIL
Chloride ($mgl^{-1}Cl$)	86.0	6.45	7.15
Nitrate ($mgl^{-1}N_{O3}$)	60.94	-	-
Dissolved Oxygen (ppm)	0.8	6.72	6.12
Dissolved CO_2 (ppm)	NIL	4.55	4.84
Turbidity (FTU)	325	26	27
Colour ($mgl^{-1}pt$)	1050	109	
pH	10.5	8.0	7.95
Conductivity (cm^{-1})	3000	255	249
Odour	Objectionable	-	-
Salinity (%)	-	12.07	11.0

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DISCUSSIONS:

COMMENTS:

Research has been going on in the Lake for about 30 years yet most points raised seem conjectural. Perhaps what we need is some cooperation between researchers and the general Managers to combine their knowledge to ascertain use of the research information in management.

ANSWER:

Most of the earlier research was by itinerant; researchers without much contact and commitment to management. The establishment of the Research institutes since the collapse of the EAC has encouraged development of local research staff.

In any event, most of the serious research started in late 1960's and early 1970's.

COMMENT:

A researcher's work is to ascertain the problem and inform the policy makers. Researchers can advise on the protection of spawning periods for some species. Then it is upto the policy makers to prohibit for example, beach seining. Similarly, the researcher may advise on protection of anadromous and catadromous species. Then it is upto the policy makers to protect the rivers and keep passage free.

Upto now, however, there has been virtually no coordination between the Researchers and Managers, ie., KMFRI and the Fisheries Department.

QUESTION:

What have you recommended for restocking ?

ANSWER:

The Institute considers restocking areas for the riverine species. But we are not sure how successful it will be. For instance, when the fingerlings are released they may be quickly caught by those using "mosquito nets" or they fall prey to lates nilotica.

We are considering other possible areas of cooperation. Approaches will be geared to establish causes of depletion. There may be diseases, overfishing, effect of papyrus or floating islands at the mouths of rivers.

There are limitations but we will continue with fingerlings.

COMMENT:

There may be a problem of liaison with policy makers. However, it seems clear that most of the research todate is fragmentary and inconclusive. This presents a problem for policy makers. The research must seem determined to be taken seriously by policy makers.

COMMENT:

Causations of natural/physical changes are often manifold. But once there is a specific causation established policy makers ought to act on it.

For fisheries one factor causing decline in stocks should be tackled at once.

COMMENT:

It has been submitted earlier that the early researchers were itinerant and perhaps took data with them. What has been the criteria for research for the EAC institutions or for the KMFRI ?

COMMENT:

As one who has been involved in the EAFFR I agree that a priority conference is necessary. There are new factors such as pollution which should be taken into account now.

QUESTION:

Researchers hold that policy makers do not use research findings. In turn policy makers argue that research is inconclusive. Where are the research findings taken to ?

ANSWER:

Research findings are communicated to the policy making body - The Fisheries Department, and in some cases they have used the information as is the case of control of spawning areas mentioned earlier.

COMMENT:

There is no agreement as to what the correct procedures are for transmission of information from the researchers to policy makers.

The fact is that there is no communication of that kind in Kenya. Researchers decide what they will do unless there is actual specific request.

COMMENT:

This workshop should put together a recommendation on links between the information from the researchers to the policy making machinery.

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DISTRIBUTION AND ABUNDANCE OF FISHES IN THE KENYAN PART OF LAKE VICTORIA

BY

OKEMWA EZEKIEL

ABSTRACT

Replicate trawling was done in each month at each of 15 locations in Lake Victoria (Kenyan Part) from October 1977 through December 1981. In 806 hauls, 392,361 fishes were caught, and 20 species (II families) were identified from the collections, (Haplochromis spp. were treated as one group).

Movement of Haplochromis out of Nyanza gulf to main lake because of predation from Lates niloticus is suggested. Other movements by Bagrus and Clarias out of the gulf are discussed.

Size analysis for some of the more abundant species shows that adults and juveniles were found in all areas of the gulf. Nursery ground for Lates niloticus was located.

INTRODUCTION

In the past the former East African Community carried out Fisheries research which covered the whole of Lake Victoria.

But after the collapse of East African Community in 1977 each state bordering Lake Victoria was to go it alone. In 1977 the Kenya Marine and Fisheries Research Institute (K.M.F.R.I.) embarked on bottom trawling survey of Kenyan part of Lake Victoria. (Okemwa (1981).)

The first lake-wide exploratory bottom-trawl survey of Lake Victoria was made by Bergstrand and Cordone (1971). Later Kudhongania and Cordone (1974) made a generalized bottom trawl explerat ory survey in Lake Victoria to define the distributional pattern and magnitude of the lake wide demersal stocks.

None of the above ichthofauna studies surveyed all of the bays and shallow areas of less than 5 metres in Kenya water of Lake Victoria with the same sampling frequency. A different sampling frequency in different habitats (i.e. stratified sampling) in Nyanza gulf was applied, and compared with the means of unbiased reconstruction of the whole lake community structure from the previous workers.

The objectives of this research were to ascertain the species composition, relative abundance, and distribution in Kenyan waters of Lake Victoria.

STUDY AREA

The study area is shown in Figure 1. For sampling and analytical purposes the survey area was subdivided into three major sub-areas. Trawling stations were arranged according to 5m depth intervals.

Subdivisions and the density of stations within sub-area I were based on the location of fish landings set out by Kenya Fisheries Department. We attempted to sample systematically by trawling in a set direction and at set distance between hauls in sub-areas II and III. We had hoped to sample the various depths in proportion to their abundance, but this goal could not be attained because of commercial gill-nets and shoreline irregularities which our research vessel was to avoid when turning.

A description of each sub-area with respective sampling density follows:-

Sub-area I, included nearshore waters (1-5) metres. Sampling density was planned at one station near each fish landing.
Sub-area II, covered areas of (6-10) metres.
Sub-area III, included areas of (· II) metres.

GENERAL INFORMATION ON PHYSICAL FEATURES AND HYDROLOGY OF THE LAKE

(a) Fluctuations in lake water level.

The fluctuations in the water level of Lake Victoria over the past 30 years (1935-1965) measured by the Jinja Gauge (Fig. 2) were calculated by Welcomme (1970). During this period there was a well marked cycle of five years periodicity until 1961, when a sharp rise in the level occured, and by 1964 the water level was 1.4 M. above any previous record. Subsequently the levels had declined, leaving most of the previously flooded areas dry by the end of 1966, Welcomme (1970).

The fluctuations in the level of Lake Victoria from 1969 to 1981 as measured by the Kisumu Gauge (Kenya Ministry of Water Development, 1981) are shown in Fig. 3. Water heights in the lake determine the extent of flooding of marginal areas, thus by calculating back from the previous recorded depths, a rough timetable of the inundation of the shores can be worked out. At present the water level in Lake Victoria has not changed very much from the record of 1966.

The vegetation that surrounds many of the shallow bays in Nyanza gulf of Lake Victoria was affected by the rising water level.

During rainy season, the Lake Victoria water level rises to a maximum and drops the following dry season (Fig. 3). With the rise of lake water level during rainy season in Lake Victoria (Kenyan Part), large areas occupied by papyrus and Vissia cuspidata are dislodged, floating freely to different areas of the lake with the continued rise in lake water level. In dry season some of the papyrus either die leaving shallow inlets and pools within the Nyanza gulf, or are planted in different shallow areas awaiting next rains and the cycle continues.

(b) Solar radiation

The solar radiation in Lake Victoria for over 12 years as measured by the Kisumu Solarimeter (Kenya, Hydrometeorological Department) are shown in Fig. 4. The average value for radiation is 450 (ca/cm^{-2}).

There is a negative correlation between monthly solar radiation and monthly rainfall in the lake. There were high values of solar radiation during periods of rainfall minimum.

(c) Rainfall

Rainfall in the Nyanza gulf of Lake Victoria from 1970 to 1981 as recorded by Kenya Hydrometeorological Department is shown in Fig. 5. The amount of rainfall in the lake basin varied from a minimum of 6.3 cm to a maximum of 394.1 cm with a mean value of 109 ± 89.3 cm.

The rain pattern in Lake Victoria can be classified into two seasons, rainy and dry.

(d) Surface water temperature

Surface water temperatures of Nyanza gulf of Lake Victoria in the period 1977 to 1981 is shown in Fig. 6. The monthly mean surface water temperature was variable, rising to 32.3^0C and dropping to 16.7^0C.

MATERIALS AND METHODS

Okemwa (1981) described the methods that were employed for this survey.

The trawl used throughout had a 13.7m headrope and 38mm mesh codend. Bottom trawls were made at approximately 2.5 knots for a period of 30 minutes at each location. Specimens in each sample were sorted to species except Haplochromis spp. and individuals of each species were counted and weighed to the nearest 1 gram.

Length was determined for about 50 specimens of each species, and when less than 100 specimens were available all were measured. Total length was measured for all specimens except Labeo victorianus and Synodontis spp. where fork length was used.

STATISTICAL TREATMENT OF RESULTS

The sample frequency distribution of the number per haul from Kenyan waters of Lake Victoria was Poissonian and suitable for stratification.

The cumulative $\sqrt{f}$ - rule of Dalenius and Hidges (Cochran 1963) was applied.

When we come to the problem of finding confidence intervals for f, our path is again smoothed by the fact that when f is large the Poisson distribution tended to normality.

The following notation is used:

For Stratum X(X=1,2,3).

Nx = total number of hauls

nx = number of hauls in the sample

Yxi = number of fish in haul i.

$\frac{Nx}{N}$ = Stratum weight

$$Yx = \sum_{i=1}^{nx} \frac{Yxi}{nx} = \text{Sample mean}$$

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The mean number per haul for the whole area is now estimated by the weighted mean

$$\bar{Y}w = \sum_{x=1}^{3} \cdot \frac{Nx}{N} \cdot \bar{Y}x$$

Differences in the mean catch per haul between locations were tested with the Student-Newman-Keuls Test (Sokal and Rohlf 1969). Abundance by sampling month was plotted for those species represented by 2 or more individuals.

Non-parametric test, such as Contingency table tests was applied to compare fish length distributions.

RESULTS

FISH CATCHES

The total catch of fishes for the years' day tra·l collections (338 samples) was 392,361 individuals. They represented 20 species and 11 families of freshwater fishes. The catches are summarized by species in tables 1 and 2.

In 1977 the two most abundant species were (Lates niloticus and Haplochromids) which made up 14.3%, and 63.3% respectively of the total catch (78.1 kg/hr). The catch rate changed tremendously in 1981, Lates niloticus, Sarotherodon niloticus and Haplochromids represented 95.1%, 4.4%, and 0.0% respectively of the total catch of 177.9 kg/hr (table 1).

There were statistically significant differences between the mean total catches of 8 species in various stations in Nyanza gulf (table 3).

Figure 7 shows total monthly catches of different species between (1977-1981) in the Kenya part of Lake Victoria.

Chi-square test was used to test species proportions in Nyanza gulf (table 4). Comparative catch rate between day and night, and period (1971 and 1981) for two sampling occassions (Cordone and Kudhongania, 1972) are shown in table 5.

The catch rates (kg/hr) for Bagrus and Protopterus increased in night and decreased during the day, and the reverse is true for the rest of the fish species (table 5). Comparing species composition in 1971 and 1981 it is clear that all indigenous fish species have disappeared from Nyanza gulf while the introduced Lates niloticus has colonised the gulf (table 5).

The species composition in 1977 and 1981 differed slightly i.e. in 1977 we recorded 18 species, whereas 6 species were collected in 1981. Species diversity progressively decreased with time in Nyanza gulf (table 1).

DISTRIBUTION AND ABUNDANCE:

Out of 338 trawls, only two specimens of Sarotherodon esculentus were caught. Sarotherodon leucostictus was found in stratum III at 3m depth.

Tilapia zilli and Sarotherodon variabilis were found in the depth range of (0-9)m. Sarotherodon niloticus inhabited a wider depth range of (1-14)m.

Very few numbers of Alestes spp., Mastacembelus frenatus and Schilbe mystus were caught in the Lake (Table 1) during the period (1977-1981). Xenoclarias spp. was only found in offshore waters of 15m depth, while Mastacembelus frenatus had the narrowest bathymetric distribution (0-4m).

Seasonal changes in abundance and composition of the fish fauna of Lake System occured during the survey. The catches by seasons for all species are listed in Table 2, and the percentage of the total catch of fishes and the total number of species are shown in Figure 8. With the onset of dry season, the grouped percentage of total catch for all the months declined to a lower value of 22.4%.

In the rainly season, catches were highest, 77.6% of the total. Only in the dry season did we observe a slight change in the number of species in our collections. The number of species was 19 in the dry season, while it was 20 during the rainy season (Fig. 8).

Abundance in dry and rainly season for those species that were represented by 1000 or more individuals (Table 2) and arranged in order of decreasing magnitude were as follows: Haplochromids, Lates niloticus, Bagrus docmac, Synodontis spp., Sarotherodon niloticus, Sarotherodon variabilis, and Clarias mossambicus.

FREQUENCY DISTRIBUTION:

From the data of the survey 1981 3 strata have been constructed by using the cumulative $\sqrt{f}$ - rule. All the hauls taken from Nyanza gulf of Lake Victoria have been considered under:

Stratum I: 1-5 n_1 = 74 hauls
Stratum II: 6-10 n_2 = 62 hauls
Stratum III: $>$ 11 n_3 = 62 hauls

The individual hauls are classified into the three strata as given in Table 6. The mean number per haul and its confidence limits with variance are calculated and given as:

$$\bar{Y}w = 815.83$$
$$\text{Var } \bar{Y}w = 8253.57$$

90% confidence limit of $\bar{Y}w = 815.83 \pm 149.9$.

SIZE

Comparisons of lengths distribution of the very important commercial species were made between different sampling areas (Tables 7-12).

The mean total length for (Lates niloticus, Bagrus docmac, Clarias mossambicus, Sarotherodon niloticus, Sarotherodon variabilis and Tilapia zillii) were tested and these data were compared between locations (Table 13). In general, the smaller individuals of most fishes were found in shallower areas in the Nyanza gulf and the larger fishes were more frequently observed in all areas in the gulf.

No significant differences in comparisons of mean total lengths between locations were found for Clarias mosambicus and Bagrus docmac.

Lates niloticus were found in aggregation of a cohort of many juveniles with 2-5 adults. In some cases juveniles and adults were moving separately.

Two largest fish species ever recorded in Lake Victoria were caught during this survey: Sarotherodon variabilis which was albino was caught at Kaloka in July, 1980, with a length of 44.7 cm and weighed 1.7 kgs; Bagrus docmac was caught at Usoma in May 1980, with a length of 98 cm and weighed 15 kgs.

DISCUSSION

Between 1961 and 1964 the water levels of Lake Victoria increased tremendously. This increase produced changes around the lake shoreline creating new habitats in the form of papyrus swamps and lagoons (Fig. 1). Chemically and Physically these new regions resembled small tropical fish ponds, with a nocturnal reduction in both dissolved oxygen and temperature (Welcomme 1970).

Protopterus aethiopicus and Clarias mossambicus have inhabited papyrus swamp in Nyanza gulf (Fishermen - Per. Comm.). The mat of floating vegetation or papyrus swamp, by reason of the de-oxygenated conditions that exist under it, acts as a form of biological filter. Thus, fish from the lake can only penetrate to the swamp or floating vegetation if they can tolerate the low de-oxygenated conditions.

The effect of floating papyrus in the lakes, is that they take away fish nets, block trawl net during trawling operation, and become barriers to beaches used for beach seining and fish landing.

The suggestion has been made by Beauchamp (1958), that a great improvement in fish production would result if the papyrus, which blocks most of the shallow water bays and inlets in the lake, were either totally or partially cleared. The waters that have come into existence, as a result of the recent rises in lake level, resemble those that would be produced by such partial clearance, and those waters or lagoons have infact become colonized by several species of fish. Sarotherodon leucostictus, Haplochromis spp. and other species. This observation agrees with the finding of Welcomme, (1970). Species diversity decreased with increase of depth. Movements or migrations fish species are suggested and are probably related to depth and predation (from Lates niloticus).

The decline and gradual disappearance of Haplochromids (prey) from shallow areas (Nyanza gulf) which hitherto had formed the greater percentage of the Nyanza gulf catch was followed by rapid growth in numbers of Lates niloticus (predator) (Okemwa, 1981). High catch rates of Haplochromids were found in the main lake where Lates niloticus does not occupy because of depth intolerance. A corresponding increase of catch rate was observed in the main lake for Clarias mossambicus and Bagrus docmac (both predators).

It could suggest that the two predators moved away from areas where Lates niloticus occupy, because of competition from the later. It is suggested here that Lates supports the inshore water fishery of Lake Victoria, while Haplochromids supports the offshore water fishery.

Powell (1977) suggested that Clarias and Bagrus have declined recently in the Nyanza gulf. Okemwa (1981) reported that Haplochromids have disappeared from the Nyanza gulf.

It is suggested here that Clarias, Bagrus and Haplochromids have moved from Nyanza gulf to the main lake.

There were seasonal variations in the abundance and species composition in our catches (Fig. 8).

Adults and juveniles of all fish species were found in all areas in Nyanza gulf. The notable occurrance of juvenile forms (3.5 - 25.0 cm) of Lates niloticus in our trawl samples and in all months throughout the year suggests that Open Water (Homa - point to Mbita Light house), and Rusinga Channel provided a nursery ground for this species.

The catch rate (Kg/hr) of Sarotherodon niloticus and S. variabilis also portray seasonal variations with higher catches occurring during the rains.

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Table 1: Monthly mean catch rates in kg/hr of fishes caught in bottom trawling in Nyanza Gulf of Lake Victoria Kenya portion.

PERIOD	1977			1979			1981		
No. of Trawls	167			107			64		
	Mean	SD	%	Mean	SD	%	Mean	SD	%
SPECIES									
Alestes spp.	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Bagrus docmac	6.7	4.7	8.6	3.7	2.2	7.5	0.5	0.3	0.2
Barbus altianalis	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
CLARIAS MOSSAMBICUS	2.7	1.4	3.5	1.2	1.1	2.3	0.2	0.4	0.1
Haplochromis spp.	49.4	39.6	63.3	6.7	8.9	14.5	0.0	0.0	0.0
Labeo victorianus	0.3	0.2	0.4	0.2	0.1	0.4	0.0	0.0	0.0
Lates niloticus	11.2	8.4	14.3	34.6	15.8	70.3	169.1	48.4	95.1
Mormyrus kannume	0.4	0.1	0.5	0.0	0.0	0.0	0.0	0.0	0.0
Mastacembelus frenatus	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Protopterus aethiopicus	1.1	2.1	1.4	0.0	0.0	0.0	0.0	0.0	0.0
Sarotherodon leucostictus	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Sarotherodon niloticus	3.0	2.5	3.9	0.7	0.6	1.4	7.9	9.1	4.4
Sarotherodon variabilis	1.1	1.0	1.4	0.7	0.5	1.4	0.0	0.0	0.0
Schilbe mystus	0.2	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Synodontis afrofischeri	0.4	0.6	0.5	0.7	1.1	1.4	0.1	0.2	0.1
Synodontis victoriae	0.9	1.5	1.2	0.5	0.3	0.9	0.1	0.2	0.1
Tilapia zillii	0.2	0.2	0.2	0.1	0.2	0.1	0.0	0.0	0.0
Xenoclarias spp.	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Mean total catch in kg/hr	78.1	37.4	100	49.1	23.0	100	177.9	74.7	100
Species diversity	18			10			5		

Table 2: Seasonal catches by numbers of fishes in Lake Victoria Kenyan Part (1978 - 1979).

SPECIES	SEASONS				
	RAINY	%**	DRY	%**	TOTAL
Alestes spp	6	1.1	2	1.0	8
Barbus spp	690	1.4	22	1.0	712
Bagrus docmac	4482	80.1	2170	64.0	6652
Clarias mossambicus	1457	22.0	788	13.0	2145
Labeo victorianus	895	4.0	324	1.0	1219
Lates niloticus	26577	100.0	16122	98.4	42699
Haplochromids*	260316	100	64897	93.4	325213
Mastacembelus frenatus	7	1.0	4	0.0	11
Mormyrus Kannume	115	5.0	1	1.0	116
Sarotherodon esculentus	1	1.0	1	1.0	2
S. leucostictus	12	3	28	2.0	40
S. niloticus	2688	74.7	1049	65.3	3737
S. variabilis	1689	3.6	712	2.0	2401
Protopterus aethiopicus	4	1.0	1	1	5
Schilbe mystus	260	6.1	38	2.0	298
Synodontis afrofischeri	2071	20.1	710	11.0	2781
S. victoriae	2342	23.2	501	12.1	2843
Tilapia zillii	506	7	221	4	727
Xenoclarias spp	46	2.0	0	0.0	46
Engraulicypris argentus	506	9	200	5	706
Total catch	304,570		87,790		392,361
Percent of total catch	77.6		22.4		100
Number of species	20		19		20
Percent of total species	100		95		-

*Haplochromids were treated as one group, because of identification difficulties.

** Bottom trawl percentage frequency of occurrence.

TABLE 3.: Comparisons of mean total catch (Kg/hr) of some fishes between locations caught by trawling in Nyanza gulf of Lake Victoria (1977 - 1981).

SPECIES	Location, mean total catch () and significant lines*							Degrees of Freedom
Bagrus docmac	(1.9)	(3.8)	(6.4)	(16.6)	(16.0)			44
	2	1	6	14	13			
Clarias mossambicus	(0.4)	(0.2)		3.4	1.9	2.6		45
	3	2		14	15	11		
Haplochromids	(1.2)	(0.7)	(1.2)	(6.7)	4.2)	(125.6)		56
	5	2	1	6	3	14		
Sarotherodon niloticus	(1.0)	(1.0)	(1.3)	(2.6)	(4.2)	(8.0)		36
	6	4	1	3	5	12		
Sarotherodon variabilis	(3.1)	(1.6)	(0.3)	(0.4)	(0.2)	(0.7)		32
	10	12	1	3	5	4		
Synodontis afrofischeri	(0.1)	(0.2)	(0.2)	(0.2)	(0.1)	(0.4)	(3.2)	40
	2	4	3	1	2	6	5	
Synodontis victoriae	(0.2)	(0.1)	(0.3)	(0.3)	(0.4)	(4.2)		44
	1	4	3	6	2	15		
Tilapia zillii	(0.1)	(0.3)	(0.4)	(0.4)				46
	3	1	2	10				
Total catch	(31.4)	(34.0)		(47.8)	(96.2)	(64.8)		50
	6	5		12	7	10		

* The location underscored by the same line have been tested and found to be significantly similar at the 5% level, (The student - Newman - Keuls Test) but differing from the next group of localities, underscored by different line.

TABLE 4.: Chi-square in testing the significance of the difference between proportions.

S P E C I E S	df	X^2	Contingency coefficient	P
Lates niloticus vs Sarotherodon niloticus (1)	5	19.71	0.33	*
Bagrus vs Clarias (1)	5	37.82	0.53	*
Labeo sp. vs Schilbe mystus	5	4.5	0.33	n.s
Synodontis spp. vs Sarotherodon variabilis (1)	5	61.36	0.53	*
Lates niloticus vs Sarotherodon niloticus (2)	13	318.11	0.29	**
Bagrus vs Clarias vs Labeo sp. (2)	10	12.81	0.51	n.s
Schilbe vs Synodontis spp. vs Sarotherodon variabilis (2)	10	24.62	0.59	*

(1) Sample tested that of 1977

(2) Sample tested that of 1981

* Tested and found to be significant at P = 0.01

** Tested and found to be significant at P = 0.001

n.s Tested and found to be not significant at P = 0.05.

TABLE 5.: Comparative catch rates in kilograms per hour for 38 mm codend mesh size fished along the same transect at three different locations in Lake Victoria.

Location (depth fished, m)	Homa-Bay ** (4-6)	Homa-Bay (1) * (4-6)	Homa-Bay ** (7-12)	Homa-Bay (1) (2) * (7-12)	Homa point **	Northeast of Madundu point (1) * (11-18)
Codend mesh size (mm)	38	38	38	38	38	38
Time of day (hours)	0800-0900	0800-0900	1700-1800	2245-2345	1115-1215	1115-1215
Haplochromids spp	0.0	150.0	0.0	82.0	0.0	316.0
Tilapia esculenta	0.0	40.0	0.0	0.7	0.0	-
Bagrus docmac	0.8	11.5	0.2	28.0	0.0	136.0
Clarias mossambicus	0.0	9.0	0.0	6.0	0.0	16.0
Protopterus aethiopicus	0.0	10.0	0.0	45.0	0.0	14.5
Synodontis victoriae	0.0	0.4	0.1	0.1	0.0	1.0
Lates niloticus	101.4	1.4	227.2	1.5	689.4	1.3
All except _Haplochromis_	102.2	72.3	227.4	81.3	689.4	168.8

1. All hauls made with the 24 m trawl in Nyanza Gulf, Kenya.
2. Comparisons made during night hours.

* Source: Cordone and Kudhongania, (1972).

** Present research.

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TABLE 6.: Classification of the individual hauls from the 1981 survey.

Individual hauls per stratum

STRATUM I			STRATUM II			STRATUM III	
80	98	24	528		838	710	1046
76	80	80	440	458	210	2100	1456
173	155	266	120	222	176	1100	2010
78	38	84	512	268	356	1101	1209
72	108	56	230	324		1120	1221
334	170	130	118	172	196	1760	1620
54	22	82	172	128		1247	1448
170	76	46	506	116		1144	3121
94	156	20	826	202		11108	1210
58	20	110	460	342		1360	1680
58	132	76	432	710	340	1280	2160
70	56	106	413	118	320	1100	2441
52	86	36	80	1186	236	1421	4588
46	72	62	360	508	288	5744	1260
148	164	94	104	630		1950	2850
44	44	62					
108							
50	62	74	1110	134		1625	1884
74	141	2	318	568		3120	
110	92	150					
34	56	68	204	382			
127	97	75					
	61	89					
$n_1 = 66$			$n_2 = 44$			$n_3 = 33$	
$\bar{Y}_1 = 89.21$			$\bar{Y}_2 = 371.84$			$\bar{Y}_3 = 2127.09$	
$S_1^2 = 3080.29$			$S_2^2 = 65317.39$			$S_3^2 = 3,700,227.9$	

TABLE 7.: Length distributions of Lates niloticus caught in Trawls around Nyanza Gulf of Lake Victoria during the period 1977 - 1979

Area / Season	Dunga Jan - Dec			Kaloka Jan - Dec			Kendu Bay Jan - Dec			Open Water A & B Jan - Dec			Sango Jan - Dec			Usoma Jan - Dec		
Year	1977	1978	1979	1977	1978	1979	1977	1978	1979	1977	1978	1979	1977	1978	1979	1977	1978	1979
Length distribution 5	2	2	123		4	15	1	7	46		12	34	7	5	31		5	24
10	22	156	211	1	99	124	92	577	109	13	164	121	20	168	60	19	282	154
15	20	121	64		110	107	29	269	24	5	54	83	40	100	31	25	120	53
20	37	66	18	5	88	140	29	117	29	3	31	36	42	34	18	48	105	16
25	69	51	24	11	68	103	18	58	31	3	9	36	16	5	17	42	86	17
30	73	23	19	24	41	37	20	11	35	2	9	18	11		7	42	38	19
35	35	16	41	22	30	23	5	4	14	3	6	23	3	3	3	37	30	47
40	35	20	26	18	11	27	5	6	8		8	38	1	2	1	17	28	15
45	13	7	25	11	27	27	1		4		3	52		2	5	19	26	6
50	2	2	29	7	11	25		2	8			47	1	4	3	3	14	3
55	1		12	1	4	15	1	1	4			43		2	6	2	3	8
60	2	1	2	4	1	9	1	1	2			24	1		8	2		
65				2		8	1		1			9	1		4	1		
70						1						2			1	2		
75					1	1						3	1				2	1
80				1		1						2				4		
>85	2		1	1		1						3	1			1		2
Mean weight Sample in kg/hr	17.5	7.1	22.2	15.1	19.1	50.4	6.7	5.7	32.3	0.4	2.3	56.7	3.4	7.3	10.1	24.3	13.6	36.0
Total area covered in Hectare	53.2	87.4	30.4	45.6	81.7	32.3	43.7	87.4	39.9	89.3	178.6	34.2	41.8	81.7	34.2	43.7	87.4	32.3

TABLE 8.: Length distributions of Bagrus docmac caught in Trawls around Nyanza Gulf of Lake Victoria during the period 1977 - 1979.

Area Season		Dunga Jan - Dec			Kaloka Jan - Dec			Rendu Bay Jan - Dec		Open	Open Water A & B Jan - Dec			Sango Jan - Dec			Usoma Jan - Dec		
Year		1977	1978	1979	1977	1978	1979	1977	1978	1979	1977	1978	1979	1977	1978	1979	1977	1978	1979
Length distribution	5			1					2	1							3		
	10	9	29	3	1	14	2	48	53	5	4	19	3	11	51	2	37	28	1
	15	33	24	3	5	13	8	62	62	10	11	23	1	15	39	1	53	28	1
	20	41	31	8	9	23	8	16	45	14	6	33	7	33	32		51	25	2
	25	42	37	7	25	18	13	2	43	5	23	29	9	15	29	3	42	17	
	30	33	50	9	16	16	2	7	43	9	13	63	12	14	21	6	35	8	2
	35	28	39	5	12	17	4	2	35	3	24	58	7	16	15	6	27	3	3
	40	23	16	7	8	13	2	5	23	3	20	46	17	14	20	7	21	4	2
	45	33	26	5	2	6		6	9	3	17	25	8	8	7		19	3	1
	50	27	5	2	5	2		4	3	2	12	21	4	4	4	1	8	1	
	55	2			2				1			2	1	1	1		2	1	
	60							1					1						
	65				1												1		
Mean weight Sample in Kg/hr		16.8	7.9	5.6	3.8	3.3	1.5	4.6	6.3	2.9	6.8	8.3	7.6	6.4	4.9	2.8	1.9	2.1	1.5
Total Area covered in Hectare		53.3	87.4	30.4	45.6	81.7	32.3	43.7	87.4	39.9	89.3	178.6	34.2	41.8	81.7	34.2	43.7	87.4	32.3

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TABLE 9: Length distributions of <u>Clarias mossambicus</u> caught in Trawls around Nyanza Gulf of Lake Victoria during the period 1977 - 1979.

Area Season	Dunga Jan - Dec			Kaloka Jan - Dec			Kendu Bay Jan - Dec			Open Water A & B Jan - Dec			Sango Jan - Dec			Usoma Jan - Dec		
Year	1977	1978	1979	1977	1978	1979	1977	1978	1979	1977	1978	1979	1977	1978	1979	1977	1978	1979
Length Distribution 5																		
10	1			2												2		
15	3	1		3			5			1			8	1		27		
20	6	2		11			19	2		14			33	3		25	1	
25	4	7		15	2		25	9		31	1		51	4		15	1	
30	4	3		8			30	13		26	12		45	18		19	4	
35	7	4		4	2		19	21		22	1	1	30	28	1	13	3	2
40	8	5		8	3	1	8	16		11	10		24	48	2	9	8	
45	11	2		6	2			9		5	12	3	4	38	2	9	2	3
50	1			2	2		1	7	1	2	11		2	14	4	11	1	
55	3			2		4		1	1	3	7			5	4	5	3	
60	1				1						1			3	1	6	1	
65								1			1			1		1	1	
70										1			1	1		1		
75					1											1		
80																		
≥85					1													
Mean weight Sample in Kg/hr	1.4	1.1		2.6	1.6	0.2	3.6	1.9	1.1	2.3	1.1	0.9	5.2	4.3	3.4	1.2	0.8	1.6
Total Area Covered in Hectare	53.2	87.4	30.4	45.6	81.7	32.3	43.7	87.4	39.9	89.3	178.6	34.2	41.8	81.7	34.2	43.7	87.4	32.3

TABLE 10: Length distribution of Sarotherodon niloticus caught in Trawls around Nyanza Gulf of Lake Victoria during the period 1977 - 1979.

Area Season		Dunga Jan - Dec			Kaloka Jan - Dec			Kendu Bay Jan - Dec			Open Water A & B Jan - Dec			Sango Jan - Dec			Usoma Jan - Dec		
Year		1977	1978	1979	1977	1978	1979	1977	1978	1979	1977	1978	1979	1977	1978	1979	1977	1978	1979
Length distribution	5	2				14	8		3					5				5	
	10	65	10		4	35	54	84	8	1	1	1	1	15	2		134	22	1
	15	36	4	1	2	6	23	74	13	2		1	1	18	1		161	28	
	20	22	1	4	1	1		15	8	1				11	3	1	120	10	3
	25	12			2	1	3	4						5	4	2	71	1	
	30	2			2			2	2					2		3	41		
	35	3			1			1			4				1		22		
	40	5			2				2		1				3		19		
	45	2			1			5			1				1		6		
Mean weight Sample in Kg/hr		2.6	0.4		1.3	0.8	1.3	4.2	1.0	1.8	1.0	1.0	0.9	1.0	1.0	0.3	8.0	0.9	0.1
Total Area covered in Hectare		53.2	87.4	30.4	45.6	81.7	32.3	43.7	87.4	39.9	89.3	178.6	34.2	41.8	81.7	34.2	43.7	87.4	32.3

TABLE 11: Length distribution of Tilapia zillii caught in Trawls around Nyanza Gulf of Lake Victoria during the period 1977 - 1979.

Area Season		Dunga Jan - Dec			Kaloka Jan - Dec			Kendu Bay Jan - Dec			Open Water A & B Jan - Dec			Sango Jan - Dec			Usoma Jan - Dec		
Year		1977	1978	1979	1977	1978	1979	1977	1978	1979	1977	1978	1979	1977	1978	1979	1977	1978	1979
Length Distribution	5					1	19			2						2			
	10			1	1	5	48	1	1	2					2	3			
	15		1		2	8	23	1	2						2	2		1	
	20					2	4								1	1		1	
	25															1			
Mean weight Sample in Kg/hr		0.2				0.2	0.5	0.1	0.1					0.7	0.1	0.1	0.1	0.1	0.3
Total Area covered in Hectare		53.2	87.4	30.4	45.6	81.7	32.3	43.7	87.4	39.9				41.8	81.7	34.2	43.7	87.4	32.3

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TABLE 12: Length distribution of Sarotherodon variabilis caught in Trawls around Nyanza Gulf of Lake Victoria during the period 1977 - 1979.

Area Season	Dunga Jan - Dec			Kaloka Jan - Dec			Kendu Bay Jan - Dec			Open Water A & B Jan - Dec			Sango Jan - Dec			Usoma Jan - Dec		
Year	1977	1978	1979	1977	1978	1979	1977	1978	1979	1977	1978	1979	1977	1978	1979	1977	1978	1979
Length Distribution 5																		
10		25	14		13	5		1						4			2	2
15		54	28		43	10		1			1	4		3			14	1
20		25	18		39	16		3	1		6	4		4			15	3
25		1	1		6			1				1					4	1
Mean weight Sample in Kg/hr	3.1	1.6	1.0	1.0	1.5	1.6	0.1	0.6	0.2	0.3	0.2	0.7	0.4	0.2	0.3	1.4	0.6	0.4
Total Area covered in Hectare	53.2	87.4	30.4	45.6	81.7	32.3	43.7	87.4	39.9	89.3	178.6	34.2	41.8	81.7	34.2	43.7	87.4	32.3

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TABLE 13: Comparisons of mean total length (cm) of some fishes caught by trawling between locations in Lake Victoria Kenyan Part, 1977 - 1981.

S P E C I E S	Location, mean total length () and significance lines *					Degrees of Freedom
Bagrus docmac	Luanda Naya (29.5) ±6.5	Mirunda Bay (30.6) ±5	Main Lake (26.9) ±	Homa-Bay (34.5) ±5.6	Mbita (30.5) ±4.1	10
Clarias mossambicus	Asembo Bay (39.9) ±9.1	Main Lake (39.8) ±7.1	Mbita (37.5) ±9.9	Mirunda Bay (38.6) ±8.9	Luanda Naya (41.5) ±10.1	16
Lates niloticus	Asembo Bay (31.4) ±27.2	Mirunda Bay (36.0) ±29.1	Usoma (44.4) ±34.6	Homa Point (75.2) ±26.8	Luanda Naya (80.1) ±19.3	10
Sarotherodon niloticus	Asembo Bay (16.5) ±7.8	Kaloka (21.8) ±5.6	Kendu Bay (24.1) ±4.0	Mirunda Bay (30.1) ±10.1	Luanda Naya (36.9) ±11.3	22
Sarotherodon variabilis	Luanda Naya (22.6) ±3.6	Mirunda Bay (23.4) ±4.0	Mbita (21.5) ±2.0	Kendu Bay (19.2) ±3.8	Kaloka (19.3) +4.0	24
Tilapia zillii	Mbita (15.7) ±3.1	Asembo Bay (13.8) ±4.6	Luanda Naya (16.0) ±3	Mirunda Bay (17.8) ±4.1		

* The location not underscored by the same line are significantly different at the 5% level. (Contingency table tests).

THE CURRENT SITUATION ON WATER QUALITY AND POLLUTION PROBLEM IN TANZANIA

BY

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INTRODUCTION:

A water body is a dynamic system which invariably absorbs a range of solids, liquids and gases, both natural and man-made. In addition, natural waters usually team with living organisms which can radically affect the course of events in that particular water system. All of these substances animate and inanimate, may flow, disperse, and interact physically and chemically, before they reach a sink, such as a lake or ocean; or before they reach receptors such as aquatic fauna or flora. Enroute from source to receptor, these substances may assume a variety of physical and chemical forms.

Water as H_2O is a chemical compound of unvarying composition. Consequently, natural waters are never pure. A water is regarded as impure or polluted, by one or more substances, if it is found to be unsuitable for its intended use e.g. for domestic, industrial or agricultural use; or for propagation of aquatic animals and wildlife; or for reaction and other miscellaneous purposes. Pollutants of air and soil invariably pollute waters by being carried by rains and washed into rivers, lakes and oceans.

Pollution is generally associated with heavy industrialisation and dense population. Thus all those ghastly pollutants in domestic and industrial effluents whose most favourite disposal routes are sewers, ultimately end up in streams, rivers and thence to lakes and oceons. Pesticides applied on crops, or unwanted chemicals or wastes buried in the ground often get washed off, flushed and transported by waters to water bodies.

The principal pathways for polluting substances to reach a water body are :-

(a) Discharge into the aquatic environment of domestic sewage which contain pathogens and so cause bacterial pollution and its deadly waterborne diseases such as cholera and typhoid.

(b) Discharge into the aquatic environment of industrial effluents which contain heavy metals and other toxic chemicals which affect man if he uses the water directly or eats aquatic plants or animals (food chains) which have absorbed and even concentrated these chemical pollutants.

(c) Accumulation of organic pollutants or wastes or certain nutritive salts or ions, which deoxygenate the aquatic environment and so cause gross eutrophication and build up of reducing compounds such as methane, ammonia and hydrogen sulphide - processes which kill off certain organisms living below the oxygenated surface water layer.

(d) Accumulation of other localised pollutants such as petroleum oils and their products, and hot waters from power plants.

(e) Pollution of waters and food chains there-in, by direct entry, run offs or streaming of pesticides used in the many control programmes against human and endemic diseases, as well as against agricultural pests.

Almost all these pollutants, be they chemical or micro-biological, have devastating effects on human health and on lives of other organisms living in or depending on aquatic environments. For a long time, it was assumed that Africa was safe from this modern-day ill. But, infact the more under-developed a country is, the more vulnerable it is to the harzadous effects of these pollutants. This calls for preventive measures to avert such portending dangers. But which measures, against which of the hundreds possible pollutants, responsible for which harzadous effects? The answers needed for these questions are subtle rather than simple, and scientific rather than political.

The answer is constant monitoring and assessing of the aquatic environment. This concept holds that no one can manage, modify, or repair anything, or indeed fight any enemy, unless one has a through understanding of the enemy. This fundamental datum of experience applies to clocks, engines and environments. The aim of monitoring water or any other environment is to be able to detect trends, predict events and to provide decision makers with sound information upon which to base environmental action plans.

Ideally, assessment begins with a preliminary examination of the problem, i.e., what precisely is it ? What are its priorities? What knowledge is presently available on the subject? This invariably leads to an enquiry into cause and effect, followed by prepounding a hypothesis, and instigative research into the processes which may be causing the problem, followed by monitoring, so as to keep track of the processes as they are identified. As information is gathered, a synthesis of knowledge about the problem becomes possible. With this knowledge, one can determine the scale and nature of the problem and predictives made of future trends, and of corrective action available to decision makers. Finally, corrective action too will have to be monitored, and its effects assessed.

The problem may be neurological or even carcinagenic effects caused by high levels of organochlorine compounds such as DDT, PCBs, etc. in water; or skeletal deformation caused by excessive fluoride; or dental cavities caused by total defficiency of fluoride; or methaemoglobinaemia caused by excessive nitrate, in water, etc. The monitoring tool for the water; or the monitoring tool for the organism living therein, or for man who suffers from ingesting the polluted water, is an analytical laboratory.

It is an open secret that Africa has too few analytical facilities to perform the indispensable job of monitoring our aquatic environment. Consequently, there are too many gaps in our knowledge of the pollution state of African waters. As such, it is very difficult for most African countries today to evolve a plausible action plan to protect and manage their aquatic environments before filling in these gaps. Workshops such as this offer good opportunities to exchange valuable information with which to fill such gaps. This paper outlines a few pieces of information known in Tanzania, about the Lake Victoria basin.

SOME FACTS ABOUT LAKE VICTORIA:

Lake Victoria is a vast shallow depression with a surface area of 69,000 sq. km situated between the two big rifts of equatorial Africa at an altitude of 1,140 m. It was formed through the uplifting of the rifts during the miocene period of the tertiary era. The maximum depth is 80 m and the average depth 40m. The open water is bounded, especially along the southern, north-western and northern shores by large and shallow swampy bays which occupy a high portion of the total area and are ecologically different from the open water.

The main input of water is direct rainfall. The largest single in flow is from Kagera River on the western side which accounts for approximately 40% of the total average annual inflow. Most of the remaining inflow comes from the eastern side, from rivers originating in the Kenyan Highlands. These account for about 44% of the average annual inflow. The contribution from the northern and southern shore catchments is estimated to be in the order of 5.2% and 3.6% of the total inflow. The River Nile is the only discharge. The mean annual water balance for the period 1925 - 1959 has been estimated at :-

rainfall	1,630
Inflow	259.5
Evaporation	1,583.5
Outflow	306

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Lake Victoria has a normal seasonal level rise and fall of 0.2 - 0.4 m. An unprecedented rise in level occured in 1961 to 1964 due to a climatic fluctuation which developed large areas of peripheral flooded lowlands.

Contrary to the great deep lakes of Africa Lake Victoria is not stratified to a significant extent. Due to its shallowness and form it is affectively stirred down to the bottom by winds most of the year. By this the water at the bottom is mostly well oxygenated and the nutrients, which are released by decomposition of dead organic material at the bottom, are also well distributed in the water mass most of the time.

The natural inflows provide the main ultimate source of nutrients upon which the biological production of the lake depends. The most important immediate source of nutrients is through recycling of the products of decomposition.

The photosynthetic production in the lake is high and provides rich food for the fish. The shallow inshore waters in particular as very productive, and have so far provided the most profitable fishing grounds. Fishing is a major activity along the shores of Lake Victoria. In the three Tanzania lake regions about 18,000 fishermen have been recorded during recent years. The total annual recorded catch was 60,000 tons in the late sixties but has gone down to about 40,000 tons during the last decade. It is not known whether this drop in the fish catch is the result of pollution or whether it is due to over-exploitation of the most popular fish species, or some other cause(s).

Other than fishing, the lake is used as a source for domestic water supply. The Tanzanian urban areas along the shores take most of their domestic water from the lake.

THE POPULATION OF THE LAKE VICTORIA BASIN

The population of the three Lake Victoria regional capitals, Mwanza, Bukoba and Musoma is about 215,000, while that of the Lake Victoria basin rural areas is 670,000. It has been estimated that this population will have grown to about 1.9 million people in the year 2000, of which approximately 820,000 will be confined to the urban areas of Mwanza, Bukoba and Musoma only. Assuming that half of the total lake population live in Tanzania this would mean that roughly 2 million people at present live in the areas around the lake. Assuming that the population in Kenya and Uganda portions of Lake Victoria basin would increase by the same proportion estimated for Tanzania, the Lake Victoria basin population would total up to 4 million in the year 2000.

EXISTING AND PROJECTED INDUSTRIES OF THE LAKE VICTORIA BASIN

The majority of industries and/or pollution sources in the Lake Victoria basin are confined to the major towns indicated below :-

MWANZA	MUSOMA	BUKOBA
(a) Existing*		
Soap	Dairy	Coffee
Tannery	Textile	Sugar
Starch	Domestic Sewage	Domestic Sewage
Textile		
Domestic Sewage		
Fish & Fish Products		
Vegetable Oils.		

*Most of these industries now have facilities for treatment of their effluents before discharging them into the lake or streams. Residual run-offs of pesticides widely used surrounding cotton and coffee growing areas near the lake. It seems to affect the whole Lake Victoria Basin.

(b) Projected**

Grarments	Textile(phase 11)	Banana processing
Breweries		Oil Mills
Glass		Dairy products
Starch		Tannery
Blended waste		Coffee roasting
Hedge sisal		meat processing
Paper & Package		Beers and soft drinks.
Agricultural Implements		
Pharmaceuticals		
Steel rolling mills.		

**All proposed industries have provisions for effluent treatment and proper Environmental Impact Assessment studies for them have to be carried out before their establishment is sanctioned by the environmental protection and Management Unit.

WATER QUALITY

Although data is still scanty, it appears that the bulk of the open lake water is unpolluted (see Appendix 1). Pollution is localised and confined to discharge points of domestic sewage and industrial effluents. Some small scale industries like garages which dump oil residues and vehicle washings into the lake, or chemical efforts to control vectors of bilharzia in these areas and to the pollution of the waters of the Lake Victoria Basin.

Although North Mwanza port and Bukoba port are the only sampling points in Lake Victoria used in GEMS programme since 1979, plans are under way for major laboratories in Tanzania to collaborate in a project to monitor in greater details the waters of Lake Victoria basin and other aquatic environments.

EVIDENCE OF POLLUTION

Investigations carried out recently on one or two fish oil samples showed appreciable amounts of DDT and its metabolites e.g. DDE, Endosulfan, dieldrin, Lindane metapolites and other yet unidentified pesticides. Traces of similar pesticides have been detected in equally few and unrepresentative samples of the Lake Victoria waters. No heavy metals have been detected in these samples of Lake Victoria basin waters or its biota. This is likely to be due to the too few and unrepresentative nature of the samples. Consequently, there is a great and urgent need to take and analyse more samples and to gather baseline data on the exact pollution status of the Lake Victoria basin.

POLLUTION CONTROL IN TANZANIA

From the legal point of view, the main instrument is the Water Utilisation (control and Regulation) Act, 1974 and its Amendment which incorporates the Standards for Effluents and Receiving Waters (Appendix 2.1 and 2.2) Other laws include the Public Health Act, the Fisheries (General) Regulation, 1973 made under the Fisheries Act, 1970 as well as Township, Local Government Rules, The Marine and Port Act, all of which forbid the pollution of any water likely to affect human health or fish.

Different Ministries are responsible for each of the above mentioned laws, and none of the Ministry has the resources available at present to monitor the effluents or the receiving water, or even to check that the effluent treatment plants or facilities when they exist, are operating efficiently, or that the effluent and receiving water standards set are complied with satisfactorily.

RECOMMENDATIONS

(a) Develop close cooperation between Tanzania, Uganda Kenya, Ruanda and Burundi regarding the protection and management of the Lake Victoria and its resources, as well as with other countries for the protection of

Other national and international water resources.

(b) Exchange regular information and encourage consultations between these three countries surrounding Lake Victoria, on all major activities which may affect the waters of the lakes and their basins.

(c) Synchronise monitoring programmes of the three countries by forming an Advisory Committee comprising one or two major monitoring laboratories of each country, to chart the pollution state of the lakes and their basins all the time, and advise governments on appropriate remedial measures they should take.

(d) Strengthen the national laboratories and coordinate their monitoring programmes so as to feed the Advisory Committee with the baseline data on which to base environmental action plans.

(e) Introduce intra and inter-laboratory quality assurance schemes so as to generate reliable data.

(f) Study the rates of accumulation of various pollutants in various aquatic environments and organisms.

(g) Study the toxicity of different pesticides and other pollutants and evaluate their impact on certain characteristic aquatic organisms under tropical conditions.

(h) Study the persistence of pollution and their speed of decomposition in these organisms.

(i) Identify indicator organisms which have high or low sensitivity to the effects of these pollutants.

(j) Establish models of biological equilibrium for receiving waters.

(k) Prepare and regularly review an invetory of laboratories which have the capability to perform some or all of the water and waste water analytical tests. For purposes of this recommendation as well as recommendations c,d, and e, we outline some of the laboratories in Tanzania which are capable of carrying out water analyses and their limitations (Appendix 3).

(l) Donor countries should assist these laboratories by providing them with some of the missing items.

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(m) Conduct more and more national and inter-fernforial workshops to train more and more analysts and technicians in monitoring work as well as interpretation of analytical data.

APPENDIX 1 - A - ANALYSIS OF THE SAMPLES OF SOME RAW EFFLUENTS OF SOME INDUSTRIES IN MWANZA

Date of Collection	Source/ Site	Date of Report	PH	Alkalinity PPM	Cond Micromhogen	N/NH_3	N/NO_2	N/NO_3	Permanganate Value CID Min boiling)
14.11.79	Lake -	17.12.79	7.9	-	-	0.3	-	-	3.0
"	Vic.	"	11.5	-	400	0.12	-	-	150
"	Sewage Voil	"	13.2	100,000	200,000	-	-	-	1180
"	2nd/Sewage Mwater/	"	13.4	-	5,500	-	0.26	-	140
"	Sewage Pond	"	9.2	-	500	4.2	-	2.4	16
"	Influent Pond	"	8.9	-	650	18.5	-	0.04	40
1980 "	effluent Lake Soap	12.2.80	12.2	-	25,000	-	-	-	560
1980	2nd/Sewage Voil 2nd/ Sewage	"	6.5	-	500	-	-	-	190

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APPENDIX 1 - A

B.O.D.	Total Dissolved Solids	Total Suspended Solids	E.Oli
-	80	10	828
270	320	180	-
Could not be done	-	-	-
181	2170	110	-
11	260	20	72,800
35	360	50	4,200
-	-	-	-
-	-	-	-

APPENDIX 1 'B'

Analysis of the samples of water of Lake Victoria under the GEMS Project (MWANZA NORTH PORT SAMBLING POINT)

Date of Sampling	Site	Tem °C	PH	Condunivity	D.O.	Chloride
22.3.80	North Post	26	7.3	107	5.6	6.0
2.5.80	"	26	7.2	95	8.0	5.0
2.6.80	"	24	7.1	100	6.9	8.5
1.8.80	"	24	7.2	110	8.4	7.0
2.9.80	"	24	7.0	100	8.4	8.0
2.10.80	"	25	7.4	170	8.4	10.0

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Continued..........

Alkalinity	Nitrogen NH_3	Nitrogen NO + NO3	Phosphorous Soluble reactiveas P/mg/L			
46	Not done	Not done	Not done	-	-	-
56	0.3	0.28	0.01	-	-	-
24	0.28	0.15	0.03	-	-	-
48	N.d	N.d	0.02	-	-	-
20	N.d	N.d	0.46	-	-	-
52	N.d	N.d	N.d	-	-	-

N.d. = not detected, possibly because of the lapse of time between sampling and analysis.

APPENDIX 2.1 TEMPORARY STANDARDS FOR RECEIVING WATERS

Category 1: Water suitable for drinking water supplies, swimming pools, feed and beverage industries, permaceutical industries requiring a water source of comparable quality.

Category 2: Water to be suitable for use in feeding domestic animals; in fisheries, shell-cultures, recreation and water contact sports.

Category 3: water suitable for irrigation and for industrial activities requiring water which does not have to meet the standards of category 1 or 2.

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Substances Characteristic	Unit	Maximum permissible concentration Category 1 Category 2 Category 3		
A2.1.1 General				
A2.1.1.1 Suspended matter (Turbidity)	mg/l (as SiO_2)	discharge of effluents shall not cause formation of sludge or scum in the receiving water.		
A2.1.1.2 Colour	number (Pt-co Scale)	discharge of effluents shall not cause any change in the natural colour of the receiving water		
A2.1.1.3 Taste and Odour	-	discharge of effluents shall not cause any change in the natural taste or odour of the receiving water		
A2.1.1.4 Temperature	^{o}C	discharge of effluents shall not raise the temperature of the receiving water by more than $5^{0}C$		
A2.1.1.5 Total dissolved solids	mg/l	2,000	2,000	No Limit
A2.1.1.6 pH	-	6.5-8.5	6.5 6.5 8.5	6.5-9.0
A2.1.1.7 Dissolved oxygen	mg/l	6	5	3
A2.1.1.8 Oxygen solution	%	80	60	40
A2.1.1.9 B.O.D.- 5 days $20^{o}C$	mg/l	5	5	10
- 5 days $25^{o}C$	mg/l	6	6	11
- 5 days $30^{o}C$	mg/l	6	6	12
- 5 days $35^{o}C$	mg/l	7	7	13
A2.1.1.1 Permanganate Value	mg/l	20	20	30
A2.1.2 Inorganic Substances	mg/l			
A2.1.2.1 Aluminium (Al)	mg/l	0.3	0.3	0.5
A2.1.2.2 Arsenic (As)	mg/l	0.5	0.1	0.1
A2.1.2.3 Barium (Ba)	mg	1.0	1.0	1.5
A2.1.2.4 Boron (B)	mg/l	1.5	1.5	1.5

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Substances Characteristic	Unit	Maximum permissible concentration Category 1	Category 2	Category 3
A2.1.2.5 Cadmium (Cd)	mg/1	0.05	0.1	0.2
A2.1.2.6 Chromium 111 (Cr^{3+})	mg/1	0.1	0.3	0.5
A2.1.2.7 Chromium V1 (Cr^{6+})	mg/1	0.05	0.1	0.1
A2.1.2.8 Cob-lt (Co)	mg/1	0.1	0.1	0.5
A2.1.2.9 Copper (Cu)	mg/1	3.0	3.0	4.0
A2.1.2.10 Iron (Fe)	mg/1	0.1	1.2	1.5
A2.1.2.11 Lead (Pb)	mg/1	0.1	0.1	0.2
A2.1.2.12 M-ganise (Mn)	mg/1	0.5	0.8	0.8
A2.1.2.13 Mercury (Hg)	mg/1	0.001	0.001	0.005
A2.1.2.15 Selemium (Sw)	mg/1	0.5	0.5	0.1
A2.1.2.14 Nickel (Ni)	mg/1	0.5	0.5	0.1
A2.1.2.16 Silver (Ag)	mg/1	0.05	0.05	0.05
A2.1.2.17 Tin (Sn)	mg/1	0.5	0.5	0.1
A2.1.2.18 Vanadium (V)	mg/1	0.005	0.005	0.01
A2.1.2.19 Sinc (Zn)	mg/1	0.2	0.2	1.0
A2.1.2.20 Ammonia + Ammonium (NH_3NH_4)	mg/1	0.5	0.5	2.0
A2.1.2.21 Chlorides (Cl^-)	mg/1	200	200	400
A2.1.2.22 Flourides (F^-)	mg/1	8.0	8.0	8.0
A2.1.2.23 Cyanides (CN^-)	mg/1	0.05	0.05	0.1
A2.1.2.24 Nitrates (NO_3-)	mg/1	50	50	50
A2.1.2.25 Nitrates (NO_2)	mg/1	as low as is required to prevent eutrophication or excessive weed growth if nitrogen is a limiting nutrient.		
A2.1.2.26 Phosphates (PO_4^{--})	mg/1	In waters which are susceptible to eutrophication or excessive weed growth or in rivers and streams draining into such waters, the lowest possible concentration should be aimed as if phosphorus is a limiting nutrient.		

Appendix 2.1 continued

Substances Characteristic	Unit	Maximum permissible concentration Category 1	Category 2	Cater 3
A2.1.2.27 Sulphates (SO_4^{--})	mg/l	600	600	600
A2.1.2.28 Sulphides (S^{--})	mg/l	0.01	0.00	0.1
A2.1.3.1 <u>Organic Substances</u>	mg/l	0.5	0.1	0.1
A2.1.3.1 Alkyl Benzene Sulphonates (ABS)	mg/l	0.5	0.1	0.1
A2.1.3.2 Aromatic and aliphatic hydrocarbons	mg/l	0.05	0.05	0.1
A2.1.3.3 Aromatic nitrogen containing compounds (eg aromatic amines)	mg/l	0.01	0.01	0.1
A2.1.3.4 Chloroform extract CE)	mg/l	0.5	0.5	0.1
A2.1.3.5 Formaldehyde	mg/l	0.2	0.2	0.5
A2.1.3.6 Grease & Oils (petroleum ether extract)	mg/l	0.5	1.0	5.0
A2.1.3.7 Non-volatile chlorinated compounds	mg/l	0.005	0.005	0.01
A2.1.3.8 Volatile chlorinated hydrocarbons (Cl)	mg/l	0.005	0.005	0.01
A2.1.3.9 Organochlorine pesticides (CL)	mg/l	0.0005	0.0005	0.001
A2.1.3.10 Other Pesticides	mg/l	0.001	0.001	0.005
A2.1.3.11 Phenols	mg/l	0.002	0.002	0.1
A2.1.3.12 Resins, tar etc.	mg/l	0.1	0.1	0.5

Appendix 2

Appendix 2.2. TEMPORARY STANDARD FOR EFFLUENTS

Substance/ Characteristic	Unit	Maximum permissible value: Effluents meant for direct discharge into receiving waters	Maximum permissible value: Trade & Industrial effluents meant for indirect discharge into receiving waters, e.g. via a municipal sewage treatment plant
A2.2.1 General A2.2.1.1 Suspended solids	mg/l	Not to cause formation of sludge or scum in the receiving water	No limit
A2.2.1.2 Colour	Number (Pt-Co)	Not to cause any change in the natural colour of the receiving water	100
A2.2.1.3 Taste & Odour	-	not to cause any change in the natural taste or ordour of the receiving water	No limit
A2.2.1.4 Temperature	°C	not to cause any increase of the receiving water by more than 5°C	35°C or not more than 5°C above ambient temperature of the supplied water, whichever is greater
2.2.1.5 Total dissolved solids	mg/l	3000; No resrictions for discharge into the sea	7,500
2.2.1.6 pH	-	6.5 - 8.5	
2.2.1.7 B.O.D. 5 days, 20°C	mg/l	30	No limit
B.O.D. 5 days 25°C	mg/l	34	"
B.O.D. 5 days 30°C	mg/l	37	"
B.O.D. 5 days 35°C	mg/l	40	No limit
			"
1.8 Permanganate value	mg/l	80	"

APPENDIX 2.2 CONTINUED

Substance/Characteristic	Unit	Maximum permissible value: Effluents meant for direct discharge into receiving waters	Maximum permissible value: Trade & Industrial effluents meant for indirect discharge into receiving water i.e. via a municipal sewage treatment plant
2.	INORGANIC	SUBSTANCES	
A2.2.1 Aluminium (AI)	mg/l	2.0	5.0
A2.2.2 Arsenic (as)	mg/l	0.1	0.1
A2.2.3 Barium (Ba)	mg/l	1.5	3.0
A2.2.4 Cadmium (Cd)	mg/l	0.1	0.1
A2.2.5 Chronium-111 (Cr)	mg/l	0.1	2.0
A2.2.6 Chromium-V1 (Cr)	mg/l	0.1	0.2
A2.2.2.7 Cobalt (Co)	mg/l	1.0	1.0
A2.2.2.8 Copper (Cu)	mg/l	0.1	1.0
A2.2.2.9 Iron (Fe)	mg/l	3.0	5.0
A2.2.2.10 Lead (pb)	mg/l	0.2	0.2
A2.2.2.11 Managanese (Mn)	mg/l	3.0	5.0
A2.2.2.12 Mercury (Hg)	mg/l	0.005	0.005
A2.2.2.13 Nickel (Ni)	mg/l	0.5	0.5
A2.2.2.14 Selenium (Se)	mg/l	0.5	1.0
A2.2.2.15 Silver (Ag)	mg/l	0.1	0.1
A2.2.2.16 Tin (Sn)	mg/l	2.0	2.0
A2.2.2.17 Vanadium (V)	mg/l	1.0	1.0
A2.2.2.18 Zinc (Zn)	mg/l	1.0	1.0
A2.2.2.19 Ammonia + Ammonium (NH_3 + NH_4)	mg/l	10	no limit
A2.2.2.20 Chlorides (Cl)	mg/l	800	800
A2.2.2.21 Free Chlorine (Cl2)	mg/l	1.0	5.0
A2.2.2.22 Cyanides (CN-)	mg/l	0.1	0.2
A2.2.2.23 Nitrates (NO_3-)	mg/l	50	80
A2.2.2.24 Nitrites (NO_2-)	mg/l	1.0	10
A2.2.2.25 Phosphates (PO_4--)	mg/l	6.0	45
A2.2.2.26 Sulphates(SO_4--)	mg/l	600	600
A2.2.2.27 Sulfides (S^{--})	mg/l	0.5	1.0

Appendix 2

Appendix 2 continued

Substance/Characteristic	Unit	Maximum permissible value: Effluents meant for direct discharge into receiving waters	Maximum permissible value: Trade & Industrial effluents meant for indirect discharge into receiving water i.e. via a municipal sewage treatment plant.
A2.2.3 ORGANIC SUBSTANCES			
A2.2.3.1 Alkyl benzeyl Sulfouate(ABS)	mg/l	2.0	5.0
A2.2.3.2 Aromatic and aliphtic hydrocabons	mg/l	1.0	5.0
A2.2.3.3 Aromatic nitrogen containing compounds (e.g. aromatic amines)	mg/l	0.05	0.05
A2.2.3.4 Chloroform Extract (9CE)	mg/l	5.0	1.0
A2.2.3.5 Formaldehyde	mg/l	1.0	1.0
A2.2.3.6 Grease and oils (petroleum either extract)	mg/l	5	2.0
A2.2.3.7 Non-Volatile chlorinated compounds (Cl)	mg/l	0.05	0.05
A2.2.3.8 Organachlorine pesticides (a)	mg/l	0.005	0.005
A2.2.3.9 Other Pesticides	mg/l	0.01	0.01
A2.2.3.10 phenols	mg/l	0.2	1.0
A2.2.3.11 Resins, tar, etc	mg/l	2.0	5.0
A2.2.3.12 Volatile ch chlorinated hydrocabons (Cl)	mg/l	0.05	0.05

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APPENDIX 3

THE TANZANIA STANDARDS OF QUALITY OF DOMESTIC WATER

GROUP		NO	SUBSTANCE		UNITS	INTERNATIONAL (WHO 1963) ALLOWABLE	TANZANIA STANDARDS FOR RURAL WATERS
TOXIC		1	LEAD	pb	mg/l	0.05	0.1
		2	ARSENIC	AS	"	0.05	0.05
		3	SELENIUM	Se	"	0.01	0.05
		4	CHROMIUM (6+)	Cr	"	0.05	0.05
		5	CYANIDE	CN-	"	0.2	0.2
		66	CADMIUM	Cd	"	0.01	0.05
		7	BARIUM	Ba	"	1.0	1.0
		8	MERCURY	Hg	"	-	-
		9	SILVER	Ag	"	-	-
EFFE-CTING HUMAN HEALTH		1	FLOURIDE	F^-	"	1.5	8.0
		2	NITRATE	NO_3^-	"	30.0	30/100*
SUBSTANCES AFFECTING PORABILITY AND SUITABILITY OF WATER FOR GENERAL DOMESTIC US	ORGANO-LEPTIC	1	COLOUR		mg pt/l	50	50*
		2	TURBIDITY (SiO_2)		mg/l-	25	30*
		3	TASTE		-		UNOBJECTION=ABLE
		4	ODOUR		-		
	SALINITY AND HARDNESS	5	PH		-	6.5-9.2	6.5-9.2*
		66	TOTAL FILTRABLE -0 RESIDUE		mg/l	1500	2000*
		7	TOTAL HARDNESS (Ca Ca_3)		mg/l		600*
		8	CALCIUM	Ca	mg/l	200	300
		9	MAGNESIUM	Mg	"	150	600*
		10	MAGNESIUM+SODIUM	SO_4	"	1000	1000*
		11	SULPHATE	SO_4	"	400	600*
		12	CHLORIDE	Cl	"	600	0.5*
	LESS TOXIC METALS	13	IRON	Fe	"	1.0	1.0
		14	MANGANESE	Mn	"	0.5	0.5
		15	COPPER	Cu	"	1.5	3.0
		16	ZINC	Zn	"	15	15
	ORGANIC POLLUTION OF NATURAL ORIGIN	17	BOD (5 days, at 65° F)		$mg^{O}2/l$	6	6.0
		18	PV (OXYGEN ABS. $KMNO_4$)		"	10	20
		19	AMMONIUM (NH_3 NH_4)		mg/l	0.5	2.0
		20	TOTAL NITROGEN (Excludin ding NO_3)		mg/l	0.1	1.0
	ORGANIC POLLUTION INTRODUCED ARTIFICIALLY	21	SURFACTANTS (Alkyl Benzyl sulphonates		mg/l	1.0	2.0
		22	ORGANIC MATTER (As carbon in chloroform extract)		mg/l	0.5	0.5
		23	PHENOLIC SUBSTANCE (As Phenol		mg/l	0.002	0.002

APPENDIX - 3

SOME OF THE TANZANIAN LABORATORIES CAPABLE

OF

PERFORMING WATER AND WASTE WATER ANALYSIS

TOWN/CITY	INSTITUTION	CAPABILITY	SHORTCOMINGS
Dar es Salaam	Government Chemist	Complete water analysis including pesticide analysis and heavy metal analysis	Some accessories and/or spares to some of their equipment; and the shortage of some reagents
Dar es Salaam	University of Dar-es-Salaam, Chemistry Department	-do-	-do-
Dar-es-Salaam	Ministry of Water (Laboratories)	-do-	-do-
Dar es Salaam	Tanzania Food and Nutrition Centre	-do-	-do-
About 10 Regional Centres including Mwanza and Bukoba	Ministry of Water (Laboratories	Some simpler water and effluent analysis including microbiological assays	-do-
Morogoro	University of Dar-es Salaam, Agricultural Faculty	Complete water and effluent analysis	-do-
About 15 Regional Centres	Ministry of Health (Laboratories)	Some simpler water and effluent analysis including micro biological assays	-do-
Dar es Salaam	Tanzania Bureau of Standards	Complete water and effluent analysis	-do-
Arusha	Tropical pesticides Research Institute		

The Government chemist laboratories in Dar es Salaam for example, possesses amongst other equipment the following :-

1. SP 191 Atomic Absorption Spectrophotometer - which can perform heavy metal analysis
2. SP 9-100 Atomic Absorption Spectrophotometer - " " " " " "
3. A.C. Polarograph - " " " " " "

4.	Series 104 Gaschromatograph	- which can perform pesticides analysis
5.	Series 304 "	- " " " " "
6.	Data Control HPLC Gastrophotometer	- " " " " "
7.	SP 1000 I.R. Spectrophotometer	- " " " " "
8.	SP3-100 IR Spectrophotometer	- " " " " "
9.	SP 800 UV/ Spectrophotometer Visible	- which can perform pesticides and colonmetric analysis
10.	SP 8000 Spectrophotometer	- " " " " "
11.	SP8-200 "	- " " " " "

DISCUSSIONS

COMMENTS:

Concerning the discharges: From Bukoba and Mara the most important input is silt, and that is a common denominator for all the three countries. The second are pesticides and fertilizers.

COMMENTS:

Mara, Shinyanga and Kagera areas are part of a physical development plan in the basin area in Tanzania. The purpose is to balance the land use in the area as well as to assess the pace of urbanization.

The exercise is new in Tanzania and has been introduced in Rufiji Basin Development area. A task force has been set for the Rufiji to ensure efficient development planning.

A copy of the plans will be sent to the LBDA for their information, examination and exchange of ideas.

COMMENT:

Pollutants from farming areas especially in cotton areas where organochlorinated pesticides are a critical pollutant that should also be considered as pointed out in the panel discussions.

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DISCUSSIONS Continued.

QUESTION:

How stable are the discharge standards in Tanzania? Secondly in monitoring of suspended matter what is the range of substances examined?

ANSWER:

The standards are now part of the national regulation but no standards are supposed to be static; they are subject to constant reviews and we are constantly looking for criteria and basis where changes might be necessary but the standards are not temporary as such.

Note that initially the standards were set temporarily pending consultation with industries. Then they have now been formally adopted.

On the second question generally we use indicators with broad application. There is no test of suspended matter that is fool-proof.

COMMENT:

Suspended solids will be part of the joint standard setting process for our East African countries. We should look for some broader "Universal" standards applicable in the entire catchment of Lake Victoria.

COMMENT:

Tanzania remains flexible and we could change our standards tomorrow if the colleagues in the Basin Area agree on scientifically superior standards and procedures, for dealing with suspended solids. At least that is the view of the office of the Government Chemist in Tanzania.

DISCUSSIONS Continued

COMMENT:

The nature of suspension is relative. When a stream is agitated there might be suspension may be high while the same materials settle after awhile. Therefore, common standards must apply to a specific situation.

QUESTION:

The first fishmeal plant was in Mwanza. Has any work been done to monitor the effluents from there ?

ANSWER:

We do not have specific report on that even though we know that test samples have been taken from there. We can exchange the information on that with Uganda and Kenya.

QUESTION:

How about monitoring works in diamond mining and smelting areas of Shinyanga ? Any mining has its own side-effect.

ANSWER:

There is no smelting going in Tanzania. But generally we have not started monitoring work on heavy metals including waters of the mining areas.

COMMENTS:

Tanzania used one set of standards as in Appendix 3 for domestic water use in rural areas; in the urban areas we used international standards from the WHO and other supplementary organizations.

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THE AQUATIC ENVIRONMENTAL POLLUTION IN UGANDA - CURRENT STATUS AND CONSERVATION MEASURES

BY

F.W.B. BUGENYI

ABSTRACT

The state of the water quality of the Ugandan major freshwaters (the lakes and rivers) is briefly described, pinpointing to the potential pollution problems. Of the three major divisions of aquatic pollution, Biological, Chemical and Physical; the first two pose a potential danger. Eutrophication from untreated or partly treated sewage, and the gastroenterical epidemic diseases (like cholera, typhoid fever, diarrhoea etc.) caused by the un-hygienic practises of certain portions of the population, are the most serious. This is/ will be followed by the heavy metal pollution (especially from the mining works) and the pesticides and other industrial effluents from the on-coming/on-going industrial activities and agricultural practices.

There is an urgent need to those concerned to collect and compile baseline data and knowledge on these freshwaters. It is also necessary to educate the masses of the dangers of befouling the aquatic environment. It will be necessary too, to try and monitor this environment. Those will be some of the immediate aquatic environmental conservation measures.

1. INTRODUCTION

Aquatic pollution can be defined, as, "the introduction by man, either directly or indirectly, of substances or energy into the aquatic environment, resulting in such deleterious effects which can, harm the living aquatic biota; become harzardous to human health; cause hindrance to water activities, including fishing and sporting; and impair the quality for use of the water."

In Uganda, as elsewhere in the world, water means alot to the populace, so that, however indirect the pollution effect may look, it will finally be the populace to experience the effects.

Aquatic pollution can, for the sake of convenience, be broadly grouped into three divisions: Biological, chemical and physical pollution. There are certain pollutants, however, which fall into either of any two groups above, but most others are quite distinct in their classification.

Uganda's aquatic environment cannot be said to be under great threat of pollution at the moment, at the same time, it has a great potential of pollutants, now that it is trying to develop its industries and its agricultural sector; and because of the growing population and its consequent urbanisation. What is needed most right now, is the baseline knowledge of all possible (present and future) or potential pollutants that can directly or indirectly effect the aquatic biota and human population of Uganda.

It is going to be the Educational institutions (Bugenyi,1978); the Research institutions (Bugenyi, 1977); the various chemical, water and civil Engineering firms and departments; and various Government Research departments which will undertake the duty to avail the baseline knowledge and data concerning their activities and its effects on the freshwater environment and its quality. The present status of the aquatic environment should be obtained from the general limnological surveys of the Lakes and rivers (Fig.1) and compiled.

The possible pollutants should be looked at and studied from a knowledge of the various industrial activities, engineering works, agricultural activities, mining activities and sewage works in municipalities of other countries. In Uganda now, there are many areas which are threatened by disease epidemics to human populations; freshwater "eutrophication" due to nutrient enrichment; various organic and inorganic pollutants from industrial and agricultural activities; civil, water and chemical engineering development projects and many other physical pollution effects (Figs. 1 and 2). In this paper an overview-look at some of the potential pollutants to the Ugandan Aquatic Environment and some conservation measures, is given.

2. PHYSICAL CHEMICAL AND BIOLOGICAL POLLUTION

2.1 Physical pollution:

Physical pollution is one of the three major divisions into which aquatic pollution can conveniently be grouped. It is, however, not a major threat to the Ugandan freshwaters. It is usually caused by the drastic changes from the normal physical conditions, when say, the temperature of the water suddenly rises or when there are present foreign solids objects such as floating islands; fishing nets, warm industrial effluents which raise the temperature of the water. Floating islands have often proved nuisance especially in L. Kioga and the Northern shores of L. Victoria, and especially at the Owens Falls hydroelectric dam on Victoria Nile. These prevent the smooth running of the dam's turbines; prove nuisances to water transport and fishing activities. Temperature rises decrease dissolved O_2, increases metabolic activities of the aquatic organisms and this is likely to result in high Biological Oxygen demand (BOD).

Military wastes (Fig.2) are also grouped in this division in as far as the majority affect the physical conditions of the aquatic environment first. These wastes, however, may consist of solid objects, organic material, biological and chemical warfare agents, heavy metals, petro-chemicals, out-dated explosives, defoliating agents etc- material peculiar to the military establishment. The inclusion of this information should not come as a surprise if one recalls that Uganda has just come out of the 1978-79 war of liberation. The areas most vulnerable to this are the freshwaters adjacent to Kampala city and Jinja town (Fig.1).

2.2 Chemical pollutants

This is the largest group and probably the most hazardous. It is normally sub-divided into the organic and inorganic chemical pollutants. Here lies the greatest potential of pollutants to the Ugandan freshwaters. Work is already going on at the Uganda Freshwater Fisheries Research Organisation, Jinja, on the copper (and other heavy metal) pollution studies in the Lakes George and Edward (Bugenyi, 1979, 1982) and on the pollution effects of the industrial processes in Jinja town, on the Northern shores of Lake Victoria and the upper Victoria Nile (Bugenyi and Mungoma, 1980).

Chemical pollutants can be adequately grouped into two major groups; Inorganic and organic chemical pollutants.

2.2.1. Inorganic chemical pollutants

This group consists of many chemical pollutant potential for this country: Nutrients (NO_3N and $PO_4.p$) and ammonia from detergents in domestic sewage and the agricultural and industrial effluents. The cyanides which spring from industries, like the metal plating plants, gas works and coke ovens, and from scrubbing of steel works. The acids and alkalis from the production plants e.g. sulphuric acid-manufacture plant at Tororo. This could give rise to large quantities of waste acids which could be discharged in the aquatic environment. Sulphur (as sulphite, SO_3) may enter the aquatic environment as a sulphite waste product from such industries as pulp industry and rayon manufacture. The heavy metals (apart from the pesticides) may turn out to be the most threatening pollutants in Uganda as it develops its mining industries; paints, ceramics and glass factories; steel industries, motor vehicle industries, among others. It is from the above industries and from domestic sewage that most aquatic environments get the allochthonous loads of heavy metal concentrations. The heavy metals are particularly dangerous because of their ability to accumulate in the bodies of the aquatic biota and hence their consequent chronic toxicities.

There is an ongoing project of copper pollution on the lakes George and Edward. The copper waste products which find their way into the above water system are from Kilembe copper mines, and it (and other toxic heavy metals, Co and Cd) is carried down to the lakes by the River Nyamwamba. The distribution of copper and cadmium in the waters and the sediments (Table 1) and the concentration of these in the algae has all been studied (Table 2). The phytoplanktonic algae is used as food by some Tilapia fish species. The object is to establish the acute lethal doze of copper to the Tilapis fish species and later to advise on the limit of copper concentration to be let into the water system.

The other potential heavy metal pollutants include, lead and mercury. Lead is from the storage batteries and anti-knock petrol additives (e.g. tetraethyl and tetramethyl lead). Much of this lead is released into the atmosphere of major towns in exhaust fumes and part of this does eventually find its way into the aquatic environment. Mercury is used mainly in the chlor-alkali industry. It is also widely used in agricultural chemicals, pharmaceuticals, electric switches and instrumentation, in dentistry and the dyeing industry etc. Most of this mercury ends up in the domestic sewage system.

Thus the present industrial set-up in Uganda will act as potential sources of heavy metal pollution, especially after full rehabilitation of the industries. It is necessary to have now the baseline data on all the Ugandan freshwaters. An attempt to compile all the past and present Limnological investigations in Uganda since the 1920's has been done (Bugenyi, 1980) from the scattered literature. The present state of the physico - chemical characteristics of the major freshwaters is presented in Table 3. Apart from such factors as geographical differences and the nature of catchment area the differences in these are not due to pollution effects, except in isolated instances.

2.2.2. Organic chemical pollutants

These shall be further subdivided into two groups: the Pesticides and the other organic pollutants such as organic industrial wastes. The pesticides cover a wide range of substances of differing chemical composition and class of target organisms. Apart from a few metal - containing pesticides, most of these are organic chemicals. They are solely used to control the various groups of pests; herbs,

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weeds, insects and fungus diseases. Use is frequently on a fairly large scale, and spraying from the air is a common means of application in most areas. Not all the material sprayed will reach the target area, some being lost to the atmosphere. The tendency is to spray relatively large quantities, a proportion of which will reach the aquatic environment by exchange with the atmosphere, in rain or absorbed on air-bone particulate matter. The areas most vulnerable to pesticide contamination are: the Kigezi Agricultural highlands in the South, the swampy malarial disease areas, the N.E. corner of the Napoleon Gulf in Northern L. Victoria (from the Kakira Sugar farm workr). There has been very little work done on pesticides in Uganda. Sserunjogi (1974) attempted to study the residues of organochlorina insecticides in soils, with particular reference to DDT and, Dieldrin.

The insecticides are made up of organochlorine, organophosphorus and carbamates. The organochlorine compounds: DDT, Dieldrin, Enderin, Aldrin and Endosulfan have been in use all over the world for more than thirty years. They are used either in agricultural or public health pest control.

The organophosphorus group includes inter alia, malathion, parathion and azinphos-methyl. They are more varied in chemical terms than the organochlorines.

The carbamate compounds, based on carbamic acid, are mainly used in agriculture. One form of the carbamate group, the carbaryl (or sevin) may replace DDT in future malaria control operations. A few of the carbamates are also used as herbicides and they might be expected to have minor toxic effects on the aquatic floating plants (the phytoplankton).

The herbicides are a mixed group of compounds most of which are water soluble. They include: Diquat; 2,4-D and 2,4, 5-T. The last named herbicide has proved very toxic and its production and use has been banned in many of the developed countries. This was after many countries reported explosions in the manufacturing plants of that compound, which resulted into the production of the very toxic dioxane gas. 2,4,5-T pesticide has been reported to have been responsible for miscarriages and new-born baby deformities in areas where it has been in use.

The fungicides are a variety of organic mercurial compounds used in agriculture and horticulture for the control of seed-horne and fungal diseases. They have also been used extensively in the past as slimicides in the paper industry. Most of these are strongly absorbed on to soil particles. These find their way into the aquatic environment only in times of floods.

There are also the miscellaneous metal - containing pesticides, e.g. the Bordeaux mixture (a copper salt), lead arsenate and fentin acetate. These compounds have have appreciable solubilities in water and are likely to be transported to the freshwaters by land run-offs and drainage.

2.3 Biological pollution

The most well known and common biological water contamination problem is "Eutrophication". This situation arise from the the "washdown" from watersheds of the lakes and river flood plains enriching the freshwaters with nutrients. Nutrient enrichment can also come from agricultural, industrial, urban sewage and recreational activities of man. This process of nutrient accumulation and its consequences, generally summarised under the term "eutrophication", which primarily means, a rise in the production rate and biomass of primary producers. The increased production rate is due to the increased availability of plant nutrients. Eutrophication often reduce the quality of water for drinking, bathing and domestic uses and deteriorates the suitability of the water for recreation, for the production of human food (fish) and for other human needs.

Two particular areas in Uganda have a potential for eutrophication, mainly from urban sewage, which is often under-purified before letting it into the water. These are adjacent to some portion of the Lake Victoria waters, and these are Port Bell (Luzira), a small port, which is the major outlet of the Kampala City sewerage, and another one is the freshwater environment adjacent to Jinja (Bugenyi and Mungoma, 1980). Then there is yet another not - in - the - near - future potential area, Lake George for which rainfall run-offs from the catchment area could easily cause euntrophication as the agricultural practices intensify.

The main likely future cause of eutrophication for the two areas above could be partly treated domestic sewage. When discharged untreated, this has other ensuing dangers apart from the nutrient enrichment of the receiving waters. This type of domestic sewage has five major characteristics :

(a) a high bacterial content, presence of parasites and possibly virus concentrations, contaminating the water for the aquatic biota (e.g. fish) and limiting the use of bathing areas;

(b) dissolved organic and suspended constituents which give a high BOD;

(c) settling solids (organic and inorganic) depositing on the bottom - the organic component undergoes decay with consequent oxygen depletion;

(d) high nutrient concentrations (mainly P and N compounds) leading to enrichment of receiving waters and potential hypertrophication;

(e) floatables, which may be organic or inorganic materials on the surface or in suspension, constituting a serious amenity problem and interfering with primary production and affecting self purification.

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By reason of these characteristics, sewage affects recreation, utilization of the freshwater food (e.g. fish) public health and general amenities. The production characteristics of the receiving waters may be altered and there is a possible connection with the development of toxic blooms of algae.

In Uganda, this problem will sooner or later become acute. Untreated domestic sewage and stray human faeces from deposits have been washed down the natural water systems. As a result, epidemic bacterial and viral diseases e.g. cholera (Fig 3), diarrhoea and others have hit various areas in Uganda (Figs 1 and 2). Most of these gastroenterical diseases are in areas where community health has not been emphasized, so that the homesteads do not have any pit-latrines, or in the homes of nomadic cattle keepers, without permanent homes.

Other household wastes which enter the municipal sewerage system include detergents and optical brighteners, pharmaceuticals, house and garden pesticides and other chemicals and oily and other discharges from small businesses and garages, may also be important. Another problem area has been in the West Nile along the River Nile where there has often been reported the urinery intestinal [illegible] Bilharziasis (schistosomiasis). This problem, however, had been known elsewhere, to be an invariable feature of irrigation schemes in tropical areas. In streams flowing through reservoirs, shallow shores, downstream areas of dams where the volume of water generally tends to be small and irrigation systems invariably favour the establishment of schistosome - supporting snails. Drinking, swimming in, or bathing in such water, one is liable to contract the disease.

The toxicity and other dangerous effects arising from the biological, physical and chemical potential pollutants are many and varied. It is only through serious individual investigation results of these, that managerial and conservation measures can be based.

3. CONSERVATION MEASURES

In trying to conserve the aquatic environment to maintain the quality of the freshwaters, to restore the quality of the already befouled freshwaters, and to prevent and control the water borne diseases, we should look comprehensively at and study the various pollutants (Fig.4) and take the corresponding immediate measures. Water borne diseases and all other human effects resulting from water pollution come after the pollutants mentioned above have befouled the water. Two major conservation measures can be undertaken:

(a) The control and prevention of diseases, of various pollutants (organic, inorganic, physical and biological) and

(b) making the public aware of the dangers of a contaminated aquatic environment, and generally educating the young through "Environmental science" or more particularly "Environmental chemistry" (Bugenyi, 1978).

3.1 Disease and pollutant control and prevention

Most water pollutants manifest themselves through (directly or indirectly) causing disease to human populace populace. Once this happens, then services of the public health departments are always called for. The approaches employed are therefore therapautic. Specific methods are directed against a pathogenic agent, vector or intermidiate host and these are different for the various diseases. The common attempts at controlling malaria or schistosomiasis use insecticides, molluscicides, mass chemotherapy and mass eradication of snails. Environmental measures have the advantage of being efficient against several diseases at the same time. Thus, the construction and utilization of latrines and of appropriate waste disposal systems protects the environment against contamination, particularly foecal pollution, and at the sametime hinders the transmission of viral and bacterial diseases.

Monitoring of water inputs from the various industrial establishments and the various engineering projects are measures which are always necessary to detect any overload of the inputs which is likely to endanger the quality of the natural water.

3.2 Environmental Science education

Little may be expected from a programme of aquatic environmental conservation without establishing broad contact with the population through mass education in Environmental Science Education, public health education and similar measures. For environmental chemistry education, Bugenyi (1978) proposes an introduction in the curriculum of first of all the University, then the higher schools and so on down to the primary schools.

The immediate need right now, however, is to get the initial baseline data of all the Ugandan freshwaters compiled and the water quality ascertained. This is going to be very valuable later when aquatic pollution problem becomes a reality.

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RESULTS

TABLE 1

WATER AND BOTTOM SURFACE SEDIMENTS DISTRIBUTION OF COPPER AND CADMIUM:

Concs of: 1. Cu 2. Cd		L. George	L. Edward
Surface water	(a)	1. 0.10 ± 0.02	0.015 ± 0.006
		2. 0.006 ± 0.0016	0.0011 ± 0.0004
Mid-depth waters	(a)	1. 0.09 ± 0.01	0.015 ± 0.002
		2. 0.005 ± 0.001	0.0015 ± 0.0003
Bottom waters	(a)	1. 0.11 ± 0.01	0.017 ± 0.002
		2. 0.005 ± 0.001	0.0017 ± 0.0004
Surface sediments	(b)		
		1. 0.102 ± 0.01	0.037 ± 0.008
		2. 0.0038 ± 0.0005	0.0027 ± 0.0004

(a) Conc of metal ions in ppm

(b) Conc in (mg/gm) dry sediment wt.

TABLE 2

BLUE-GREEN ALGAE CONC AND CONC FACTORS OF COPPER AND CADMIUM:

L. George	Dry wt conc (Ug. Kg^{-1}) Cu	Cd	Conc factors Cu	Cd
range	9.8 - 101.3	45.0 - 892.0		
mean	53.2	355.4	5.32×10^2	5.92×10^4
S	±32.6	±299		
L. Edward				
range	2.8 - 76.1	113.2 - 1070		
mean	39.0	614.2	2.60×10^3	55.8×10^4
S	±29.0	±318		

TABLE 3

A few comparative limnoiogical parameters for the major Ugandan fresh-waters: (a) lakes (b) rivers.

(a)	Victoria	Edward	Albert	George	Kioga
Conductivity MS.cm^{-1}	96	925	735	200	200
PH range	7.1-8.5	8.8-9.1	8.9-9.5	8.5-10.0	7.4-8.5
Approx. salinity	0.093	0.789	0.597	0.139	
Na+ meq. l^{-1}	0.430	4.78	3.96	0.59	0.47
K+ meq. l^{-1}	0.095	2.32	1.67	0.09	0.27
Ca^{2+} meq. l^{-1}	0.280	0.57	0.49	1.00	0.54
Mg^{2+}mq. l^{-1}	0.211	3.98	2.69	0.67	0.57
CO_3= mq. l^{-1}	0.900	9.85	7.33	1.91	1.17
SO_4 = meq. l^{-1}	0.037	0.89	0.76	0.23	0.65
NO_3 N ppm	1.32	1.40	0.009	1.45	0.02
PO_4P ppm	0.9	0.25	0.13	0.50	0.20
SiO_2 pmm	3.9	6.0	3.4	11.5	34.0

(b)	Victoria Nile	Kagera	Semiki
Conductivity MS. cm^{-1}	130	100	500
HCO_3 + CO_3 meq. l^{-1}		0.86	7.3
SO_4 ppm	1.5		36.4
Ca^{2+} ppm	7	5.4	15
SiO_2 ppm	2.5	17	3.8

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Fig.2

Fig.2

Fig.3

Some of the many incidences of 'cholera' epidemics that occurred in Uganda in 1980, reported in Uganda Times newspaper.

Fig.4

DISCUSSIONS

COMMENT:

A great deal of literature is available on the use of papyrus swamps for sewage treatment. It has been done in all the three East African Countries. The problem is that we still do not know what the outer limits are. There are limits, for example some sewage loads are high in salinity, which will easily kill papyrus.

It is also important that papyrus fix nitrogen from the air. A caution ought to be posed that papyrus should be used as a last resort.

COMMENT:

Papyrus swamps are generally considered a nuisance, especially in Uganda situation. One probably ought to say what uses there are to which the papyrus could be put to keep a balance of their growth. There would have to be a harvesting programme. However, harvesting of papyrus is a rather hazardous task. In any event industries using papyrus have not been particularly profitable anywhere.

QUESTION:

Would you say more on tracer copper in fish ?

ANSWER:

The results of the project are not all out and given the nature of the problem we shall wait for the final analysis.

COMMENT:

The final oxidation ponds of sewage lagoons in Jinja have been found to be suitable environments for fish cultivation. Oxygen concentration is high enough. There is luxuriont phytoplantonic growth and an abundant invertebrate fauna. Such fish that have thrived well in

DISCUSSIONS: Cont.

such habitant have included charias mossambicus and protoptasus oethiopicus. But other species could be tried.

After the passage of this effluent from the oxidation ponds through papyrus, it has been demonstrated that the effluent is very well purified. This is almost 100% oxygen saturation, efficient removed O_2 and suspended matter. Such water has been noted to support high concentrations of fish populations including Tilapia spp. "One enterprising Scientist in the 1860's from Jinja testified to the purity of this effluent water by drinking such water" (Ontidote).

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CURRENT THREATS OF AQUATIC POLLUTION IN THE UGANDA SECTOR OF THE LAKE VICTORIA BASIN

BY

PROFESSOR JOHN OKEDI

The Lake Victoria Drainage Basin covers directly five territories, namely Kenya, Tanzania, Uganda, Rwanda and Burundi, and thousands of corresponding square kilometers. Lake Victoria therefore becomes a good potential recepient of aquatic pollution from all the territories. Current sources of pollution are thought to arise mainly from: Domestic wastes, Industrial Effluents and Agricultural wastes the latter largely comprising modern chemicals used as fertilizers and pesticides.

No water quality criteria have been determined for the whole of Lake Victoria although measurements of certain parameters have been done by EAFFRO, National Departments of Fisheries and Health including the various Town Boards along the Lake Shore. It is perhaps to be expected that certain bays and gulfs close to areas of intense human activity are already experiencing pollution at different rates.

For the purpose of this short paper, it is important to highlight certain aspects of human venture in the Basin Area likely to cause pollution directly or indirectly. That the Lake Victoria waters are clean and unpolluted is an outdated opinion not reconcileable with current human activities in the Basin. Hence dirty, smelly and unsightly waters are not only the pride and shame of the industrialised world but also a monster quickly threatening Lake Victoria.

It is strongly felt that scientists, administrators and planners at all levels within and outside of Governments should appraise themselves and keep abreast of trends of developments in the quality of the Lake Victoria water body for its proper use for domestic and industrial purpose, recreation, transportation and as a medium capable of maintaining a balanced variety of fauna and flora.

A casual examination of the Lake Victoria drainage basin shows clearly that there are few large rivers draining into the the Lake. The greater mass of the Lake Victoria water body is therefore derived directly through precipitation. However, the few rivers worth noting as potential vehicles of pollution into the Lake from the Uganda side are:-

The Kagera:	Draining the highlands of Rwanda through Western Lake Region of Tanzania and entering the Lake through Uganda territory.

The Katonga: Draining from a large swampy region of Western Uganda.

There are also innumerable small rivers all along the shores of the Lake which periodically flood and empty into the lake often through systems of swamps.

From a pollution point of view, these rivers and bays will experience pollution long before the entire lake becomes polluted. Hence the need to monitor pollution in rivers, streams, bays and lagoons as a first priority. These streams empty into the lake and levels of pollution particularly for persistant agents, could become cumulative in the lake. It has been postulated that over 95 per cent of water loss from the lake is via evaporation and that the only outlet through the Nile accounts for the remainder. Accumulation of persistant pollutants then becomes real possibility with time. A survey of agro-industrial activity and urbanisation around the lake is therefore necessary. Data on measurements of desired parameters are scanty. Information on existing methods and levels of effluent treatments is not available. It is however hoped that the dangers of untreated effluent originating from domestic, industrial or agricultural activity can be surmised. A few examples are drawn form current developments and activity on the Uganda side of the Lake Basin:

1. <u>ORGANIC RESIDUE</u>:

1. <u>Domestic Sewage</u>:

Several towns ranging from, large, medium to small have ....

cropped up along the lake shore and within the drainage basin with populations of up to 300,000 people. In some of these towns e.g. Kampala, Jinja and Entebbe there is a partial treatment of sewage effluent through oxidation, activated sludge process and biological ponds. However, in some towns e.g. Majanji and Bukakata raw sewage empties directly into bays. In Kampala and Jinja an ingenious process in sewage treatment includes the passage of the treated effluent through a mat of papyrus before discharge into Murchison Bay and Napoleon Gulf respectively.

The effects of draining sewage direct into bays are complex. A few notable examples are:-

<u>Deoxygenation and Increased B.O.D.</u>:- Due to consumption of Oxygen for aerobic decomposition of organic matter.

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Eutrophication: High load of organic and inorganic nutrients (Phosphates, Nitrates, Potassium, Calcium, Magnesium etc.) leads to explosive growth of algae etc.

Introduction of Pathogens: Arising directly from excreta. The above conditions have been greatly minimised in Kampala and Jinja where no serious effects of sewage effluent have been observed in both Murchison Bay and Napoleon Gulf.

In many other smaller towns e.g. Mbale, Soroti, Gulu, Masaka, Mbarara, among others, sewage effluent is partially treated before being released into small rivers. Because of trubulence and flooding. de-oxygenation effect of sewage effluent is minimised and the streams quickly become purified downstream.

Existing cities and towns will probably grow in size and new ones will inevitably be built. Hence the thrust of argument is therefore for sewage effleunt to be treated through the activated sludge process and biological ponds. Its passage through papyrus swamp is advocated as the papyrus absorbs its high nutrient load for its own vegetative growth.

1.2. Other Organic Residue Effluent:

Most of these are rich in organic load and arise from agro-based industries, notably dairies, manure heaps, slaughter houses, sugar mills, breweries, fish meal plants and paper mills. Their composition and effect are similar to that of domestic sewage.

Because of suitable climate, good soils and availability of water, the shoreline of Lake Victoria has developed an expensive sugar cane industry. In the northern shores three large scale sugar industries exist, viz:- the Kakira, Mehta and Kinyala Sugar Enterprises involving thousands of hectares each producing thousands of tons of white sugar, mollasses and Bagass per hour.

These sugar cane mills produce large quantities of organic residue which if discharged untreated into the lake has de-oxygenating and eutrophication effects. Some of the culprits will argue that, their effluent is first discharge into rivers. Although the river is capable of self purification due to aeration and aerobic organisms, the final recipient of these processes is obviously the Lake. Therefore the wastes should be systematically treated before being introduced in the river because that salt autopurification process might not be complete. In any event, one wants to protect fauna and flora in the river too.

Several breweries occur in Kampala and Jinja and several others are planned. Brewery effluent is high in organic laod and similarly requires treatment.

One notable small paper manufacturing plant is found on the Nile just outside Jinja. Organic material from paper mills is not easily broken down by aerobic organisms hence its de-oxygenation and deliterious effects tend to be prolonged down the River.

2. Poisons:

Amongst these are heavy metals e.g. Copper, Mercury, Lead, Zinc, Cadmium and other toxic substances such as phenols, detergents, ammonia and free cyanide. They arise directly from the industrial activity of urbanised centres along the lake shore. The effect of these to-day is not pronounced due to the low level of industrialisation in Uganda but is expected to rise significantly.

Some of the potential polluting industries occur in the major towns. Jinja is the industrial town of Uganda situated on the shores of Lake Victoria. The major industries include:-

Copper Smelting: Producing Copper and its compounds and Cadmium as the main poisons which are discharged into the lake.

Match Factory: Producing effluent heavily loaded with Phosphorus and its compounds.

Steel Mill: Produces attendant poisons e.g. Cyanides and heavy metals.

Textile Mills: Two such mills producing large quantity of effluent bearing poisons such as detergents and ammonia.

Paper Industry: Producing organic effluent with sulphites as poisons.

Garages, Workshops etc: Many of these operate within the towns producing effluent rich in poisons such as mercury, lead and other heavy metals which drain directly into the lake.

The basic problem regarding these toxic substances and their compounds is the determination of permissible levels of their concentration. Nevertheless, toxicity levels differ according to major biotic communities e.g. phytoplankton, Zooplankton, insects, Fish and Man. Their toxity will rise with water hardness and higher temperature.

The overall effect of these poisons may be lethal if concentrations are high enough; may reduce growth and reproductive rate if concentrations are sub-lethal or may alter physiology and behaviour of an organism. It is therefore imperative to identify cause of pollution due to poisons and determine their adverse effects on various strata of the ecosystem.

3. OIL:

In Lake Victoria oil pollution is not marked like oil pollution at sea. Nevertheless it has its own pecularities and dangers. It arises mainly from garages, workshops and ships, Good examples are the current oil pollution as seen floating around the Railway Workshops in Port Bell and Jinja.

Beside being unsightly floating oil prevents penetration of solar energy, gaseous exchange and obstructs respiration of certain animals. Its presence makes domestic and recreational use of water harzadous. Limited areas of the lake around urbancentres are affected to differing degrees.

4. HOT WATER:

This is the result of heat exchangers and cooling systems in industries. The hot water effluent finally being released directly into a river or a bay.

A number of potential industries exist along the lake shore but their effect to-day is perhaps minimal. The most notable examples being the East African Steel Mills and Textile Mills.

A few examples of thermal limits will surfice. Most Blue Green Algae die beyond 48^0C, Diatoms above 50^0C, Photosynthetic Bacteria at 60^0C while most Invertebrates and Fish above 35^0C.

5. PESTICIDES:

Extensive use of Pesticides is carried out in the northern portion of the Lake Victoria Basin for the control of several sectors e.g. on:- Agricultural crops Cotton and Coffee. Domestic animals and for the control of schistoscmiasis onchocerciasis and Trypanasomiasis.

Several pesticides in use include the following:-

DDT, DDD, DDE
Malathion
Lindane
Endesulfan

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Dieldrine
Bayluscida
Frescon
etc.

Whether applied directly over water e.g. Mulluscicides or onto farm crops and farm animals, these pesticides finally end up in rivers and bays of the lake due to rainfall and run off. Thus their effects tend to be cumulative.

Their effect on aquatic organisms is variable. High concentrations are lethal. In invertebrates 90% mortality has been noted in certain applications. Further some of the pesticides tend to accumulate along certain trophic levels e.g. Fish, Birds and Man.

These agro-based and public health requirements for large scale applications of pesticides can not be stopped. However in several instances along the Nile (Simulium destruction) and along the Northern shore in Busoga (Glossina destruction) concentrations of applications have tended to be too high thus causing the mortality of many Invertebrates, Fish and Birds as well. Hence specificity of these pesticides should be determined against target venture and lethal doses worked out. To avoid run off accumulation, it is necessary to find time and season of best application of the pesticide.

In summary the most serious danger to aquatic pollution today in the Lake Victoria Basin in Uganda comes from the following:-

1. Sewage pollution from urban centres.
2. Organic pollution from agro-based industries.
3. Heavy metal pollution from industries and agriculture.
4. Pesticide pollution from agriculture and public health projects.

There is a need to undertake the following as a matter of priority:-

1. A survey of growth of agricultural and industrial activity and urban centres in the Basin.
2. Documentation of current methods of effluent disposal and treatment by all industries and Urban Centres.
3. Determination of current levels of pollution in Rivers and Bays in the Lake Basin.
4. Determination of lethal concentrations of various pollutants to several tropic levels of the aquatic ecosystem.
5. Determination of water quality criteria and permissable concentrations of the various polluting agents.

DISCUSSIONS

COMMENT: There are two ways in which Lake Victoria water leaves. Evaporation and outflow through the Nile at Jinja. But the outflow through the Nile constitutes only 5% of that total, which means that the other 95% is through evaporation. The implication is that most of the pollutants entering the Lake remain in it. This is something critical to consider in deciding the importance of pollution control.

Q.: What are the steps taken in Uganda to deal with the pollution - since Uganda receives water from the other parts of the basin.

COMMENT: The physical nature of Lake Victoria need to be understood clearly. The circulation of the water of the Lake affect the behaviour of the pollutants, and Uganda must first understand these processes fully, and thereafter adopt regulations.

COMMENT: The general trend of the flow in the Lake, whatever are the other physical forces, will tend towards Uganda.

A.: Most of the wind system is towards the Northeast (from Indian Ocean side) therefore the movement of water will tend to flow towards Uganda.

Secondly, even though water (upto 95%) is lost through evaporation the organochloride compounds will remain.

Thirdly, a study of the flow in the Lake show that movement of water is towards Jinja and the prime example is the Kagera which has its trench through to Jinja.

It has been pointed out that some of the species in the Lake are disappearing and I believe that some of that result from pollution.

COMMENT: Most of the - pollution load concentrate at the estuaries and immediate vicinities. This has been proven in the inland waters in the U.S. However, ultimately they move to the final outlet of the Lake.

COMMENT: There is a need for the three countries to synchoronize the work on pollution control so that all the three countries know othere efforts. The target is one and it is possible for them to cross the border and reverse movement. The same process of use of pesticides for control of vector-bone diseases should apply to pollution control.

COMMENT: The movement of water towards Jinja is still only presumed. There is a need to determine the precise movement and velocity of water towards Jinja.

COMMENT: The fisheries officials ought to conduct studies, through various techniques including tracer techniques, to ascertain the pollution agents in fish, their origins as well as persistance and toxity.

COMMENT: The danger must be traced from fish-eggs and fries because some of the traces that may be found in fish species at different ages are well beyond the impact on the impact on the younger fish.

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HOW THE KAGERA BASIN ORGANIZATION
LOOKS AT ENVIRONMENTAL PROBLEMS

BY

CHARLES BUNANE

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A Workshop of Experts which met in Geneva in March 1961, water pollution was characterized in the following manner:

> " A river is said to be polluted when the state or composition of water in it is, directly or indirectly modified by human activities which render it incapable of being used in the same way as when it is in its natural state".

Water pollution, which no doubt exists in the Lake Victoria Basin as a consequence of urbanization agriculture and industrialization which are slowly but surely in progress, is not yet a problem of high priority. However, it is not advisable to wait until the problem has reached a critical stage before taking the appropriate action.

In fact, the principal threats to the environment and ecology are approaching as the pressure on land area increases with population as well as agricultural and industrial growth; the high utilization of rangelands by livestock is beyond the carrying capacity of the land. These dangers are more prevelent on hill slopes in Ruanda and Burundi. But the studies on the impacts of projects on the environment could be taken into consideration to avoid bad consequences which might affect these projects. Similarly, a programme of studies which relates to the evaluation of informations collected to facilitate the prediction of possible ecological impacts for the development of Kagera Basin has already been proposed.

Another thing, the installation of a Secretariat as a research centre and for the protection of the environment is conceived to facilitate the establishment of protective measures which ensure the realization of minimum negative ecological impacts. Better still, the Organization has already started to consider strategy for management actions to deal with the Rusumo Falls dam construction.

The Organization's plan is that the dam will expand only existing lakes in the country above the Rusumo Falls, and that this will regulate the hydrological regime which is already properly regulated below the falls.

For macro-climate, there is no effluent arising from damming the river because the lakes concerned are relatively small if we compare to factors which determine this macro-climate. For a lake to have influence over a macro-climate, it must be as large as Lake Victoria and this is not the case. The climatic situation after the dam (lake) will be the same with the previous situation of lake and swamp. Then there will be no remarkable modification of the micro-climatic factors nor are there likely to be any local changes which may be perceived by the local people.

Considering the geology, the only effect predicted above the Rusumo falls will be the augmentation of the storage in the lateral strata which depend on the depression of Bugesera region, and that is not negative. Below, there is no risk of great modifications of under flow of the high water mark, because the hydrogramme will have small modifications. Vegetation is really abundant in the depression of Bugesera and Kagera. The principal factor which is responsible for the actual type of vegetative formations in Bugesera and the Kagera National Park is hydrometry of the river and, precisely, the levels of the ground water table.

The hydrometry already appears very much transformed in the transverse and longitudinal topography of the valley which includes many areas affected by the natural floods. The management projected for Rusumo falls will not change the annual water debit which will be constant below the falls. The only consequence will be a modification of the distribution of the river flows in the course of the year. But it is wise to anticipate the action of regulating the flow during the period of floods. This is particularly so because it could be safer to maintain the permanent debit which corresponds to the smallest low river-flow. This should be allowed to flow during a limited period of the year and flooding should correspond to the debit of the small floods.

The large wild animals are not as abundant as before, except in the Kagera National Park, in Ruanda. The specific diversity and the biomass are directly dependant on vegetation and, the presence of water. Consequently, any modification of hydrological regime causes a chain reaction with large animals as a final point. The project impacts on the human environment as well as development are diverse. The political choice to build the dam, including the development of fisheries with all its infrastrure are based on the increased employment opportunities of the population in the river basin. In a regional context the people and the large fauna are in competition; inevitably the people's presence prevail and the number of the wild animals will steadily decrease. From the human health point of view, the important problem is that of malaria. Fortunately most of the local population have great resistance against malaria. It is recommended nevertheless, that the public be informed that the use of antimalaria drugs should be taken seriously. Human migrations from affected areas and the installation of appropriate medical infrastructures will expedite the necessary protective systems. We think that, no action can be taken on the lake to eradicate malaria vectors by use of pesticides and that approach has not been pursued.

On the ecological plan, the spread of trypanosomiasis vectors will be reduced by the glossina habitats being covered by the expanded lake. But we recommend to the local populations to be vigilant in the course of the said migration and especially after they have moved into the new areas.

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Finally any modification of the environment causes cultural responses of the people. The management of this region will evidently have an impact on the region's culture. Farming communities will, for instance, start participating in fishing activities and will adopt a different life style. The only recommendation we can formulate is to respect, as far as possible, the wishes of the migrating communities.

CONCLUSION:

The organization for the Management and Development of the Kagera River Basin is conscious of the fact that the exploitation of the natural resources must finally support the social economic development (of the country). This will be manifested through changing natural areas artificially thereby changing the natural equilibrium of ecosystems that means changing the equilibrium of the population and the biotope.

Negative ecological impacts will be manifested by limitations of future utilization of natural resources at a high cost to the society. But, usually the positive impacts should predominate as far as possible to constitute satisfactory and acceptable balance to the regional and national communities.

The suscaptable sectors related to the management are: animal health, the terrestrial and aquatic ecology, the habitats, the utilization of soil and water, the biodynamics of vegetation and animals. However, the Rusumo dam construction is restricted to a maximum of 1325 metres above sea level and that will minimize the negative impacts brought about by the changes in the area.

The possibility of thermal pollution (heat pollution) will exist but it will probably be limited because long channels for hot water will be constructed to enable the [illegible] temperatures of about [illegible]

The utilization of mineral fertilizers and of pesticides is not widespread to the extent of posing a pollution danger to the environment. But precautions will have to be observed when introducing chemical fertilizers in large quantities to avoid the change of the soil chemistry and the contamination of drinking water and fisheries biotopes.

Another matter of concern is the presence of tsetse flies in some regions of the four countries. The suggestion one can advance here is that the various insecticides to be used in the tsetse control must be administered under expert supervision to avoid adverse impact on the environment. If the human population continue to rise and if the regional development atracts more people into the tsetse fly infested area, then a control programme of the flies using selected insecticides may be justified.

The recommendations from the Kagera Basin Organization are addressed to the four National Governments and the Governments are expected to ameliorate agricultural extension services to ensure maximum productivity while minimizing the negative impacts which are associated with the utilization of chemical products in agriculture. As a matter of fact, whatever may happen to Ruanda, Burundi, Uganda and Tanzania these countries are unlikely to forget that they used to be vast agricultural regions.

In conclusion, on the issue of pollution, the Kagera Basin Organization is required to make its intentions known now. Like economic development, the control of pollution and the quality of water must be undertaken at the regional level which is the only way of safe-guarding the future, using the past as a point of reference. Regional action is imposed by the economic structures of our countries which are developing, but the joint effort will help to reduce the risks arising from lack of adequate documentation. The regional action should be centralized in order to facilitate the integration of development strategies at the commencement of planning in the Basin. This Basin must be protected and developed at the same time.

DISCUSSION:

QUESTION:

Does Kagera Basin Commission intend to convene seminars of this kind to discuss pollution control ?

ANSWER:

May be not. Kagera Commission has the duty to execute projects designed by the member states and it will be expected that the four member states would convene such a seminar.

QUESTION:

The participants here might want to see what is actually happening in that part of the Lake Victoria drainage system. Is the Kagera Commission receptive to such visits ?

ANSWER:

It seems that there are several development oriented organizations around Lake Victoria. It seems that there is a need for the consultation among the organizations concerned; the Lake Victoria Fisheries Commission, Kagera Basin Commission and the LBDA. The Kagera Basin Commission would encourage such visits and consultations.

QUESTION:

Representative of Rwanda attended a GEMS meeting in Nairobi and a question was raised about the monitoring system on industries within Kagera Basin.

ANSWER:

We have not commenced the programme of monitoring. Plans are underway for that and IUCN has plans to establish a monitoring centre within the Kagera Basin Organization. There are other plans for oil pollution monitoring but they have not become operational.

CHAPTER VI

PROTECTING CONSIDERATIONS

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INDUSTRIAL SITING AND ENVIRONMENTAL PROTECTION

BY

FRANK G MULLER
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FRANK G MULLER

1. The Issue

By the time the United Nations Conference on the Human Settlement convened in 1972 in Stockholm, it had become obvious that environmental objectives of industrialised (IC) and developing countries (DC) are not necessarily identical.

While ICs have now started to mitigate environmental damages generated by unrestricted economic growth, the DCs, at least a large number among them, often view their specific environmental problems as a direct result of their underdevelopment.

Several DCs believe that their specific environmental problems can be "solved" only if they are able to achieve a larger share of world production and international trade, namely 25% share of world industrial production by the year 2000 as demanded by UNIDO in the Lima Declaration of 1975. It seems that as long as the supply of basic consumer goods and employment possibilities is insufficient, many DCs assign a higher priority to economic development than to the enhancement and protection of environmental quality.

As far as the developing countries are concerned, the notion that environmental protection is of "low priority" of even a "luxury", is deceptive and questionable on two counts at least: (a) In DCs the nature of many environmental problems pose a serious threat to the economic well-being, and often even to survival, of a large segment of the population. The consequence of soil erosion and deterioration of terrestrial and aquatic eco-systems are often extremely serious or even catastrophic - the degradation of Africa's Sahel, for example - and not only limiting the improvement of standard of living, but also endangering people's lives. Obviously the environmental problems cannot be viewed as Luxury'. (b) The argument that high priority should be given to meet the basic material needs and ignore problems of the polluting industries is dangerous. Since the existing knowledge is relatively limited about the ecosystems of tropical and sub-tropical environments, it is adviceable to proceed cautiously with the industrialization in DCs since some of these investments may cause more irreverrible damages in DCs than in temperate regions of the ICs.

Those DCs, however, who attach a lower priority to environmental quality believe that there is a possible trade-off between these two socio-economic objectives. In this respect, less restrictive environmental legislation are considered a comparative economic advantage which could accelerate the industrialization process and thereby create additional income and jobs.
Since most DCs are short of investment funds, some attempt to use this comparative economic advantage to attract and stimulate foreign investments. Their assumption is, that increased production costs in ICs caused by the stiffer environmental protection laws are a sufficient reason for companies to increase their investments in DCs.

While some DCs hope to achieve more rapid economic development by ignoring environmental damages, the ICs fear that international differences in environmental quality standards may produce distortions in international competition. Although it may be desirable to locate polluting production activities in DCs, where the assimilative capacity of the environment is not yet fully utilized, this change of industrial siting, however, may reduce investment spending and create additional employment in ICs. In fact, representatives of industry and trade unions of ICs have expressed their warnings of an "increasing" flight of polluting industry to the less restrictive DCs. The extent to which differential environment laws and enforcement have contributed to the relocation of production activities to DCs is not yet established. Available studies claim that such environmentally induced capital movements do occur, but they generally suffer from a lack of conclusive evidence and unreliable data to determine convincingly the importance of this relationship. (YEZER, 1974; PEARSON, 1976; WALTER, 1977). A case study for example, about German Investment behaviour concludes, that the German industry derives no investment incentive when DCs intentionally sacrifice environmental quality in favour of accelerated economic development. Consequently, less restrictive environmental policies do not provide DCs with much additional foreign investment than could be attracted for other reasons (KNODGEN, 1979).

Over the last decade industrial development programmes and siting has increasingly become subject to public controversies in those DCs which have begun to take environmental concerns into account. In some DCs, legislation and/or guidelines for the implementation of environmental assessments for industrial siting are already in existence or are being prepared. However, there are still misgivings among decision makers in the Third World about the costs, and possible delays, connected with carrying out environmental impact assessment, and about the ability and skills of the assessors to provide useful advice. The issue of the extent to which it is necessary or worthwhile to get involved with environmental impacts is a difficult one for developing countries, because the first claim on their natural resources is for domestic consumption and for earnings foreign exchange. Furthermore, the manpower responsible for environmental

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management is often inadequately trained and organized for an efficient implementation of environmental laws and regulations. It is in this context that a simplified, cost-effective and yet practical and effective environmental impace assessment format needs to be designed as the basis for a comprehensive environmental policy in developing countries.

It is here not intended to present a systematic discussion of all determinants and motivations for selecting a particular industrial siting, such as dependable supplies of natural resources, availability of skilled labour, winning new markets and avoidance of high tariff barriers. All these various aspects are subject of specialized branches of economics, such as regional and location economics. The following the focus will be on methods to mitigate industrial pollution, namely, on environmental impact assessment (EIA) and benefit cost analysis (BCA), including economic pollution control strategies, and some of their problems of application.

2. Assessment Methods

The CBA - and EIA - reports are proposed as a means to prevent undesirable surprises of post-development consequences of industrial siting and to avoid the less-than-ideal solutions which may result from conflicts of the affected social groups. In addition, the assessment methods are designed to identify environmental modifications as soon as possible during the planning and/or implementation process, so that appropriate actions and project modifications can be suggested and undertaken.

To accomplish these tasks the assessment methods must (1) identify, (2) measure, and (3) evaluate environmental impacts. Some methods focus mainly on enumeration of potential impacts and on collectio addressed on how well impacts are listed and measured. Very little or no provision is made for the core problem, namely the weighting and evaluation of environmental impacts.

In the early 7970's EIA became available as an additional instrument of project assessment methods that first began with the extensive application of CBA in the 1950's; followed by Planning, Programming and Budgeting (PPB) and Cost-Effectiveness Analysis (CEA) in the late 1970's.(1) Despite its relatively new arrival to the arsenal of assessment methods, EIA is not really that new. It has to be noted that some countries have had already introduced for example sophisticated land use planning methods well in advance of the introduction of the National Environmental Policy Act (NEPA) by the U.S.A. in 1969. The introduction of NEPA, however provided an additional momentum to the international environmental management. It made EIA internationally accepted as a special effort required to assess the impacts of proposed development activities.

As factors which led to the introduction of EIA and the extension of the conventional framework of CBA, can be identified: (a) the increasing scale and following side-effects of industrial developments and resource development schemes; (b) the rise of active and informed protest by well organized interest groups and prominent individuals in opposition to several proposed and implemented development programmes and policies; and (c) the shortcomings of the

(1) A complete list of assessment methods would include also environmental risk assessment multiple-objective analysis, systems analysis and optimization models, and finally, input-output analysis. All these methods can be regarded as environmental impact assessment methods in the broader sense

available assessment methods to accommodate appropriately socio-economic and environmental impacts into the applied method.

The dimension and apparent economic urtency to undertake largescale development schemes, like energy supply, infrastructure, water management and mining development, caused all kinds of environmental effects to the ecosystems as well as local, regional and international communities and become too threatening to be ignored. The very size and spread of these developments, which took place and are still ongoing in industralized and developing countries, over-whelmed any conventional project appraisal technique. As a response to this, environmental activism emerged in several countries and it manifested itself in an efficient combination of tactics such as establishing better information base, improved analysis and methods by the opponents of the short-comings of the proposed development schemes and could develop itself most effectively in political democracies that protect and guarantee individual's right to object. It appears that in many developing countries only few persons and small groups have the information base and the resources to raise objections against major industrial development programmes and rarely receive either governmental or constitutional support for probing such proposals. Therefore, it seems that any pressure for enhanced environmental quality is more probably to come from the technically better informed international community of the industralized countries and from international agencies, such as UNEP and the World Bank.

2.1 The Cost-Benefit Analysis

Cost benefit analysis has many applications and is the foundation for most pollution control strategies. It is designed to allow informed value judgements to assist the decision-makers and planners in ranking investment projects according to their economic efficiency. Planners require both qualitative and quantitative considerations, but no model or decision rule can generate the 'best' decision by itself. Economists hope that cost-benefit analysis can guide the final decision by identifying the uncertainties and classifying the assumptions involved. (Hollick, 1981; Nash et al, 1975). Although specific formulations differ from case to case, cost-benefit analysis usually involves some combination of the following steps

a) specify the goals and objectives of the project(s);
b) identify the expected benefits and costs for each alternative;
c) define the unit of measure applicable to each of the outputs and estimate the quantitative number of units;
d) apply monetary terms as common index of relative value to allow comparability and additivity;
e) introduce weighting factors in recognition that value judgement will be part of analysis. Weighting factors in recognition that value judgement will be part of analysis. Weights are employed to adjust the estimates of monetary value for non-market considerations of social, cultural and ecological aspects of the evaluation process;
f) estimate, aggregate and discount benefits and costs of the identified consequences of the project; and
g) employ ranking criteria to evaluate alternatives.

Traditionally, cost-benefit analysis has proved to be quite valuable to industrial and resource managers in general and to environmental managers in particular. However, it has to be noted that cost-benefit analysis is not a prescriptive tool. It is most useful, and less controversial, for the application of relatively small, single-purpose projects with few externalities. Evidently, environmental managers rarely face such situations. Substantial: shortcomings are associated with the cost-benefit analysis such as the relative ease with the expected flow of benefits and costs can be manipulated according to the planner's interest; the necessity of restricting the scope of the project since large projects and programmes tend to alter the entire range of relative values and outputs; selection of an appropriate rate of social discount; determination of the proper estimates for values to be considered in the case of imperfect or non-existent market evaluations (such as environmental quality); considerable faith in the ability of competitive markets to produce socially desirable results; justification for the inclusion or exclusion of certain benefits and costs; and the assessment of income redistribution effects. Some of these shortcomings (not all and only to a certain degree) can be adjusted reasonably well. However, regardless of the degree of sophistication of the cost-benefit analysis approach applied, no present cost -benefit analysis is equipped to eliminate the need for substantive value judgements in the final stage of the planning and decision making process. Instead, the planners have to rely on interdisciplinary orientated teams to assess the value issues which are inadeuately reflected in the cost-benefit framework (Muller 1982). Some of the shortcomings will be discussed further below.

2.2. Environmental Impact Assessment

The demand for environmental impact assessment (EIA) has generated proposals for so-called methodologies to satisfy the planning or decision -makers' requirements. Most of these proposals suggest or prescribe a list of data requirements and most differ only in their suggestions for presentation of the information (Munn, 1976).

EIA can be thought of as a basic tool for the thorough assessment of industrial development programmes and/or proposals. The characteristic of EIA is that it attempts to use scientific knowledge to assess the possible consequences of development action on the environment. EIA aims to identify, predict and assess the likely primary and secondary repercussions that may result as a consequence of a proposed industrial development and, the results, compiled and evaluated as systematically and objectively as possible, are presented in an Environmental Impact Statement (EIS) or EIA - report.

Basically, EIA - reports (viewed conceptually in a narrower sense) can be arranged into four groups: (a) checklists, (b) matrices, (c) networks and (d) map overlays. Occasionally, computer simulations are mentioned as another alternative. The checklist is a common feature and usually represents a catalogue of possible impacts that might be expected from various types of activities. As such, this type of catalogue provides only meagre information about the extent of impact and its relative importance. (Edmonds and Letey; Rowe et al., 1978). Matrices instead combine a list of impact possibilities with various project activities that might be associated with or produce such consequences. The purpose of these matrices is more to be explicit in discerning which actions have an impact on which environmental characteristics. Network proposals attempt to describe more comprehensively case and effect relationships, listing impacts and indicating how these are generated through effects on resources.

Finally, map overlays try to identify areas of lesser conflict among resource uses and environmentally important values. This is accomplished by superimposing maps describing various uses for values (such as vegetation, water ccurses or unique wildlife habitat). The method is employed in locational screening of alternative project sites. However, its chief shortcomings are that it fails to differentiate the weight or relative importance between the respective resource uses, nor does it indicate the interrelationships among them. Environmental impact assessment may give assurance to planners that their decisions on industrial siting are made on a broader scope of values than would otherwise be the case. However, the separately conducted study or listing of environmental factors has not been a particularly efficient or convincing approach for the inclusion of environmental considerations in prevailing development appraisal and planning methods. Implementation of such considerations has frequently been costly and time-consuming.

Most of the times, EIA reports have been requested for truly massive or unusual projects. For such projects, unique environmental procedures may very well be advisable but they become questionable when applied to the numerous routine projects planned annually in nearly every country. Obviously, EIA - reports must be efficient, manageable and operational.

In most cases, EISs were conducted following the directive which centered on data to be generated and the form for presenting this gathered information, avoiding almost entirely any comparison and accommodation of economic considerations.

Sometimes, it was even specified that economic values were not to be included in the EIS (Knetsch, 1979). With emphasis on producing data on purely environmental matters, it is not surprising that the normal response of programme proponents is towards side study, usually contracted out to people independent of those involved in planning the project itself and with the sole purpose of collecting environmental information. With such a narrow scope, these studies obviously have little focus, less point and do not improve interdisciplinary planning methods. (2) All methods of assessing the environment are fraught with major difficulties. A major problem among these is the assignment of values to the relative significance of predicted changes (Bisset, 1978). Whereas the more traditional cost-benefit analysis (CBA) of development projects lends itself to some measurement in monetary terms, the impact of

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(2) It seems that the necessity to show environmental concern to the court in several countries, this perverse tendency to assemble masses of information over relevant information was even reinforced, since the environmental interest lawyer will not challenge the adequacy of the EIS if its 'weight' is overwhelming enough.

projects on the ecosystem have not yet been usefully and reliably quantified, in particular on commensurate scales. Deciding what is of greater or lesser importance is a generic problem. Though cost-benefit analysis is much used nowadays, the fact remains that EIA, - report in the narrower sense is still a form of cost-benefit accounting except that the various items are not calculated strictly in monetary terms. Current EIA methods, almost be definition, vary with the evaluater involved and have to be viewed as a personal value judgement. Comparability and reproductivity of inter-project ratings - sometimes even among the specialists themselves - remain a constant source of concern. Guidelines repeat the need for more objectivity. Furthermore, attempts to aggregate and/or summarize different impacts in some sort of quality index are also inherently arbitrary and highly subjective. An additional problem with current EIA methods is how to deal effectively with basic unknowns and uncertainties of possible impacts. The present understanding of causal factors in the environment is far from complete.

3. EIA Procedure for Developing Countries

An EIA report is only one of several tools for determining industrial impact and managing the environment. Even in DCs where planning procedures are not fully established, EIA could be beneficial. In this context attention is drawn to the two-steps approach to EIA, outlined below, as a useful and cost-effective procedure for DCs to implement.

For any EIA - system is it necessary to have a procedural framework in which EIA will operate. UNEP has published such a framework and those countries in which EIA is being implemented have established their own EIA procedures. It is not feasibile to suggest an EIA procedure which would be applicable to and acceptable by all DCs, since they each have developed their own decision-making and planning systems for authorisation of development programmes and/or projects. Therefore, here we will only present a general, idealized EIA procedure. (UNEP 1980).

The effective operation of EIA depends upon a review of the potential environmental effects of policies, programmes, plans, and/or projects by an agency. In the initial step, it is to decide on the scope of the assessment which specifies how extensive and intensive the EIA will have to be. This decision, determined by the regulation or review procedures of the country concerned, sets the stage for the extent of the EIA system required and the details necessary for it. The agency, which undertakes the initial step, for undertaking the screening activities may be a local, state or federal government authority or a specialised agency.

The objectives of the review agency can be facilitated by requesting a submission of a project brief describing the proposed industrial siting of the planned activity. Another important aspect at this initial stage is the selection of personnel for the team preparing the EIA. A basic requirement is that this team should be technically competent and be capable to prepare an objective scientific report. The EIAs may be conducted by the proponent, consultants, government officials or a combination of all three.

Since most EIA experiences are related to projects and only to very few plan, - programmes, - and- policy-EIAs have been conducted. in the following, the general attention is directed toward project EIA. The EIA-team screens the proposed industrial siting for potential adverse environmental effects. Screening is a procedure which attempts to identify, as soon as possible, those industrial sitings with potential impacts which may be of major significance and should, therefore, be scrutinized by EIA. Projects which might have "significant" environment effects can be investigated and, if no such effects are detected, they can then, obviously, be excluded from further environmental analysis and their implementation can advance. (JAIN et.al.1981).

However, there is a "grey area" of identification of environmental impacts. Within this "grey area" it is possible to identify a further three types of projects. Firstly, those with no significant effects which could be mitigated through minor project modifications and/or by appropriate environment management. If this is the case, then no further EIA becomes necessary and the project implementation goes ahead. Secondly, there are projects where the nature of potential detrimental environmental effects may not fully be known. Thus, a preliminary EIA, but not yet a full and comprehensive EIA is required to evaluate the significance of the impacts. The findings from this initial assessment will show whether a detailed EIA is necessary or not.
Thirdly, there are projects where the nature of adverse environmental impacts are obviously significant and require a detailed EIA. Thus, the function of the screening procedure is to determine in a cost-efficient and expeditious manner whether a project should be subjected to a comprehensive EIA. This project to project approach is proposed in UNEP guidelines (Fig.2). The Fig. I depicts a sequence of preliminary (steps 1 - 5) and detailed (steps 6 - 9) assessment steps to analyse and assess potential impacts by a proposed development and its available set of alternatives. The essentially straight forward nature of the preliminary assessment procedure implies that steps 1 - 5 can be successfully executed within short time. For many projects not having significant environmental impacts the requirements of time and resources

will not be substantial, provided that the project brief is adequately specified. For example, step 4 requires a systematic identification of possible interactions between the nature and the characteristics of the development site, illustrated by use of an interaction matrix. Step 5 applies a screening test in order to determine those elements (e.g. environmentally sensitive areas) and sub-elements (e.g. coastal zones) of the environment upon which there may be important impacts. The results from these tests indicate whether a detailed EIA will be required. Step 6 - 9 covering the comprehensive, detailed EIA procedure which requires examination of the significant impacts in more detail through increases analytical precision of detailed baseline and process studies. The two-step procedure is illustrated in Fig. 2.

The recommended two-step approach to EIA consists of a preliminary or minimal environmental impact assessment and, if necessary and required, a detailed environmental impact assessment. The preliminary EIA report should include at the minimum the following elements:

- a listing of the potential environmental emissions of the planned industrial siting;
- an environmental inventory of the possible project location;
- identification of the magnitude and relevance of the expected environmental impacts;
- consideration of siting alternatives, technical and locational;
- report on overall assessment including possible environmental protection measures.

Basically, the preliminary EIA report collects, organizes and analyses the readily available information about the "significant" and "substantial" environmental impacts of the proposed activity. It is realized that the operational difficulties in defining in advance criteria for the selection of development activities to be scrutinized either by a preliminary and/or detailed EIA are considerable. Conditions in developing countries differ too widely in relation to their socio-economic feasibility and in terms of their ecosystems and national resources base to lay down broad prescriptions. Realistically, the definition of what is a "significant" impact must ultimately be left to the judgement of the review agency in the country in question.

The EIA process will involve the collection of information relating to the release of various types of pollutants of the proposed industrial siting to environment. With this type of information and knowledge of prevailing environmental conditions, it is also possible to use EIA as a tool for abating the emission of pollutants. Obviously, abatement cannot be implemented directly but the information gained from EIA reports can become an important prerequisite for designing pollution control strategies.

Finally, it has to be recognized that there is reluctance of some countries, in particular developing countries, to prepare and implement EIA procedures . This reluctance is based to a large extent, on the belief that EIA reports are very expensive. Experience, however, has shown that the cost of preparing an EIS is relatively low, ranging from 0.25% to 0.75% of the total project cost. According to a study carried out by the Environmental Protection Agency of the U.S., the EIA costs are approximately only 0.19% of the total project cost. Furthermore, with increasing know-how and improved data-banks a further downward trend in costs may be expected. The costs are obviously commensurate with the complexity and significance of the environmental problem and the level of detail required. These costs may be borne by the development proponent, the authorizing agency and/or some other agency. Measuring the benefits and costs of individuals EIA - reports and EIA - procedures is a very complex undertaking, namely, it is rather difficult to conduct a full monetary cost-benefit analysis of EIA reports because some of the environmental benefits and costs escape quantification. Nevertheless, if one attempts to compare the costs of preparing EIA reports with the costs of combating pollution and preventing environmental degradation, it seems that the costs of EIA reports are minimal and should not be viewed as an obstacle to introducing EIA procedures in developing countries.

4. Economic Strategies of Controlling Industrial Pollution

4.1. Optimal Level of Pollution

Probably the most difficult practical problems in evaluating environmental impacts and, thus, combating industrial pollution are the determination of the significance and the resulting pollution damage costs. CBA requires a lot of information about these costs for the determination of an optimal level of environmental damage. In particular, the knowledge of the shape and position of the damage function over a wide range of environmental degradation is required. The idea, however, of an economic optimal level of pollution generated some controversy among the scientists. Biological criteria to determine acceptable levels of pollution have been suggested as alternatives to the economic optimum. An economist who responded to this controversy is Pearce who argues that biological and environmental considerations set limits to the applicability of CBA and the concept of optimal environmental damages. (Pearce 1976, Muller 1975).

The main thought in Pearce's argument is that physical environments have a definable "assimilative capacity" for pollution. For some types of waste the assimilative capacity depends on biological and physical factors (for example, biological decomposer populations). Above some critical level of waste emission, the decomposer population will not be able to regenerate, if the waste emission exceeds this level of absorptive capacity, ecological imbalance results. Consequently, the absorptive capacity itself will be reduced before the waste is decomposed. This process will continue until the assimilative capacity is destroyed and, consequently, the waste will build up in the environment.

It is in situations like this that Pearce and others question the relevance of CBA and argues in favour of biological and environmental standards as criteria for acceptable levels of pollution, instead of optimal level of pollution determined by CBA. According to these authors, the problem with the economic approach is that the optimal level of pollution, which it defines may well, exceed the assimilative capacity of the environment so generating ecological instability and, thus, entails risks of large-scale non-survival. Looked at in this way, a CBA appears to be redundant, because such analysis requires prior physical and biological knowledge of where and when waste emission will cause ecological crisis: information which EIA-reports supposedly can provide. Consequently, it is quite possible to argue, that the use of ecological standards to define assimilative capacity and limit the level of waste emission, is an efficient and practicable procedure of achieving ecological stability. However, it is not quite convincing,

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why such ecological standards have to be considered as preferred alternatives to economic optimization. (3) In fact, in general the economic optimal level of pollution should coincide with ecological standards for assimilative capacity, and not exceed them. The argument that CBA is inapplicable and/or redundant when there is incipient ecological instability is far from clear, because it is not obvious that the determination of an impact's ecological significance is easier to establish than its monetary evaluation. The ecological significance is based on a scaling/ weighting system which involves the use of value judgement at two stages:

(1) in scaling the magnitude recorded within each impact category according to some form of value function intended to indicate the relative importance of different magnitudes within any given impact category;

(2) in weighting the scaled magnitude to the relative importance of the impact category to which they belong.

Besides the fact, that some scaling/weighting systems are with technical problems, the main difficulty with them is that they include value judgements. (Lee, 1982).

In the following, various economic strategies for combating industrial pollution will be discussed.

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(3) A formal illustration of this concept will not here provided. (see Pearce 1976; Cooper, 1981 pp.43).

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4.2. Pollution Control Policies

Many theoreticians and practioners suggest a great variety of proposals for the solution to industrial pollution problems. Some of these appear more analytically elegant than practically possible, and others favour particular interest groups to the expense of others. However, common to all these proposals of abating industrial emissions is the notion that the fundamental factor underlying most environmental problems is the failure of the economic system to allocate resources efficiently because of pervasive external spillover effects of consumption and production. Given this fact, it follows that the main justification for governmental intervention in the economic system for environmental purposes should be to mitigate these external effects (i.e. pollution) and to internalize for society those effects that are external to individual households and firms. It is relatively easy to design theoretically how an elightned, efficiency-oriented government should act in a world where full information is available and at reasonable cost in order to reduce pollution and, thus, to improve the functioning of the economic system. The myriad policy proposals are mostly variants of a relatively limited number of basic policy instruments.[4]

(a) Taxes or effluent charges

In general, properly designed tax or effluent schemes are appropriate instruments of influencing resource allocation

(4) There exists an extensive body of literature on this subject. For introductory purposes see (Seneca and Taussig, 1979, Furrows 1980, Baumol and Oates, 1975).

and environmental quality. These measures rely on creating economic incentives for consumer and producer that, in conjunction with the profit motive, change economic activities. The potential aims of taxes as a general fiscal instrument are varied and could include such items as industrial emissions, incomes, factors of production, or specific outputs. Any specific tax has the effect of an economic penalty and deterrent to the taxed activity. Within this general arsenal of tax instruments, effluent charges are the particular form of taxation for the direct application to industrial pollution. The tax or effluent charge may be uniform, or it may be different for different polluters. Furthermore, the level of the charge may either be centrally determined by the government and/or pollution control agency, or be the outcome of an auction of "polluters" rights - to - pollute administered by the pollution control agency.

A per unit tax on industrial effluent discharges means that the "zero-price tag" associated with the use of environmental services for waste disposal such as air and water resources, is removed and thereby the government is narrowing the unrestricted property rights implicit in the free use of environmental services. Consequently, a policy of environmental effluent charges implies that the government or control agency formally establishes its property rights to environmental resources and sets the price that must be paid for their use. An effluent charge, therefore generates incentives for companies to assess alternative costs associated with production modifications with the purpose of avoiding the tax. The profit-motive will influence the polluter to search for a minimum - cost solution and this may result in a combination of output reduction, employing alternative and less polluting technologies, waste treatment and, maybe, payment of the effluent charge.

(b) Polluter Subsidies
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An alternative to the effluent charge is to encourage pollution abatement through the offer of a government subsidy to cover all or part of the production costs. A government offer of a subsidy of a certain amount acts as a "bribe not to pollute". The subsidy has to be viewed as an opportunity cost in terms of foregone revenues and also possesses the effect of internalizing the social costs of waste disposal. A polluter subsidy implies a fundamental difference in the structure of property rights in environmental resources from that of an effluent charge scheme, namely, the property rights of discharging waste into the environment accrue to the polluting firms. Since the government provides a payment to the polluter not to exercise his right, the industrial polluter considers waste abatement as another potentially marketable good (i.e. the selling of rights to pollute) and tries to maximize profits when the government offers the subsidy.
One major objection to a polluter subsidy scheme is that it may produce incentives to generate waste if the abatement costs are less than the per unit waste subsidy. This may even result in some firms going into the "waste-producing" business in response to the perfectly elastic demand schedule for abated waste created by the government's offer of a flat per unit polluter subsidy. Since this perverse behaviour exist, it is a strong objection against the implementation of the subsidy scheme.

zoning regulations, each site would tend to be devoted to a use that maximized the profit of the individual owner. The aggregate of such individual maximizing behavior would not necessarily lead to the most efficient use of all sites because of the importance of external costs in land development. In many situations, pollution damages tend to increase with proximity. For example, if land in a residential area were not zoned exclusively for this purpose, the owner of the potentially polluting firm might find it profitable to construct his factory into the residential area or at least threaten to do so and then demand a sufficiently large bribe paid by the threatened residents for changing his initial intension. In general, it seems that zoning is an important component of an overall national or regional planning process which intends to achieve a proper balance between the various possibilities of land uses. In principle, the zoning process would distribute tracts of land among well-planned commercial, industrial, residential and recrational land uses and then allow the market system to distribute individual sites within each of the specifically designated tracts. Thus, proper national and/ or regional land use planning would avoid the occurrence of many forms of social costs of unplanned land use development and, therefore, would contritute to achieve allocational efficiency within the regulated zoning scheme.

(e) Government Production of Environmental Services
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Production of environmental services in the public sector is another environmental policy alternative open to the government. A classic case of government provision of environmental services is the highly organized river basin authorities in Germany. The German approach of coordinating river basin authority is a rather complex institutional structure to control water pollution. The German river basin organizations are calle Genossenschaften, which means cooperative associations. Of particular interest is the Genossenschaft of the Ruhr River Valley, which is heavily industrialized with concentrations on iron, steel, and related manufacturing activities, all of which are heavy polluting industries. Furthermore, the population density is relatively high (approximately 8 million people) and the river system is a relatively small one by North American and African standards. Consequently, the river system carries an enormous amount of pollution, while simultaneously it is providing the water supply for households and industry and outdoor recreational facilities.

The management approach taken by the Genossenchaft is the main element for the success. Since river basins are treated as a whole, the Genossenschaften can take advantages of many economies of scale in water pollution technology. For example, certain sections of rivers have been zoned for recrational and amenity purposes, while other parts are used exclusively for effluent discharges. Furthermore, the Genossenschaften have also contributed to the relocation of industrial sitings, when the environmental effects of the proposed siting were considered as undesirable for water and environmental quality. Several specialized and cost-effective effluent treatment techniques have been employed.

The basic philosopny of the Genossenschaften has been to distribute the costs of pollution abatement to the sources of pollution by making use of direct effluent charges related on the type and quality of waste discharged by individual companies. The experience of this approach seems to favour a system management approach to pollution problems and a reliance on the fundamental economic principle of achieving an efficient allocation of costs. (BOWER and KNEESE. Chap.12, 1968).

In sum, if society decides to abate pollution a number of viable policy strategies exist to enhance environmental quality. However, one has to realize that the application of exclusively one strategy to all types of pollution is not feasible but rather of mix of policy strategies seems to be desirable. (5)

4.3. Measuring Pollution Damages

In the present section some issues of measuring environmental damage costs will be addressed. Economic damages due to environmental externalities can be categorized into two classes:

(a) environmental impacts may affect material outputs, or change production costs in which case damage costs are measured by the monetary value of lost production and consumer surplus; and

(b) environmental impacts may have direct effects on persons' welfare, quite aside from the effect of output losses.

In this situation, the costs, of damage are evaluated by referring to people's willingness to pay to have environmental pollution abated.

(5) A lengthy discussion of the advantages and disadvantages of the various pollution abatement strategies can here not be provided due to space limitation.

Examples of output effects resulting from environmental damages are manifold: soil degradation reduces crop yields; water pollution diminishes fish catches; air pollution in urban areas can cause bronchial illnesses; and inadequate sanitation can cause water-borne diseases.
Direct effects on persons' welfare are more elusive because they depend on individual's subjective responses to environmental impacts, but they have to be included in damage costs as well as output effects. Several output effects are associated with direct effects as well. For example, ill health reduces productivity and the incomes of the sick. But, in addition, it leads to distress to sick individual himself and to his/her families and friends. Furthermore, persons who are not even affected by the health hazard may nevertheless suffer distress because of the misery of those who are. Their welfare is reduced by the knowledge that others are ill. The utility due to these various kinds of discomfort and distress are not included by the measured output effects of illness. Unfortunately, because of the conceptual difficulties to measure them, they are frequently left out or underestimated in CBA and EIA - reports.(6)

Direct effects on individual welfare also include general disamenities. Persons put subjective valuations on the destruction of natural environments for various reasons: destruction of scenery could be an irreversible loss in itself; destruction of wilderness may represent a loss of recreation opportunities.
The relative importance of these two classes of environmental damages are likely to be different between industrialized and developing countries, because there is a high income

(6) For various methods of estimating environmental effects see Freeman, 1979.

elasticity of demand for environmental amenities which individuals consume directly (Pearson and Pryor, 1978). Though damage costs due to loss of output may be more important compared to disamenity in DCs than in ICs, it can not be concluded that disamenity and direct effects on the individual as consumer are generally unimportant.

The conceptual and empirical problems of estimating individual willingness to pay (WTP) for the prevention of environmental damage are not yet satisfactorily solved. The "free-rider problem" still represents a major difficulty and the "revealed preference" methods of estimation are only a partial solution to this problem. Furthermore, there are two additional general problems about determining WTP. The first problem refers to the fact, that it is only possible to measure total damage costs at some given level of environmental deterioration. Total damage costs, however, are an inadequate guide for establishing the optimal level of pollution, which is derived from marginal damage costs. For the measurement of the marginal damage costs, the knowledge of the shape of the total damage costs curve over a substantial range is required - a prerequisite which is seldom fulfilled (Cooper, pp.50, 1981; Krutilla and Fisher, Chap.2, 1975).

The second problem is that for many policy measures it is not only required to know the ex post estimates of damage costs, but the ex ante estimates, and these are especially difficult to determine. The replies of direct questioning and revealed preference methods are unlikely to be different from the perceptions they might have later of the disamenity value of actual environmental damage. These shortcomings and problems about the measurement of those pollution damage costs which can only be directly estimated through WTP, apply with equal weight in DCs as in ICs. Furthermore, measures of WTP create particular problems in most DCs, since the validity of the measures of 'revealed preferences' depends on complete monetisation and perfect markets, and these conditions are unlikely prevailing in DCs.

Even if relevant data on WTP can be collected, their interpretation is likely to be complicated mainly for two reasons:

(a) the income distribution is usually much less equitable in DCs than in ICs, and in many cases even viewed as politically destablizing. The aggregate of individual WTP is, however, a result of the distribution of many incomes.

(b) The WTP concept is only appropriately applicably to other types of economic organization is questionable.

In situations of most DCs, where income distribution is considered as unsatisfactory, it is just not adequate to apply directly monetary valuations in CBA of environmental impacts, without considering who loses and who gains from environmental damage and its control, and without attaching some weight on the income effects on different socio-economic groups. This relationship between WTP for a cleaner environment and various income levels has implications for economic evaluation, namely it questions the adequacy of damage costs measurements which ignore different income levels of various persons affected by pollution damages.

In addition, the measurement of WTP poses particular problems in DC, because of the difficulties that the interpretation of such date generated in only partially monetised economies.

Methods of revealed preferences' on WTP are confronted with particular problems where a significant proportion of people's income consist of goods they produce for their own use, and only a part consists of money.

Often subsistence farmers enter the market only because they need money to purchase goods they cannot produce for themselves (e.g. medical supplies). Obviously, these circumstances bear implications for the way they may respond to questions about their WTP.

Some of these problems may be reduced, if "payments" for combating environmental degradation can take the form of allocations of labour-time, for example. If this is the case, then the problem of valuation of environmental damage can be "solved" by asking individuals about their "willingness to work". However, people may be willing to contribute fully to environmental improvement through self-help schemes, provided the free-rider problem does not arise.

5. Strategy for the Use of CBA and EIA Methods for Industrial Siting

The separation of EIA-reports from economic evaluation prevents environmental impacts being considered at an earlier stage in the planning of the proposed industrial project. It is possible that this separation may tend to make planning decisions sequential by first preparing an economic feasibility study and then, at a later stage, considering the environmental impacts and their abatement. If this describes the usual planning process, then there is hardly any (or no explicit) trade-off among alternative choices made in the formulation stage of the programme and/or project, thus adding substantial inflexibility to the planning process. Consequently, the burden of proof is such that an extremely convincing case has to be made to cause changes in an industrial project since at this planning stage, the set of alternatives is already reduced and such changes at a later stage will probably also be more costly.

Thus, at the moment, EIS are often viewed more as an adversary reports than an instrument to enhance in planning process. The practice of environmental impact accounting, with little or no requirement to consider environmental and economic-trade-offs, can also lead to inconsistent treatment of environmental impacts across different projects and, therefore, result in wasteful allocations of resources. In fact, without priorities, the request for environmental data collection is very much open-ended, rather expensive and often proves of little benefit to the integrated planning process (Knetsch and Freeman, 1979).

The separation of EIA from project/programme planning may also generate conflict between the development planning team and the EIA team and thus, prove to be rather obstructive to an integrated planning process. What seems to be required for an integrated planning process, if the EIA - report are to be substantive and useful, are procedures which emphasize explicity the trade-off between measurable economic gains and more intangible environmental impacts. This connection of environmental effects to economic gains and losses could be achieved by linking the EIA to the criteria of CBA and requiring the necessity of a supported judgement.

Despite the previously mentioned shortcomings, the CBA has one major virtue - an explicit conclusion concerning the expected benefit/cost ratio. As a consequence, the awareness of this feasibility test, and the obligation to demonstrate that the evidence supports the conclusion, influences planning, from the very beginning of the project/programme, to select carefully options that reduce the costs and increase the gains.

Cost-benefit analysis as the theoretical foundation for the assessment of environmental impacts and pollution control strategies, has advanced in recent years so that even amenities and other uses of environmental impacts and other uses of environmental resources can - or at least for the most part - be expressed in monetary terms (Weisbroad, 1964; Cicchetti and Freeman, 1971).[7] A positive recommendation for

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7 However, recent contributions have extended the conventional CBA through the inclusion of the option value concept for preserving natural environments.

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implementing an industrial project implies that any negative environmental impacts are outweighed by beneficial gains to other objectives and considerations, or that any positive environmental impacts outweigh any negative effects on economic welfare or other social-political objectives. Thus, a decision rule of such an integrated planning approach would require that recommendations for decisions to proceed with a project/programme include an explanatory statement that the net economic benefits of the industrial project under consideration exceed any negative environmental impacts, or that the negative economic benefits are exceeded by the expected, positive environmental benefits. In this exercise of value comparison, the EIA - report would become central.

The integration of these two concepts according to the suggested comparison, would force the decision-makers and planners to demonstrate that the benefits exceed the costs. Furthermore, it also provides a point of orientation for the collection of required information and leads to interdisciplinary cooperation.

Any statement of the relative values would be required to be substantiated by details of evidence and assumptions used to justify implementation of the project. This evidence should be arranged in such a way as to clearly illustrate a comparison of the net economic gain with any negative environmental effects. This comparison would require the following steps:

(a) to identify the potential effects on the environment associated with the project alternative under consideration;

(b) to assess the nature of values associated with the identified effects and separate quantifiable values (usually expressed in monetary terms) from non-quantifiable values; and

(c) to state necessary assumptions to support a judgement of economic and environmental justification of project choice over others, including the assumptions of how values are expected to change over time in response to

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changes in demands for both project outputs and uses of natural environment.

An important element in this comparison is the assumption of values concerning the time paths of expected benefits of preserving resources and alternative development projects. Thus, the analysis would illustrate any expected change in the field of benefits over time from each of the alternative options and show how these assumed growth-paths lead to the conclusion reached about the relative values of environmental and developmental benefits. The respective time path has to include:

(a) the expected life of any facilities related to alternative development;

(b) changes in the demands for any of the commodities of each alternative over time (including any other possible consideration that would affect the flow of benefits over time);

(c) the degree of available substitutes for commodities to be produced as a result of the suggested project (including those stemming from non-development); and finally,

(d) the consequences of any irreversible characteristic of change in the use of the resources being considered (Krutilla and Fisher, 1975).[8]

The necessity of explicit statements on the economic desirability of the project, and the associated judgement that any identified environmental costs are less than the net economic gains (thus presuming it to be the most efficient choice), require the decision makers and planners to arrange the information and to make an explicit judgement about the values involved. The suggested strategy, of explicitly noting the economic and environmental trade-offs, lends itself to efforts to account for changing values associated with natural areas, or other unique environmental assets.

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[8] This approach was developed and successfully employed by Krutilla and Fisher in the Hells-Canyon Case. U.S.A

6. Conclusion

Looking at the environmental management system as a whole in general and at industrial sitings in particular, they reveal their appalling complexity. Many of its components are not yet fully understood and require substantially more research efforts. Obviously, it would be ideal if this system were fully comprehended before implementing environmental policies. The knowledge of abatement costs for several types and sources of pollutants is sketchy, the current available information on the value of pollution costs is almost non-existant for many exotic forms of pollution. The valuation of pollution costs requires both information on the magnitude of the damage measured in physical units and an accepted means of converting these into a common unit of measurement, namely monetary values. Many of these problems, such as evaluation methods of pollution damages and decision-making under uncertainty and lack of information despite their importance were here only briefly mentioned and/or omitted due to time and space limitations.

Since environmental policy cannot await perfect knowledge - an unrealistic demand -, we must use the available considerable insights we have gained from a more partial view of the environment, knowing its imperfections, to improve policy and management of environmental quality. Up to this point, we have to realize, that governments and decision-makers have not even made good use of what is already known - especially what is known of the economic nature of the environmental problem.

If society decides to control industrial pollution, a large number of policy strategies and quantitative methods, for example CBA and EIA, are available to achieve improvements of environmental quality and were discussed above.

From the presented analysis follows, that several steps are urgently required. Although they alone are in themselves not sufficient, but they definitely will push environmental policy and management in the right direction:

(a) Wherever possible, pollution control instruments should be imposed on the use of environmental services for waste disposals.

(b) Institutions should be established to manage whole river basins and airsheds as an integrated environmental system.

(c) The functioning and the power of the legal process should be improved.

(d) Government support for research on all aspects of the environment should be funded adequately.

(e) The political decision-making process should be improved so as to increase its accessibility, accountability and representativeness for the public.

This set of steps are the minimal requirements for a more efficient environmental policy. The challenge of environmental destruction, however, requires basic and substantial changes in our present way of doing things.

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EFFLUENT MONITORING AND POLLUTION CONTROL
IN THE LAKE BASIN CATCHMENT AREA

BY

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INTRODUCTION

Pollution is the introduction into the environment (air, water or land) of contaminants, the quantities, characteristics, and durations of which are likely to be injurious to human's, animal's and plant life.

It is the concern of the Ministry of Health to protect human health and to create a healthful environment. In areas where population concentration is likely to grow rapidly and in areas which are becoming industrialised - as is the case with the Lake Victoria Basin and its Catchment areas - maintenance of a healthful environment calls for careful monitoring of the impact of Effluent discharge and Pollution on the said environment.

ECOLOGY AND CHANGE

Ecology is the science dealing with the inter-relationship of living organisms and their surroundings. The earth, its surrounding envelope of life - giving water and air, and all its living things comprise the Biosphere.

However man's total environmental system include not only the Biosphere but also his interactions with his natural and manmade surroundings.

Changes in ecosystems occur continually. Many interactions take place at every moment of the day as plants and animals respond to variations in their surroundings and to each other. Since interactions are so numerous, they form long chains of reactions so small changes in one part of the ecosystem are likely to be felt.

Dramatic examples of change can be seen where man has altered the course of nature. It is vividly evident in his economic far-reaching intentions which are often poorly thought out and which ultimately tamper with river and lake ecosystems. The Aswan Dam for example was primarily built to generate electric power. It produced power but it also increased the fish population, increased the number of disease bearing aquatic snails, and markedly lowered the fertility of the Nile valley below.

The lesson is not that such activities as the Aswan Dam should be stopped, rather that the consequences of such construction projects - or for that matter starting any project, must be carefully studied and understood before construction planners and managers embark on its implementation. They must appreciate the enormous interrelated complexity of the environment, weith and compare potential environmental harm against the benefits of such undertakings; look at alternatives, and incorporate environmental safeguards into the basic design/planning of new projects.

TYPES OF POLLUTION

Although pollution may be the most prominent and immediately pressing environmental concern, it is only one facet of environmental problems. It is usually a highly visible, and sometimes dangerous sign of environmental degredation. Pollution threatens natural systems, human health, and aesthetic sensibilities.

Historically, man has assumed that the land, water and air around him would absorb his waste products without limits. The Oceans, lakes, rivers, the atmosphere and even the earth were viewed as receptacles of infinate capacity. It is quite clear now that man may be exceeding natures capacity to assimilate his wastes.

Most pollutants eventually decompose and diffuse throughout the environment. When organic substances are discarded, they are attacked by bacteria and decompose. However some synthetic products of our advanced technology resist natural decomposition. Plastics, some cans and bottles, as well as various persistent chemicals such as pesticides fall into this category. Many of these materials are toxic and pose serious dangers to health.

Some pollutants which may be thinly spread throughout the environment tend to concentrate in natural food chain.

When pesticides diffuse in water, many water animals filter cut particular kinds of chemical compounds, including pesticides, and accumulate them in certain parts of their bodies. Such accumulations are usually at concentrations far higher than in the water they live in. In turn, higher concentration may occur in the birds or mamals that have eaten the fish When the accumulation of the toxic substances reaches a high enough level, it may kill the mamal/bird directly or interfere with its reproductive system or otherwise.

Water pollution is a problem throughout the world. It is however most acute in densely settled or industrial section of our communities. Organic wastes from municipalities and industries enter rivers, lakes and oceans where they are attacked and broken down by organisms in the water. But in the process, oxygen in the water is used up. Nutrients from cities, farms, etc. nourish the algae, which also use up oxygen when they die and decompose. And when oxygen is taken up from the water, the river "dies". The oxygen is gone, the fish disappear, plants rot, and the stench of decay reaches for miles. - This is a situation which we should never reach and all efforts should be exploited so as to prevent it.

THE MINISTRY'S OBJECTIVES

In the Lake Basin and for that matter in the entire country, the Ministry of Health has a duty to ensure that all the existing and planned factories (Industries) do not cause pollution to their immediate environment. To achieve this we have officers in all the districts who are charged with the duties of monitoring effluent discharge into the environment. This is being well coordinated from the national level to ensure uniformity

RESPONSIBILITY

The Law is a formal expression of policy and discussions of the Government, and the means by which it discharges its functions. The Ministry of Health has powers under the Public Health Act (Cap. 242) .... to maintain a healthful environment by controlling pollution, controlling and preventing occupational diseases, and looking into the welfare of the people of this country.

Section 118 of the same act goes on to define what constitutes a nuisance. In Sub-section (c) it says: "Any noxious matter, or waste water, flowing or discharged from any gutter or side channel of any street, or into any nullah or watercourse, irrigation channel, or bed thereof not approved for the reception of such discharge" is nuisance. Similarly the Act provides in sub-section (q) of the same section that "any chimney sending forth smoke in such quantities or in such manner as to be offensive or injurious or dangerous to health," is a nuisance.

In section 115, 116 and of the same Act it provides that "No person shall cause a nuisance or shall suffer to exist on any land or premises owned or occupied by him or of which he is incharge any nuisance or/other conditions liable to be injurious or /any dangerous to health". Subsequently the Act provides that it is the duty of the Local Authority to maintain their districts in clean and sanitary condition at all times. They shall in so doing "take all lawful, necessary and reasonably practicable measures for preventing or causing to be prevented or remedied all conditions liable to be injurious or dangerous to health ......".

The Ministry of Health has identified foecal pollution in the Lake Basin Catchment Area as frightfully high. This is due to the high population density In some areas, the soil is lose, the water table is high and in others it is swampy. This presents a great problem in our efforts to dispose of the foecal matter sanitarily. As a result foecal, contaminants (pathogenic organisms) find their way either through runoff water, or to a lesser degree, through underground water into our valuable bodies of water. This is possibly why we have high incidents of enteric fevers within the Lake Basin.

The Ministry of Health has undertaken to improve foecal matter disposal. We have developed a new technology in pit latrine construction which we are convinced is suitable for such conditions. A pilot project has been planned and is now in the early stages of implementation in Busia District where we have very lose soil and high water tables. This project will be progressively extended to cover the entire country.

We realise however that there are differing social behaviours of the people within these areas and that this can defer our efforts and expectations. It is with this in mind that we have intensified our health education programmes within these areas. We hope to motivate the people to accept change and realise the need to use these facilities.

The Ministry also realises that water is very important if efforts to improve sanitation were to be fruitful. We have supported and will continue to support small scale self help water projects within the Lake Basin catchment area with availability of funds.

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C O N C L U S I O N

In a country like Kenya, much can be done to reverse the trend of environmental degradation. This calls for the participation of all. Individuals, industries and all levels of government can be called upon to act in ways which will improve environmental quality.

It is however clear that long-range environmental improvement must take into account the complex interactions of environmental processes. In the future the effects of actions on complete ecosystems must be considered if environmental problems are to be managed and solved in a more systematic manner. Each environmental problem must not be treated in an ad hoc fashion. The strong, existing interactions between various parts of the problem must be neglected or ignored. Even today most environmental problems are only dealt with temporarily, in a piecemeal way and often only after they have become critical. It is important to recognise the fact that the environment cuts across established institutions and disciplines and that it is our duty to prevent and safeguard environmental degradation. I would therefore call upon every one in this country to devote all necessary energy in the PREVENTION of environmental degradation. After all "Prevention is better than Cure".

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DISCUSSION

Q. The Ministry of Health is trying to get rid of foecal pollution, you say, but what is the procedure for achieving the goal?

A. The Ministry of Health has encouraged pit latrines but there has been a number of problems. Population has been increasing rapidly. Secondly, there are ethnic taboos and these have reduced the use of pit latrines.

There has been a physical problem. In most of Nyanza the soil is loose and pit latrines collapse very easily. Therefore, we have pilot projects in pit latrine technologies. As stated above, the pilot project has started with Busia District.

Q. Ministry of Health and Ministry of Water Development seem to have same goals. Has the Ministry of Health attempted projects in dealing with pollution in lower plains where flooding is a problem?

A. Ministry of Health has tried public education to increase awareness of the problems of sanitation. These educational centres are still in process.

The question of floods is one that Ministry of Health cannot deal with alone. Until we have technology for effective control of floods the problems will remain. Cholera cases tend to increase with rainy seasons and this is an area where both Ministries must cooperate.

COMMENT: The LBDA ought to establish a special programme of cholera control, but in actual fact the Ministry of Water Development should provide safe water supply for the rural areas. It seems that this is a more urgent and immediate problem than tsetse extermination.

Projects on shallow wells that are particularly protected is under way and a number are already in Kano.

As to lose soil question, there are reinforcement stabs which can be used to prevent collapse. This can be done

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and their technology is well known. Their construction ought to be commenced in the Authority area.

There are also transterritorial transfer of cholera from neighbouring Tanzania and Uganda. These characteristics necessitates a regional concerted effort. But these require finances and political goodwill.

Q. How will the Ministry of Health deal with the question of ethnic taboos?

A. There are repeated appeals to the population during times of crisis. When there are outbreak the population is easier to convince and we have often conducted campaigns to explain the need for use of latrines.

COMMENT: Cholera immunization gives minimal percentage of immunity. Therefore, Ministry of Health prefers to concentrate on public education campaigns. Immunization is still being conducted but to a small extent. The immunization duration for cholera is only six months, and people do not like it. Besides, it is costly. Therefore, the Government has concentrated on the latrines and education as the preferred approach.

Ventilated improved latrines (VIP Latrines) has been tried in Zambia and it is an approach that needs study as one of the new technologies.

These the so-called VIP latrines have been tried in Kenya. Ventilation is to keep down the smell. This has the advantage of keeping out the breeding of mosquitoes (filariasis causing mosquitoes). It therefore has an advantage.

COMMENT: The cost of pit latrines in the rural areas must be taken into account. There are so called "mount latrines" for areas of high water level but it has serious limitations.

The country ought to focus on delivery of safe water supply as the surest way to prevent water borne diseases.

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PRETREATMENT FOR THE DISCHARGE OF INDUSTRIAL WASTES
INTO MUNICIPAL SEWERAGE SYSTEMS

BY

PHILIP C. SINGER

I. PRETREATMENT PROCESSES

A. EQUALIZATION

1. For industrial plants which have a highly variable wastewater, either in quantity or quality.

   a) OBJECTIVE: to release an effluent to the municipal system, or to the industrial waste treatment plant, that is much more consistent in its characteristics than each of the component waste streams that are discharged from the plant. (See Figure I.)

   b) Especially suitable for plants which have many products and a diversity of wastewaters, e.g. textiles.

   c) Stabilization of pH and BOD, and removal of heavy metals and suspended solids can be achieved effectively through equalization.

   d) Equalization consists of the construction of a holding basin with a retention time equal to the frequency at which the process streams vary.

   e) Simply holding the waste is not sufficient to equalize it. Each unit of waste must be adequately mixed with the contents of the equalization basin.

B. SEGREGATION

1. Segregation of waste streams from different processes in an industrial plant may reduce the strength and the difficulty of treating the final waste from the plant.

   a) Segregation usually results in the generation of concentrated waste streams which are small in volume and weaker wastes with almost the same volume as the original unsegregated waste.

   b) The concentrated wastes, in small volume, can usually be processed economically using methods specific to that waste stream.

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c) In many instances, segregation of concentrated waste streams may result in the recovery of raw materials.

d) The segregation of a concentrated waste may render the major part of the waste remaining more amenable to conventional, inexpensive forms of treatment.

e) Segregation of cooling water and storm water from process wastewater may result in appreciable savings.

C. NEUTRALIZATION

1. Acidic or alkaline wastes can adversely affect receiving streams and biological waste treatment processes.

   a) pH values between 6 and 9 are usually required prior to discharge either into a stream or a municipal sewer.

2. Procedures for neutralizing acidic or alkaline wastes.

   a) Mixing of acidic and alkaline waste streams.

   b) Addition of lime (CaO) or limestone ($CaCO_3$) slurries to neutralize acidic wastes.

      i) $CaO\ (S) + H_2O \qquad Ca^{+2} + 2OH^-$

      ii) $CaCO_3\ (S) + H^+ \qquad Ca^{+2} + HCO_3^-$

      iii) If the waste contains high concentrations of sulfate, calcium sulfate (gypsum) will precipitate, requiring sludge disposal.

      $$Ca^{+2} + SO_4^{-2} \qquad CaSO_4\ (S)$$

   c) Addition of soda ash (Na_2CO_3) or caustic soda (NaOH) to neutralize acidic wastes.

      i) These alkaline agents are usually more expensive than lime or limestone, but are easier to handle.

   d) Passate of acidic wastes through limestone beds.

e) Addition of CO_2, either from compressed cylinders or waste boiler flue gas (~14% CO_2) can neutralize alkaline wastes.

f) Addition of sulfuric acid to neutralize alkaline wastes.

D. COAGULATION AND PRECIPITATION

1. The addition of coagulants such as alum ($Al_2(SO_4)_3 \cdot 18H_2O$), ferric sulfate ($Fe_2(SO_4)_3$), ferric chloride ($FeCl_3$), or lime ($CaO$) can bring about the destabilization of collodal particles (particles 1 mu to 1 u in size) which allows them to grow to a size whereby they can be readily removed by sedimentation. (See Table I).

   a) Mixing facilities are required to rapidly disperse the coagulant through the wastewater. Such dispersal can be readily achieved in turbulent regions of flow, e.g. venturis, Parshall flumes.

   b) Gentle mixing, or flocculation, is required to promote collisions between the destabilized particles, thereby allowing them to grow into a larger, settleable floc. This can usually be achieved effectively using a baffled flocculation chamber.

   c) Alum and the ferric salts are acidic compounds; lime is an alkaline agent.

   d) Coagulants have been used effectively to remove dyes from textile wastewaters, lignin from wood-processing wastewaters, proteinaceous material from animal-processing wastewaters, heavy metals and other inorganic species such as arsenic and fluoride from a wide variety of industrial wastewaters.

      i) Many metals are quite insoluble at neutral pH. When found at high concentrations in acidic wastewaters, they can be rendered insoluble, as hydroxides or carbonates, by simply raising the pH. The solids generated can then be chemically coagulated and removed by sedimentation.

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e) The sludge generated by coagulation and sedimentation must be disposed of. If the sludge contains potentially hazardous material, disposal in a secure landfill may be necessary in order to prevent seepage into ground or surface waters.

f) Synthetic organic polymers (either cationic, anionic, or nonionic) can also be used to bring about coagulation of colloidal particles, at much lower dosages, thereby resulting in possible cost-savings (although the polymers are appreciably more expensive than alum, lime, or ferric salts) and producing less sludge to be ultimately disposed of. (See Table II)

E. MISCELLANEOUS PRETREATMENT METHODS

1. Oxidation-recuction chemical treatment.

a) Reduction of Cr (VI) to Cr (III) using SO_2, SO_3^{-2}, or ferrous sulfate under acidic conditions. The Cr (III) is subsequently precipitated as chromium hydroxide by raising the pH back to neutrality. (See Figure II)

b) Oxidation of CN^-, under alkaline conditions, using chlorine. (See Figure III)

2. Solvent extraction.

a) Removal/recovery of specific contaminants from concentrated waste streams in order to render the wastewater more amenable to subsequent treatment or to recover valuable by-products.

i) Extraction of phenol from coke oven wastewaters using butylacetate or di-isopropyl ether.

II. REGULATION OF PRETREATMENT REQUIREMENTS AND SEWER USE

A. CONTENTS OF A SEWER USE ORDINANCE
(A Sewer Use Ordinance Checklist is attached)

1. Introduction
2. Definitions

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a) For example:

Biochemical Oxygen Demand -
Cooling Water -
Compatible Pollutants -
Director (Superintendent) -
Domestic Wastes -
Garbage -
Incompatible Pollutant

3. Prohibitions and Limitations on Wastewater Discharges

a) Prohibitions - oil and grease, explosive mixtures, noxious material, improperly shredded garbage, radioactive wastes, solid or viscous wastes etc.

b) Limitations - specific concentration or mass limitations on arsenic, barium, boron, cadium, chromium (trivalent, hexavalent), chlorinated hydrocarbons, copper, cyanide, etc.

4. Control or Prohibited Wastes

a) Regulatory actions, submission of plans, pretreatment facilities operation, admission to property, protection from accidental discharge, reporting of accidental discharge.

5. Industrial Wastewater Monitoring and Reporting

a) Discharge reports, records and monitoring, inspection, sampling, and analysis.

6. Industrial Discharge Permit System.

a) Wastewater discharge permits required, permit application, permit conditions, duration of permits, transfer of permits, revocation of permits.

7. Enforcement procedures

a) Notification of violation, show cause hearing, legal action, penalty, costs.

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FIGURE I

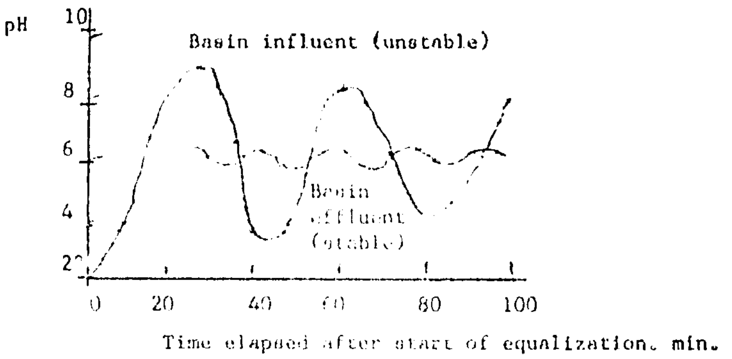

TABLE I PROPERTIES OF COMMON COAGULANTS

Common Name	Formula	Equiv. weight	pH at 1%	Availability
Alum	$Al_2(SO_4)_3 \cdot 14H_2O$	100	3.4	Lump - 17% Al_2O_3
Lime	$Ca(OH)_2$	40	12	Lump - as CaO Powder - 93-95% Slurry - 15-20%
Ferric Chloride	$FeCl_3 \cdot 6H_2O$	91	3-4	Lump - 20% Fe Liquid - 20%Fe
Ferric Sulfate	$Fe_2(SO_4)_2 \cdot 3H_2O$	51.5	3-4	Granular - 18.5% Fe
Copperas	$FeSO_4 \cdot 7H_2O$	139	3-4	Granular - 20% Fe
Sodium aluminate	$Na_2Al_2O_4$	100	11-12	Flake - 46% Al_2O_3 Liquid - 2.6% Al_2O_3

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FIGURE II - BATCH CHLORINATION OF CYANIDE WASTES. (AFTER ORSANCO (156))

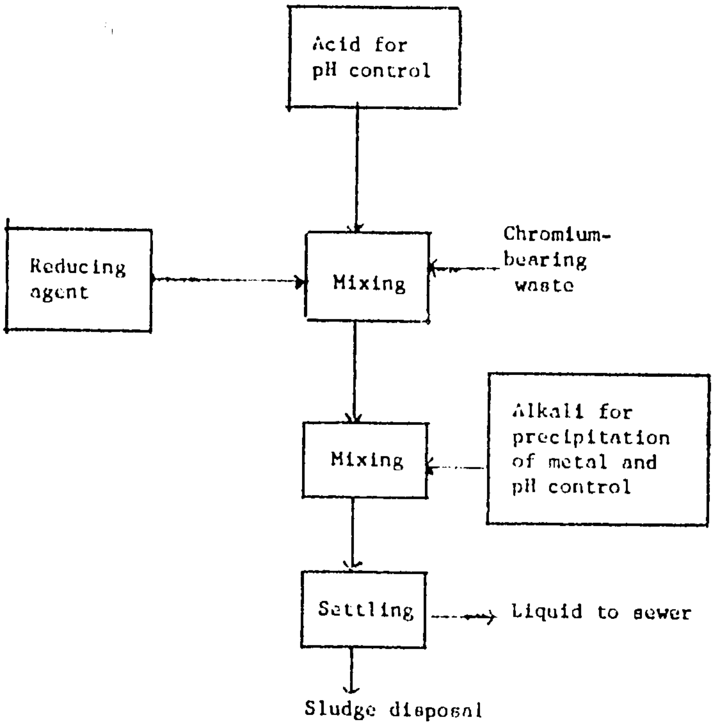
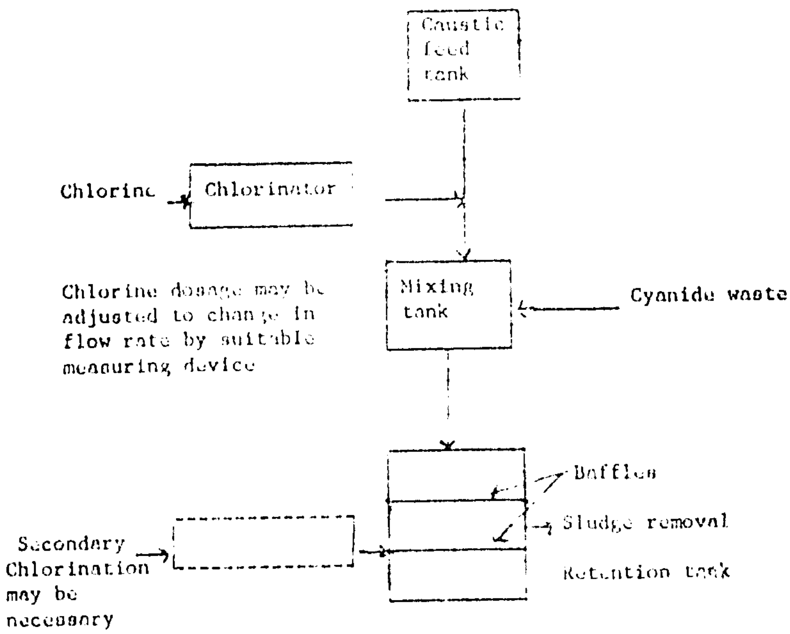


TABLE II - SOME CHARACTERISTICS OF ORGANIC POLYMERS

CLASS	MOL. WT. RANGES	FORM AND AVAILABILITY
1. Cationic coagulants Polyamines Polyquaternaries PolyDADMAC Epi-DMA	Below 100,000	All are available as aqueous solutions
2. Cationic Flocculants Copolymers of: Acrylamide and DMAEM Acrylamide and DADMAC Mannich amines	Over 1,000,000	Powders or emulsions
3. Nonionic Flocculants Polyacrylamides Copolymers of acrylamide and acrylate	Over 1,000,000	Powders or emulsions

NOTE: DADMAC: diallyl-dimethly ammonium chloride
Epi: epichlorhydrin
DMA: dimethylamine
DMAEM: dimethyl-aminoethyl-methacrylate

FIGURE III - CONTINUOUS CHLORINATION OF CYANIDE WASTES. (AFTER ORSANCO (156))



SEWER USE ORDINANCE CHECKLIST REVIEW

Grantee ______________________________ Project No. ____________________

1. INTRODUCTION (Brief statement on the purposes, jurisdiction, and scope of the Ordinance, with reference to penalties for violation if such are to be imposed).

2. DEFINITIONS (Given to clarify the intent of all parts of the Ordinance, eliminating differences of interpretations).

3. REGULATIONS REQUIRING USE OF PUBLIC SEWERS (Where available) (Primarily set up to prevent unsanitary wastewater disposal facilities that eventually lead to public health hazards.)

   A. "Reasonable Accessibility" clause - (clause requiring connection to public sewer system if property owner's property line is within X number of feet of the public sewer.)

   B. "Compliance Time" clause - (a customary clause that provides the property owner with proper notice that he is being requested to provide a connection to the public sewer. Compliance time, a reasonable time allowance for completion of the work, usually varies from 30 to 90 days. The longer time limits are usually allowed for installation of toilet facilities and plumbing when necessary.)

4. REGULATIONS CONCERNING PRIVATE SEWAGE DISPOSAL (where public sewers are not available)

   A. Clause prohibiting privies, cesspools and septic tanks in sewer service areas.

   B. Clause prohibiting the discharge of septic tank effluent or cesspool overflow to any open drain, ditch, stream or well penetrating water-bearing formations if cesspools and septic tanks are allowed in sparsely settled incorporated areas.

   C. Clause giving specifications or minimum lot area that can be approved for a private sewage disposal facility.

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D. Clause giving authority to municipality to approve or reject private sewage disposal facilities in accordance with a standard set of plans and specifications for installation of such facilities. Permits for these facilities should be issued when approved and periodic inspections should be made by the plumbing inspector or the local health department, depending on who issues the permits.

5. REGULATIONS CONCERNING THE BUILDING OF SEWERS AND CONNECTIONS (Building sewer regulations are properly covered in plumbing and building codes, and should be included in the sewer use ordinance only if they do not appear elsewhere in the city code.)

A. Clause requiring Permit for building sewers. Clause authorizes proper authority to approve permit as well.

B. Clause requiring separate building connections to sewers except by special permits for unusual cases.

C. Clause prohibiting new connections to the sanitary sewer system from inflow sources. (Satisfies Title II Regulation 35.927 - 4)

D. Clause designating responsibility for the proper installation of building sewers (to the proper authority).

E. Clause introducing costs for processing sewer applications and connection inspections.

F. Clause concerning the reuse of existing building sewers.

G. Clause concerning the minimum grades and sizes for building sewers.

H. Clause giving specifications for building sewer materials.

I. Clause prescribing approved building sewer construction procedures.

J. Clause requiring that all pertinent OSHA requirements be met.

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6. REGULATIONS RELATING TO RATE OF DISCHARGE AND CHARACTER OF WATERS AND WASTES ADMISSIBLE TO PUBLIC SEWERS

A. Clause prohibiting discharge or surface runoff waters into sanitary sewer system when separate storm and sanitary systems are available.

B. Clause prohibiting discharge of sanitary wastewater into storm sewer system without exception.

C. Clause prohibiting ground paper products from being discharged into the sewer system. Also, more specific rules, regulations and requirements concerning grinders and their use should be set forth.

D. Clause limiting or prohibiting the discharge of all waters that would damage or interfere with the operation of the treatment works. (Industry should be discouraged from diluting their wastes with uncontaminated water.)

E. Clause excluding certain wastes which prove to be detrimental to the sewer system (wood, glass, fire or explosion hazards, ashes, sand, cinders, unshredded garbage, etc.).

F. Clause prohibiting the discharge of flammable substances or materials that obstruct the flow in public sewers.

G. Clause allowing discharge of uncontaminated cooling water to storm sewer system (added volume of unpolluted volume increases pumping costs, and reduces detention periods of settling tanks, aeration units, etc.)

H. Clause limiting the temperature of wastes and wastewater introduced into the sanitary sewer system.

I. Clause limiting or prohibiting the amounts of oil and grease that may be introduced into the sanitary sewer system.

J. Clause limiting the pH of various substances and materials introduced into the sanitary sewer system.

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K. Clause requiring the establishment of characteristics of normal domestic wastes parameters to be used in the definition of the lower limit of any applicable US/ICR Subchargers.

7. REGULATIONS CONCERNING PRETREATMENT OF INCOMPATIBLE POLLUTANTS BY INDUSTRIAL USERS

A. Clause requiring all industrial users to meet pretreatment requirements of BPT if they are discharging incompatible or toxic pollutents (see Federal Register, dated November 8, 1973, Pretreatment Standards). For P. L. 92-500 projects this is a contract condition; for 660 projects, this is a contract condition, compliance with the pretreatment requirements must be met by July 1, 1977.

Note: Pretreatment requirements must be met by all projects, in order to meet NPDES permit conditions for July 1, 1977.

8. REGULATIONS RELATING TO SAMPLING AND ANALYSES (Clause allowing sample collection and analyses and flow measurement by the proper authority under municipal jurisdiction).

9. SPECIAL REGULATIONS (if any)

A. Clause concerning service to adjacent unincorporated areas.

B. Clause concerning punitive action and penalties due to malicious damage to treatment works and all appurtenances.

C. Clause requiring the incorporation of User Charge Industrial Cost Recovery in other municipal legislative enactment if not incorporated in the present ordinance.

10. PROVISION FOR POWER AND AUTHORITY FOR INSPECTORS

A. Clause designating Administrative Authority (under municipal jurisdiction) to handle treatment works responsibilities.

B. Clause empowering duly appointed officials to enter private property for the purpose of making inspections and tests.

11. ENFORCEMENT AND PENALTIES (to make Ordinance effective) (Clause setting forth and explaining all penalties, fines and prosecution procedures).

12. LEGAL REQUIREMENTS (to protect the Ordinance's validity)

   A. Validity (or Contract) Clause

   B. Enacting Clause - clause giving effective date of legal enforcement of the Ordinance.

   C. Passage - signatures of proper authorities and Attest.

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INDUSTRIAL WASTES: - A SUMMARY

Reference: McGauhey, PH, Engineering Management of Water Quality, McGraw-Hill Book Co., New York (1968)

Table 5-5 Types of industrial wastes and principal industries producing each type

Chiefly mineral, or partly mineral-partly organic materials	Chiefly organic materials
Brine wastes	Hydrocarbons:
Mineral washings, e.g. stone sawing, sand and china clay wash	Oil wells
Mine drainage (coal pit water)	Petroleum refining
Pickle liquor (Fe, Cu, and Zn)	Styrene manufacture
Electroplating	Butadiene plants
Water softening	Processing natural rubber
Cooling water	Gasoline stations, garages
Boiler blow off	Copolymer rubber plants
Inorganic chemical wastes	Miscellaneous organic chemicals:
Battery manufacture	Munition plants
Inorganic pigments	Synthetic pharmaceuticals
Coal washing	Synthetic fibers
Photographic wastes	Organic chemical manufacture
	Paints and varnishes
	Oil and grease processing
	Phenolic wastes:
	Gas and coke byproducts
	Tar distillation and creosoting
	Chemical plants
	Synthetic resin plants
	Wood distillation
	Dye manufacture
	Biological wastes:
	Biological processing
	Tanneries and leather tra
	Pharmaceuticals
	Alcohol industries
	Misc. fermentation industr
	Glue, size, and gelatin plants

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Table 5-5 Continues

Chiefly mineral, or partly mineral-partly organic materials	Chiefly organic materials
	Biological wastes:
	Biological processing
	wool scouring
	Textile manufacture
	Floor cloth manufacture
	Paper manufacture
	Laundries
	Food processing
	Canneries
	Meat packing etc.
	Milk and dairy wastes
	Corn products plants
	Beet sugar factories
	Cane sugar factories
	Fish processing
SOURCE: Ettinger (7). Reproduced by permission of the publisher	Food dehydration

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Table 5-6 Some significant chemicals in industrial waste waters

Chemical	Industry
Acetic acid	Acetate rayon, pickle and beetroot manufacture
Alkalies	Cotton and straw keiring, cotton manufacture, mercerizing, wool scouring, laundries
Ammonia	Gas and coke manufacture, chemical manufacture
Arsenic	Sheep-dipping, fell mongering
Chlorine	Laundries, paper mills, textile bleaching
Chromium	Plating, chrome tanning, aluminium anodizing
Cadmium	Plating
Citric acid	Soft drinks and citrus fruit processing
Copper	Plating, pickling, rayon manufacture
Cyanides	Plating, metal cleaning, case-hardening, gas manufacture
Fats, oils, grease	Wool scouring, laundries, textiles, oil refineries
Flourides	Gas and coke manufacture, chemical manufacture fertilizer plants, transistor manufacture, metal refining, ceramic plants, glass etching
Formalin	Manufacture of synthetic resins and penicillin
Hydrocarbons	Petrochemical and rubber factories
Hydrogen peroxide	Textile bleaching, rocket motor testing
Lead	Battery manufacture, lead mining, paint manufacture, gasoline manufacture
Mercaptans	Oil refining, pulp mills
Mineral acids	Chemical manufacture, mines, Fe and Cu pickling, DDT manufacture, brewing, textiles, photoengraving, battery manufacture
Nickel	Plating
Nitro compounds	Explosives and chemical works
Organic acids	Distilleries and fermentation plants
Phenols	Gas and coke manufacture, synthetic resin manufacture, textiles, tanneries, tar, chemical, and dye manufacutre, sheep-dipping

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Table 5-6 continues

Chemical	Industry
Silver	Plating, photography
Starch	Food, textile, wallpaper manufacture
Sugars	Dairies, foods, sugar refining, preserves, wood process
Sulfides	Textiles, tanneries, gas manufacture, rayon manufacture
Sulfites	Wood process, viscose manufacture, bleaching
Tannic acid	Tanning, sawmills
Tartaric acid	Dyeing, wine, leather, and chemical manufacture
Zinc	Galvanizing, plating, viscose manufacture, rubber process

SOURCE: Klein (8). Reproduced by permission of the publisher

Table 5-7 BOD of wastes from selected industries

Source of waste	5-day, 20°C BOD of waste mg/liter
Beet sugar refining	450-2,000
Brewery	500-1,200
Beer slop	11,500
Cannery	300-4,000
Grain distilling	15,000-20,000
Molasses distilling	20,000-30,000
Laundry	300-1,000
Milk processing	300-2,000
Meat packing	600-2,000
Pulp and paper	
Sulfite	20
Sulfite-cooker	16,000-25,000
Tannery	500-5,000
Textiles	
Cotton processing	50-1,750
Wool scouring	200-10,000

Table 5-9 - Summary of industrial waste: its origin, character, and treatment

Industries Producing wastes	Origin of major wastes	Major characteristics	Major treatment and disposal methods
		Food and drugs	
Canned goods	Trimming, culling, juicing, and blanching of fruits and vegetables	High in suspended solids, colloidal and dissolved organic matter	Screening, lagooning, soil absorption or spraying irrigation
Dairy products	Dilutions of whole milk, separated milk, buttermilk, and whey	High in dissolved organic matter, mainly protein, fat, and lactose	Biological treatment, aeration, trickling filtration, activated sludge
Brewed and distilled beverages	Steeping and pressing of grain, residue from distillation of alcohol, condensate from stillage evaporation	High in dissolved organic solids, containing nitrogen and fermented starches or their products	Recovery, concentration by centrifugation and evaporation, trickling filtration; use in feeds
Meat and poultry products	Stockyards, slaughtering of animals, rendering of bones and fats, residues in condensates, grease and wash water, pickling of chickens	High in dissolved and suspended organic matter, blood, other proteins, and fats	Screening, settling and/or floation, trickling filtration
Beet sugar	Transfer, screening and juicing waters, draining from lime sludge, condensates after evaporator, juice, extracted sugar	High in dissolved and suspended organic matter, containing sugar and protein	Reuse of wastes, coagulation, and lagooning
Pharmaceutical products	Mycelium, spent filtrate, and wash waters	High in suspended and dissolved organic matter, including vitamins	Evaporation and drying, feeds

Table 5-9 - Summary of industrial waste: its origin, character, and treatment (continues)

Industries producing wastes	Origin of major wastes	Major characteristics	Major treatment and disposal methods
		Food and drugs (continued)	
Yeast	Residue from yeast filtration	High in solids (mainly organic) and BOD	Anaerobic digestion, trickling filtration
Pickles	Lime water; brine, alum and turmeric, syrup, seed and pieces of cucumber	Variable pH, high suspended solids, color, and organic matter	Good housekeeping, screening equalization
Coffee	Pulping and fermenting of coffee bean	High BOD and suspended solids	Screening, settling and trickling filtration
Fish	Rejects from centrifuge, pressed fish, evaporator and other wash water wastes	Very high BOD, total organic solids, and odor	Evaporation of total waste, barge remainder to sea
Rice	Soaking, cooking, and washing of rice	High in BOD, total and suspended solids (mainly starch)	Lime coagulation, digestion
Soft drinks	Bottle washing, floor and equipment cleaning, syrup-storage-tank drains	High pH, suspended solids and BOD	Screening, plus discharge to municipal sewer

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Table 5-9 Summary of industrial waste: its origin, character, and treatment

Industries producing wastes	Origin of major wastes	Major characteristics	Major treatment and disposal methods
		Apparel	
Textiles	Cooking of fibers, desizing of fabric	Highly alkaline, colored, high BOD and temperature, high suspended solids	Neutralization, chemical precipitation, biological treatment, aeration and/or trickling filtration
Leather goods	Unhairing, soaking, deliming and bating of hides	High total solids, hardness, salt, sulfides, chromium, pH precipitated lime and BOD	Equalization, sedimentation, and biological treatment
Laundry trades	Washing of fabrics	High turbidity, alkalinity, and organic solids	Screening, chemical precipitation, flotation, and adsorption
		Chemicals	
Acids	Dilute wash waters; many varied dilute acids	Low pH, low organic content	Upflow or straight neutralization, burning when some organic matter is present
Detergents	Washing and purifying soaps and detergents	High in BOD and saponified soaps	Flotation and skimming, precipitation with $CaCl_2$
Cornstarch	Evaporator condensate, syrup from final washes, wastes from "bottling up" process	High BOD and dissolved organic matter; mainly starch and related material	Equalization, biological filtration

Table 5-9 - Summary of industrial waste: its origin, character, and treatment (Continued)

Industries producing wastes	Origin of major wastes	Major characteristics	Major treatment and disposal methods
		Chemicals (Continued)	
Explosives	Washing TNT and guncotton for purification, washing and pickling of cartridges	TNT, colored, acid, odorous, and contains organic acids and alcohol from powder and cotton, metal, acid, oils and soaps	Flotation, chemical precipitation, biological treatment, aeration, chlorination of TNT, neutralization
Insecticides	Washing and purification products such as 2,4-D and DDT	High organic matter, benzene ring structure, toxic to bacteria and fish, acid	Dilution, storage, activated carbon adsorption, alkaline, chlorination
Phosphate and phosphorus	Washing, screening, floating rock, condenser bleed-off from phosphate reduction plant	Clays, slimes and tall oils, low pH, high suspended solids, phosphorus, silica, and flouride	Lagooning, mechanical clarification coagulation and settling of refined waste
Formaldehyde	Residues from manufacturing synthetic resins, and from dyeing synthetic fibers	Normally has high BOD and HCHO, toxic to bacteria in high concentrations	Trickling filtration adsorption on activated charcoal
		Materials	
Pulp and paper	Cooking, refining, washing of fibers, screening of paper pulp	High or low pH; colored; high suspended, colloidal, and dissolved solids; inorganic fillers	Settling, lagooning, biological treatment, aeration, recovery of byproducts
Photographic products	Spent solutions of developer and fixer	Alkaline, contains various organic and inorganic reducing agents	Recovery of silver, due discharge of wastes into municipal sewer

Table 5-9: - Summary of industrial waste: its origin, character and treatment (Continued)

Industries producing wastes	Origin of major wastes	Major characteristics	Major treatment and disposal methods
	Materials (Continued)		
Steel	Coking of coal, washing of blast-furnace flue gases, and pickling of steel	Low pH, acids, cyanogen, phenol, ore, coke, limestone, alkali, oils, mill scale, and fine suspended solids	Neutralization, recovery and reuse, chemical coagulation
Metal-plated products	Stripping of oxides, cleaning and plating of metals	Acid, metals, toxic, low volume, mainly mineral matter	Alkaline chlorination of cyanide, reduction and precipitation of chromium, and lime precipitation of other metals
Iron-foundry products	Wasting of used sand by hydraulic discharge	High suspended solids, mainly sand; some clay and coal	Selective screening, drying of reclaimed sand
Oil	Drilling muds, salt, oil, and some natural gas, acid sludges and miscellaneous oils from refining	High dissolved salts from field, high BOD, odor, phenol, and sulfur compounds from refinery	Diversion, recovery, injection of salts; acidification and burning of alkaline sludges
Rubber	Washing of latex, coagulated rubber, exuded impurities from crude rubber	High BOD and odor, high suspended solids, variable pH, high chlorides	Aeration, chlorination, sulfonation, biological treatment
Glass	Polishing and cleaning of glass	Red color, alkaline non-settleable suspended solids	Calcium chloride precipitation
Naval stores	Washing of stumps; drop solution, solvent recovery, and oil recovery water	Acid, high BOD	Byproduct recovery, equalization, recirculation and reuse, trickling filtration

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Table 5-9: - Summary of industrial waste: its origin, character, and treatment (Continued)

Industries producing wastes	Origin of major wastes	Major characteristics	Major treatment and disposal methods
		Energy	
Steam power	Cooling water, boiler blowdown, coal drainage	Hot, high volume, high inorganic and dissolved solids	Cooling by aeration, storage of ashes, neutralization of excess acid wastes
Coal processing	Cleaning and classification of coal, leaching of sulfur strata with water	High suspended solids, mainly coal; low pH, high H_2SO_4 and $FeSO_4$	Settling, froth flotation, drainage control, and sealing
Nuclear power and radioactive	Processing ores, laundering of contaminated clothes, research-lab wastes, processing of fuel, powerplant cooling waters	Radioactive elements; can be very acid and "hot"	Concentration and containing or dilution and dispersion

SOURCE: Nemerow (10). Reproduced by permission of the publisher

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LEGISLATION FOR WATER QUALITY CONTROL IN KENYA

BY

PETER WERU
MINISTRY OF WATER DEVELOPMENT, KENYA

Supplemental References (Available from the seminar library)

I. US ENVIRONMENTAL PROTECTION AGENCY PUBLICATIONS

A. PROCESS DESIGN MANUALS

1) Suspended Solids Removal (January 1975)

2) Upgrading Existing Wastewater Treatment Plants (October 1974)

3) Land Treatment of Municipal Wastewater (October 1977)

4) Wastewater Treatment Facilities for Sewered Small Communities (October 1977)

5) Sludge Treatment and Disposal (October 1979)

6) Onsite Wastewater Treatment and Disposal Systems (October 1980)

B. TECHNICAL CAPSULE REPORTS

1) Color Removal from Kraft Pulping Effluent by lime Addition

2) Pollution Abatement in a Brewing Facility

3) First Progress Report: Static Pile Composting of Wastewater Sludge

4) Efficient Treatment of Small Municipal Flows at Dawson, MN, USA

C. INDUSTRIAL SEMINAR PUBLICATIONS

1) Upgrading Textile Operations to Reduce Pollution (2 vols)

2) Erosion and Sediment Control - Surface Mining in the Eastern USA (2 vols)

3) Pollution Abatement in the Fruit and Vegetable Industry (3 vols)

4) Controlling Pollution from the Manufacturing and coating of Metal Products (3 vols)

D. MUNICIPAL SEMINAR PUBLICATIONS

1) Upgrading Lagoons

2) Upgrading Existing Wastewater Treatment Plants - Case Histories

3) Flow Equalization

4) Sludge Treatment and Disposal (2 vols)

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E. BROCHURES

1) Environmental Pollution Control Alternatives Municipal Wastewater.

2) Irrigated Agriculture and Water Quality Management

F. HANDBOOK

1) Monitoring Industrial Wastewater (1973)

G. INDUSTRIAL ENVIRONMENTAL POLLUTION CONTROL MANUALS

1) Pulp and Paper Industry - Part 1/Air (October 1976)

2) Textile Processing Industry (October 1978)

H. SUMMARY REPORT

1) Control and Treatment Technology for the Metal Finishing Industry Series: Sulfide Precipitation

I. ENVIRONMENTAL REGULATIONS AND TECHNOLOGY PUBLICATIONS

1) Environmental Regulations and Technology: The Electroplating Industry

2) State-of-the-Art Review of Pulp and Paper Waste Treatment

3) State-of-the-Art Wastewater Management in the Beverage Industry

J. POINT SOURCE CATEGORY

1) Raw Cane Sugar Processing

2) Leather Tanning and Finishing

3) Textile Mills

II. WATER POLLUTION CONTROL FEDERATION

1) Design and Construction of Sanitary and Storm Sewers (MOP9)

2) Design of Wastewater and Stormwater Pumping Stations (MOP FD4)

3) Financing and Charges for Wastewater Systems

4) Municipal Wastewater Treatment Plant Design (MOP8)

5) Operation and Maintenance of Wastewater Collection Systems (MOP 7)

6) Operation of Wastewater Treatment Plants (MOP11)

7) Preliminary Treatment for Wastewater Facilities (MOP OM2)

8) Pretreatment of Industrial Wastes (MOP FD3)

9) Regulation of Sewer Use (MOP3)

10) Simplified Laboratory Procedures for Wastewater Examination

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11) Waste Stabilization Ponds Training Package

12) Wastewater Sampling for Process and Quality Control

III. WATER AND SANITATION FOR HEALTH PROJECT

1) WASH Project - Mid-contract Summary (31 March 1982)

IV. OTHERS

1) Mara, D., Sewage Treatment in Hot Climates, John Wiley and Sons, London (1976).

2) Selected Industrial Wastes, Reference: Nemerow, NL, Industrial Water Pollution: Origins, Characteristics, and Treatment.

3) Sewer Use Ordinance Information

4) North Carolina Procedures Manual for Preparing a POTW Pretreatment Program Submission

5) Dairy Processing: Water and Wastewater Management by Carawan, RE, JV Chambers, RR Zall; Extension Special Report, January 1979.

Mr. Chairman, Ladies and Gentlemen.

I would like firstly to take this opportunity to thank the:

Lake Basin Development Authority,
The University of North Carolina,
together with
The Environmental Training and Management in Africa (ETMA)
and the United States Agency for International Development
(USAID)

for having supported this workshop on Water Quality and Pollution control in the Lake Basin, a responsibility which is under the Ministry of Water Development. I would also like to take the opportunity to thank the COTU College in Kisumu for having extended the use of the College facilities to participants of this workshop during the duration of the workshop.

The purpose of organizing this workshop is to review the current state of pollution and the water quality in the Lake Basin, to identify the specific sources of pollution and how to alleviate them. Besides, the workshop shall look into ways and means of monitoring and enforcing the existing legislation in order to regulate urban or industrial discharges reaching the rivers flowing into Lake Victoria.

During this international decade for drinking water and sanitation decade there is need to improve on the quality of our water sources be they rivers, lakes and underground aquifers. The slogan should be that a healthful water course means a healthy community. This can only be attained through effective pollution control of effluents from industrial, agricultural or urban sources. This in effect requires proper legal backing for effective enforcement of standards of discharge.

In Kenya, abstraction and use of water is controlled and regulated under the Water Act, Cap. 372 of Laws of Kenya. In order to abstract and use water one is required to obtain authority from the Water Apportionment Board. All applications for use of water are scrutinized by the Board and where water is to be used for any purpose likely to discharge any effluent to any watercourse, the Board does not approve the application until plans showing proper anti-pollution measure to be undertaken have been submitted and approved by the Ministry's Pollution control Officers.

The Board also imposes the effluent discharge standards required to be discharged at any given point of any affected watercourse. Rules 71-80 of Water General Rules of the Water Act are designed to prevent and control pollution as well as discharge of effluents into any watercourse.

In pursuance of these goals the Ministry's Pollution control division has carried out various inspections of industries which are likely to pollute our rivers and action has often been taken against those found to be polluting.

However, the provisions of the current Water Act have been found not to be comprehensive enough to deal with all aspects and sources of water pollution. There is an urgent need to monitor likely sources of pollution which may not be requiring authority to use water apportionment board. Some problems have been encountered in trying to enforce the present provisions of the law. The Water Act has therefore, been reviewed to incorporate those measures which have been found necessary to have effective control of water pollution. These amendments will soon be tabled in Parliament and when passed will help in controlling current and future sources of pollution.

Kenya, like any other developing country, is faced with the threat of water sources pollution by industrial, agricultural and domestic discharges. The accelerated industrialization of our urban and rural areas often results in massive discharge of domestic and industrial wastes into our rivers. To cope with this threat there is need to urgently review the national requirements (manpower and financial resources) and lay strategies at broadly based national fora in order to adequately plan and be able to harmonize development with proper environmental protection and management.

The Government of Kenya identified the threat posed by human activities to national resources and to this end created a water quality and pollution control division within the Ministry of Water Development in 1972. The Division is current') staffed with a multidisciplinary force of professionals ranging from environmental engineers, chemists, biologists, and laboratory technologists whose duties include raw and potable monitoring and pollution control inspections on a country wide basis.

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The monitoring is carried out with a view to assessing the quality of water, its load, and assimilative capacities. The Division is also responsible for identifying sources of pollution and utilizing the data acquired for the enhancement of the quality of water. In this regard we hold that water is a vital but scarce resource. Professional advise through the Director of Water Resources on whether satisfactory anti-pollution measures have been implemented is sought before the Water Apportionment Board grants or renews a water permit for factory operation.

In Kenya, the Lake Basin is a high potential agricultural area. There are, within the Basin such agro-industries as sugar mills, pulp and paper mill, coffee industries, textile mills as well as tea factories, just to mention a few. The factory processes involved in arriving at the end-product in any of the factories uses large quantities of water which ends up as a effluent for discharge into the receiving water courses.

The effluent may/discharged in a raw, partially or fully treated /be state. In some cases however, the assimilative capacity of the receiving water course is rather low relative to the organic load discharged. This discharge in some cases, particularly from sugar mills has resulted in gross pollution of the rivers. The effect is low dissolved oxygen levels with such consequences as death of fish and other aquatic life. Besides, such water resources are rendered unsuitable for livestock, agricultural, domestic or some industrial purposes. Continued discharges of this type can only result in destroying our rivers and ultimately the Lake Victoria itself.

The Ministry of Water Development, having identified the threat posed by these discharges into the Lake Basin water sources has stationed two officers in Kisumu to constantly carry spot checks to ensure the discharges are in accordance with the Ministry's laid down standards. The stationing of such offices in Kisumu is, however, not the end of the problems. Certain constraints must be overcome before full protection in the Lake Basin is achieved. One of the major constraints is in form of a properly equipped laboratory for water and wastewater analysis. This facility is vital in arriving at reliable data for advisory or prosecution purposes.

Lastly, the Division has laid down national guidelines on pollution control. These are in form of location or siting of factories to afford proper dilution of the final effluent. The Ministry has also undertaken to establish well equipped laboratories and well staffed provincial offices. To meet manpower requirements, a training programme has been arranged to provide the requisite professional preparation to the officers both locally or abroad. In the field of wastewater and water treatment, the Ministry has recently established a research section to deal with problematic cases. For example, during this fiscal year it is arranged to have research work going on in the fields of Tannery, Coffee, and Sugar waste treatment and disposal, also in wastewater reclamation and fish culture - Deflonidation.

DISCUSSIONS

Q. What is the Ministry of Water Development doing on instances such as the Nairobi River?

A. The Local Authorities are water undertakers under the Water Act and the Nairobi City Council is an example. In most cases they have performed less than any acceptable standard. This applies to Nairobi and Ngong Rivers. The Ministry of Water Development has decided to establish monitoring centres. At the same time, the Tana and Athi River Development Authority has embarked on monitoring work for Ngong River. The Ministry has not decided on how to act against Nairobi City Council for non-enforcement of discharge standards in both rivers and the decision will not be an easy one to carry out.

COMMENT

The Ministry of Water Development has been criticized for not supplying adequate clean water for domestic consumption. This is a position that the Ministry has taken but there have not been enough money allocated by the Exchequer for water delivery programmes.

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COMMENT:

Water quality and public health are inseperable and the government ought to make the proper supply a priority. Yet most of the projects of the Ministry of Water Development have broken down; in most cases the reason given for the collapse and the long time of dysfunction is due to lack of spare parts because of import limitations. Is the government really seriously commited to clean water supply to rural areas?

A. The Ministry is committed except that the economic constraints are often unsurmountable.

Q. On the treatment of coffee the Ministry of Water Development has several modalities. Has there been a system for removal of heavy metals like mercury?

A. Generally, the Ministry does not believe there are any heavy metals in coffee processing. The industries use copper compounds.

COMMENT:

There have been instances of mercury poisoning in Kenya. In Kiambu area it is believed that the mercury in the water is largely from pesticide in coffee. Phenol mercury is used for seed treatment, legally in Kenya.

COMMENT:

The latest analytical data is that the mercury poisoning result from mercury in pesticides used at home. Children reach it because of mishandling.

COMMENT:

Operation at night by the coffee industry is true and this presents problem for supervision monitoring and enforcement. There are not enough men to do the work day and night.

Q. If there are chemicals such as sugar in the pulp which can be utilised, can they be extracted and utilized? Can the dry rather than wet methods of processing be used?

A. The sorts of sugars produced in the process are minimal and extraction would be uneconomical. It would perhaps be more economical if the pulps were processed and compressed into charcoal.

The wet process has higher quality coffee. It also takes care of propoteptiz which is a polluter. The dry process require indiscriminate creshing of the beans, without purification.

Finally, there are 1200 factories in the country but their registration to ascertain effluents is rather recent. So far it has not been possible to ascertain exactly to what extent they comply with the discharge standards. Some of the farmers had worked for over 50 years by the time the Ministry of Water Development was established and for all that time, the farmer had never heard of any standards. For that reason the process of enforcement is slow. With the recent cases the enforcement has been easier.

COMMENT:

Coffee wastes contain upto 10% sugar. It has not been extracted because of the limited technology. The products could be used for the production of alcohol.

COMMENT:

We should be careful in disposal of the coffee industry not to pollute underground water. See-page pits used for disposal of the coffee wastes will easily affect ground water.

There have been efforts to prohibit sinking of pit latrines or coffee waste disposals. This may not have gone very far but it is an effort, nevertheless.

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CHAPTER VII

TECHNOLOGY AND DESIGN

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NEW TECHNOLOGICAL DEVELOPMENT IN MUNICIPAL AND INDUSTRIAL WASTE TREATMENT

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1. INTRODUCTION

Municipal and Industrial wastewater treatment has made tremendous progress since the latter part of the last century. Improvements in applied technologies, arising from a better understanding of the physical, chemical and biological treatment concepts employed in wastewater treatment schemes have over the years evolved from the simple "hole in the ground" technologies to complex, sophisticated integrated systems capable of achieving any required degree of removal of suspended colloidal, dissolved organic and inorganic contaminants contained in these wastes. Today we have at the disposal of planners, design engineers and plant operators an array of physical unit operations, chemical and biological unit processes which can be systematically put together to constitute a "best available wastewater treatment train" economically achievable.

Because they are artificial entities located in restricted spatial areas and densely populated with people, urban areas have critical wastes as well as storm waters. The rapid and efficient disposal of these wastes is required in order to safeguard the public health, avoid nuisance and protect the environment from a pollution overload. While the provision of portable drinking water takes precedence in the order to provision of environmental engineering services, the importance of sewerage and sewage treatment cannot be lost sight of and cannot be allowed to lag behind because all the water used by the community has to flow back as sewage loaded with the wastes from the community.

Unless properly collected, treated and disposed of, this would create serious pollution problems. More prosperous communities have attempted to look at water supply and sewerage as an integral whole but such an outlook, while acceptable, has not been possible to adequately implement in this country primarily because of lack of resources. Nevertheless, there has been a steady effort in recent years to provide sewerage and sewage treatment facilities to cover at least all the "major" urban centres.

In this presentation, no specific new technology is going to be described in detail. Detailed descriptions of the many methods and variations that have been developed would be too cumbersome and would serve no useful purpose in the context of the present seminar. The approach I am going to follow in this presentation gives the following perspectives:

(1) An overview of the present state of the art in municipal and industrial waste treatment.
(2) Suggest appropriate applicable technologies in African context.
(3) Propose directions of technical research worth pursuing in the development of an appropriate municipal and industrial waste management system.

2. TREATMENT OBJECTIVES

Engineered intensive methods of municipal and industrial wastewater treatment have been developed in response to the concern for public health, environmental nuisance in the residential areas, commercial and industrial establishments and the adverse conditions caused by the uncontrolled discharge of water to the environment.

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The purpose of treatment is to accelerate the forces of nature under controlled conditions in treatment facilities of comparatively small size.

In General, treatment objectives are concerned with:

1. The removal of suspended and floating material.

2. Reduction of stablization of biodegradable organics.

3. Elimination of pathogenic organisms.

While the above-named treatment objectives remain valid, the required degree of treatment for the adequate protection of the Lake Victoria e.g., may have to be significantly increased, and additional treatment objectives and goals be added to include:

- The removal of nitrogen and phosphorus;
- The removal of toxic organic compounds; and
- Removal of refactory organics, heavy metals, pesticides and dissolved solids.

3. CHARACTERISTICS OF WASTEWATER

An understanding of the nature of wastewaters is essential in the design and operation of treatment facilities. The physical properties and the chemical and biological constituents of wastewater and their sources as well as the important contaminants of interest in wastewater treatment are shown in Tables 3.1 and 3.2 and 3.3 and 3.4.

As already stated above the objectives for wastewater may be concerned with the removal of biodegradable organics, suspended solids and pathogens. More stringent standards developed fairly recently deal with the removal of nutrients and the improved removal or organics. When water is to be re-used, standards may include requirements for removal of refractory organics, heavy metals and in some cases, dissolved inorganic solids.

4. CLASSIFICATION OF WASTEWATER TREATMENT METHODS

The contaminants in the wastewater are removed by the physical, chemical and biological means. The individual methods usually are classified as physical unit operations, chemical unit processes and biological unit processes. These operations and processes may occur in a variety of combinations in treatment systems.

4.1. PHYSICAL UNIT OPERATIONS

The applications of the physical forces predominate in these operations for examples, gravitational forces, screening, mixing flocculations sedimentation, flotation and filtration are typical unit operations, (see Table 4.1).

4.2. CHEMICAL UNIT PROCESSES

The removal or conversion of pollutants is brought about by the addition of chemicals or by other chemical reactions. Precipitation, Gas transfer, Adsorption and disinfection are the most common examples in wastewater treatment (see Table 4.2).

4.3. BIOLOGICAL UNIT PROCESSES

The removal of contaminants is brought about by biological activity. Aerobic and anaerobic suspended growth or attached growth systems are commonly used. They are used primarily to remove and stabilize the biodegradable organic (colloidal or dissolved) in the wastewater. Basically these substances are converted into gases that can escape to the atmosphere and into biological cell tissue that can be removed by sedimentation. (See Table 4.3).

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5. APPLICATION OF TREATMENT METHODS

The unit operations and processes can be grouped together to provide what is known as primary, secondary and tertiary (or advanced) treatment. The term primary refers to the physical unit operations; secondary refers to chemical and biological unit processes, and tertiary refers to combinations of all three. These terms are arbitrary and in some cases are of little value. A more rational approach is first to establish the degree of pollutant removal (treatment) required before the wastewater can be re-used or discharged to the environment. The required operations and processes necessary to achieve that required degree of treatment are then grouped together on the basis of fundamental considerations.

The principal methods currently used for the treatment of municipal and industrial wastewater and the resultant sludge are shown in Tables 5.1 and 5.2. Primary treatment is directed at generally removing suspended solids, secondary treatment at generally the removal of biodegradable organics and suspended solids.

In general, the methods used to remove these contaminants are well established. To further protect the environment in some critical areas treatment may be directed toward the removal of nutrients and toward achieving lower levels of oxygen demand than are now possible with secondary treatment techniques. When wastewaters are to be re-used removal of refractory organics, heavy metals and dissolved inorganic solids may be required. In general, processes used to remove these constituents are not as well documented as the secondary treatment processes and they are costly. In most situations, the complexity of the treatment process flowsheet will depend both on which constituents need to be removed and the required levels of removal. Some of the important factors that must be considered when sellecting and evaluating unit operations and process are shown in Table 5.3. Advanced wastewater operations and processes are shown in Table 5.4.

6. TREATMENT SYSTEMS

As already stated a systematic combination of physical operations and chemical and biological process can be put together to constitute a treatment system capable of producing an effluent of the required quality. The only constraint is generally the cost of the scheme (capital, maintenance and operational). Treatment levels generally achievable with the various unit operations and processes are shown in Table 6.1.

7. SOME NEW TECHNOLOGIES

Below are listed some of the new technological developments that have taken place in the field of municipal and industrial wastewater treatment.

7.1. ACTIVATED SLUDGE PROCESS - PURE OXYGEN

Aerobic stablization process i.e. instead of air, pure oxygen is supplied and higher oxganic loadings and treatment efficiencies attained.

7.2. EXPANDED BED AND FLUIDISED BED: REACTORS:

Here waste is fed upwards through a bed of inert porous support material (such as sand or sythetic granuber materials) and such an approach velocity that the bed is expanded or fluidised. Dense growth of micro-organisms occur on the fluidised particles and degrade the waste water (aerobically or anaerobically). Because of the increased surface area, for colonization by the micro-organisms, higher loadings of organic matters can be tolerated and reacted size is reduced. When operated anaerobically it has been demonstrated capable of treating

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dilute wastewaters (96 urg/l BODs).

7.3. ANAEROBIC ROTATING BILOGICAL CONTACTORS

This is the application of the rotating Biological contactors for treating wastewaters anaerobically. Ducts made of synthetic materials provide surfaces for colonisation of bacteria.

7.4. UPFLOW ANAEROBIC SLUDGE BLANKET PROCESS

The upflow anaerobic reactor concept resembles the upflow sludge blanket processes employed in water treatment, except that the reactor has been equipped with a proper gas solids Separator. It has been successfully used to treat industrial wastes.

8. DEVELOPMENT OF APPROPRIATE TECHNOLOGIES

Many muncipalities and local authorities have problems associated with funding of sewerage systems, operation and maintenance of treatment plants, training of operators for running the treatment of plants. Development of appropriate technologies could go some way in helping to solve some of the above problems, as already stated technologies exist that can produce any required degree of treatment. In the context of Kenya appropriate technologies should have the following characteristics:

- It must be low or moderately energy intensive
- It must be relatively easy to maintain and operate

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- It must have the potential of development into commercially viable treatment system, and capable of small scale implementation.

Technologies that satisfy the above characteristics are the following:

1. Waste stabilization Ponds

   - for algal recovery for production of chicken feed
   - for fish production

   caution: domestic wastes should be separated from industrial wastes.

2. Anaerobic Fermentation Schemes

   Production of methane gas using Flundised Bed Reactors, Expanded Bed Reactors, and Biological contractors, by the treatment of domestic and municipal wastewaters. The development of the above technologies may open the way to using sewage, on a commercial basis as useful raw material. This would enable the Municipalities and other local authorities to sell sewage to commercial enterprises. These commercial enterprises would then recover the useful products for sale to the public and make a profit out of it. In turn the local authorities would be able to raise funds for further extension of the sewerage systems; then expand and strengthen their monitoring capabilities.

9. CONCLUSION

Existing technologies for treatment of Municipal and Industrial wastewaters are capable to producing effluents of any required quality. However, methods currently used in Kenya are operating unsatisfactorily because of lack of proper operation and maintenance. Some of the treatment systems, e.g. waste stabilization ponds have resource recovery potential but this has not been explored to date.

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Development of technologies which are low energy intensive, low in operational costs, low in maintenance cost, high in resource recovery potential and capable of small scale application may make it possible for local authorities to raise funds by selling sewage for treatment by private commercial interests for resource recovery. In this way it may be possible to make municipal and Industrial pollution pay. The local authorities would then be able to strengthen their ability to extend coverage by sewerage and their monitoring capability.

Table 3.1

PHYSICAL, CHEMICAL, AND BIOLOGICAL CHARACTERISTICS OF WASTEWATER AND THEIR SOURCES

CHARACTERISTICS	SOURCES
Physical properties:	
Colour	Domestic and industrial wastes, natural decay or organic materials
Odor	Decomposing wastewater, industrial wastes
Solids	Domestic water supply, domestic and industrial wastes, soil erosion, inflow-infiltration
Temperature	Domestic and industrial wastes
Chemical constituents:	
Organic:	
Carbohydrates	Domestic, commercial and industrial wastes
Fats, oils and grease	Domestic, commercial and industrial wastes
Pesticides	Agricultural wastes
Phenols	Industrial wastes
Proteins	Domestic and commercial wastes
Surfactants	Domestic and industrial wastes
Others	Natural decay of organic materials
Inorganic:	
Alkalinity	Domestic wastes, domestic water supply, groundwater infiltration
Chlorides	Domestic water supply, domestic wastes, groundwater infiltration water softness
Heavy metals	Industrial wastes
Nitrogen	Domestic and agricultural wastes
pH	Industrial wastes
Phosphorus	Domestic and industrial wastes, natural runoff
Sulfur	Domestic water supply, domestic and industrial wastes
Toxic compounds	Industrial wastes
Gases:	
Hydrogen sulfide	Decomposition of domestic wastes
Methane	Decomposition of domestic wastes
Oxygen	Domestic water supply, surface-water infiltration
Biological Constituents:	
Animal	Open watercourses and treatment plants
Plants	Open watercourses and treatment plants
Protista	Domestic wastes, treatment plants
Viruses	Domestic wastes

Table 3.2.

IMPORTANT CONTAMINANTS OF CONCERN IN WASTEWATER TREATMENT

CONTAMINANTS	REASON FOR IMPORTANCE
Suspended Solids	Suspended solids can lead to the development of sludge deposits and anaerobic conditions when untreated wastewater is discharged in the aquatic environment
Biodegradable organics	Composed principally of proteins, carbohydrates, and fats, biodegradable organics are measured most commonly in terms of BOD (biochemical oxygen demand) If discharged untreated to the environment, their biological stabilization can lead to the depletion of natural oxygen resources and to the development of septic conditions.
Pathogens	Communicable diseases can be transmitted by the pathogenic organisms in wastewater
Nutrients	Both nitrogen and phosphorus, along with carbon, are essential nutrients for growth. When discharged to the aquatic environment, these nutrients can lead to the growth of undesirable aquatic life. When discharged in excessive amounts on land, they can also lead to the pollution of groundwater.
Heavy metals	Heavy metals are usually added to wastewater from commercial and industrial activities and may have to be removed if the wastewater is to be reused.
Dissolved inorganic solids	Inorganic constituents such as calcium, sodium, and sulfate are added to the original domestic water supply as a result of water use and may have to be removed if the wastewater is to be reused.

Table 3.3.

NUISANCE AND PATHOGEN ORGANISMS IN WATER

Organism	Reason For Concern
Nuisance organisms	
Actinomycets	Cause undesirable tastes and odors
Algae	Cause undesirable taste and odors, clog filters.
Coliform bacteria	An indicator organism grouping used as the index for the hygienic quality of water. A high coliform count is presumptive evidence of fecal contamination.
Fecal streptococci	An indicator of fecal contamination, sometimes used as an alternative to the coliform index.
Iron bacteria	Produce slimy, often red colored, growth in wells and water mains. Levels of 0.1-0.2 mg/l iron are sufficient for growth.
Bacterial pathogens	
Vibrio cholera	Causes cholera. Initial wave of cholera epidemic is waterborne; secondary cases by contact, food, and flies.
Salmonella typhi	Causes typhoid fever. Principle modes of transmission are food and water.
Shigella dysenteriae	Causes Bacillary dysentery (Shigellosis)
Shigella flexneri	Caused by fecal-oral tranmission via water, milk, food, flies, or direct contact
Shigella sonnei	
Salmonella paratyphi	Causes paratyphoid fever. A few outbreaks are waterborne.
Protozoan pathogens	
Entamoeba histolytica	Causes Amebic dysentry. Endemic cases are by personal contact, food and possibly flies. Rare epidemics are mainly waterborne.
Viral pathogens	
Virus not isolated	Infectious hepatitus can be transmitted by water, milk and food.

Table 3.4.

TYPICAL CHEMICAL CONSTITUENTS THAT MAY BE FOUND IN WASTEWATER AND THEIR EFFECTS

Constituent	Effect	Critical concentration mg/L
Inorganic		
Ammonia	Increases chlorine demand, toxic to fish can be converted to nitrates, in the process, can deplete oxygen resources; with phosphorus, can lead to the development of undesirable aquatic growths	Any amount Variable(a) Ary amount
Calcium and magnesium	Increase hardness and total dissolved solids	
Chloride	Imparts salty taste; interferes with agricultural and industrial processes	250
Mercury	Toxic to humans and aquatic life	75-200
Nitrate	Stimulates algal and aquatic growth; can cause methemoglobinemia in infants (blue babies)	0.00005 0.3(b) 10 (c)
Phosphate	Stimulates algal and aquatic growth; interferes with coagulation; interferes with lime-soda softening	0.015 (b) 0.2-0.4 0.3
Sulfate	Cathartic action	600-1,000
Organic		
DDT	Toxic to fish and other aquatic life	0.001
Hexachloride	May be related to the development of cancer; also may cause taste and odor problems in water	0.02
Petrochemicals		0.005-0.1
Phenolic compounds		0.0005-0.001
Surfactants	Cause foaming and may interfere with coagulation	1.0-3.0

(a) Depends on pH and temperature

(b) For quiescent lakes (12)

(c) U.S. Environmental Protection Agency: Part 141 - National Interim Primary Drinking Water Regulations, Federal Register vol. 40, no.248, December 24, 1975.

Table 4.1

APPLICATIONS OF PHYSICAL UNIT OPERATIONS IN WASTEWATER TREATMENT

Operation	Application
Screening	Removal of coarse and settleable solids by interception (surface straining)
Comminution	Grinding of coarse solids to a more or less uniform size
Flow equalization	Equalization of flow and mass loadings of BOD and suspended solids
Mixing	Mixing of chemicals and gases with wastewater and maintaining solids in suspension
Flocculation	Promotes the aggregation of small particles into larger particles to enhance their removal by gravity sedimentation
Sedimentation	Removal of settleable solids and thickening of sludges
Flotation	Removal of finely divided suspended solids and particles with densities close to that of water. Also thickens biological sludges.
Microscreening	Same as filtration. Also removal of algae from stabilization-pond effluents.

Table 4.2.

APPLICATIONS OF CHEMICAL UNIT PROCESSES IN WASTEWATER TREATMENT

Process	Application
Chemical precipitation	Removal of phosphorus and enchancement of suspended solids removal in primary sedimentation facilities used for physical-chemical treatment.
Gas transfer	Addition and removal of gases
Adsorption	Removal of organics not removed by conventional chemical and biological treatment methods. Also used for dechlorination of wastewater before final discharge of treated effluent.
Disinfection	Selective destruction of disease-causing organisms (can be accomplished in various ways)
Disinfection with chlorine	Selective destruction of disease-causing organisms. Chlorine is the most commonly used chemical .
Dechlorination	Removal of total combined chlorine residual that exists after chlorination (can be accomplished in various ways)
Disinfection with ozone	Selective destruction of disease-causing organisms
Others	Various other chemicals can be used to achieve specific objectives in wastewater treatment.

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Table 4.3.

MAJOR BIOLOGICAL TREATMENT PROCESSES USED FOR WASTEWATER TREATMENT

Type	Common name	Use *
Aerotic processes:		
Suspended growth	Activated-sludge process Conventional (plug flow) Continuous-flow stirred-tank Step aeration Pure oxygen Modified aeration Contact stabilization Extended aeration Oxidation ditch	Carbonaceious BOD removal (nitrification)
	Suspended-growth nitrification	Nitrification
	Aerated lagoons	Carbonaceous (nitrification)
	Aerobic digestion Conventional air Pure oxygen	Stabilization, carbonaceous BOD removal
	High-rate aerobic algal ponds	Carnonaceous removal
Attached growth	Trickling filters Low-rate High-rate	Carbonaceous BOD removal (nitrification)
	Roughing filters	Carbonaceous BOD removal
	Rotating biological contactors	Carbonaceous BOD removal (nitrification)
	Packed-bed reactors	Nitrification
Combined processes:	Trickling filter, activated sludge Activated sludge, trickling filter	Carbonaceous BOD removal (nitrification)
Anoxic processes:		
Suspended growth	Suspended-growth denitrification	Denitrification
Attached growth	Fixed-film denitrification	Denitrification
Anaerobic processes:		
Suspended growth	Anaerobic digestion Standard-rate, single-stage High-rate, single-stage two-stage	Stabilization, carbonaceous BOD removal
	Anaerobic contact process	Carbonaceous BOD removal
Attached growth	Anaerobic filter	Carbonaceous BOD removal stabilization (denitrification)
	Anaerobic lagoons (ponds)	Carbonaceous BOD removal (stabilization)
Aerobic/anoxic or anaerobic processes:		
Suspended growth	Single-stage nitrification-denitrification	Carbonaceous BOD removal nitrification, denitrification

Cont'd...

Type	Common name	Use
Attached growth	Nitrification-denitrification	Nitrification-denitrification
Combined processes	Facultative lagoons (ponds)	Carbonaceous BOD removal
	Maturation or tertiary ponds	Carbonaceous BOD removal (nitrification)
	Anaerobic-facultative lagoons	
	Anaerobic-facultative-aerobic lagoons	Carbonaceous BOD removal

* Major use is presented firs; other uses are identified in patentheses.

Table 5.1.

UNIT OPERATIONS AND PROCESSES AND TREATMENT SYSTEMS USED TO REMOVE THE MAJOR CONTAMINANTS FOUND IN WASTEWATER

Contaminant	Unit Operation, unit process, or treatment system
Suspended solids	Sedimentation Screening and comminution Filtration variations Flotation Chemical-polymer addition Coagulation/sedimentation Land treatment systems
Biodegradable organics	Activated-sludge variations Fixed-film: trickling filters Fixed-film: rotating biological contactors Lagoon variations Intermittent sand filtration Land treatment systems Physical-chemical systems
Pathogens	Chlorination Hypochlorination Ozonation Land treatment systems
Nutrients: Nitrogen	Suspended-growth nitrification and denitrification variations Fixed-film nitrification and denitrification variations. Ammonia stripping Ion exchange Break-point chlorination Land treatment systems
Phosphorus	Metal-salt addition Lime coagulation/sedimentation Biological-chemical phospporus removal Land treatment systems
Refractory organics	Carbon adsorption Tartiary ozonation Land treatment systems

Cont'd...

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Heavy metals	Chemical precipitation Ion exchange Land treatment systems
Dissolved inorganic solids	Ion exchange Reverse osmosis Electrodialysis

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Table 5.2

SLUDGE PROCESSING AND DISPOSAL METHODS

Processing disposal function	Unit operation, unit process, or treatment method
Preliminary operations	Sludge pumping and grinding Sludge blending and storage
Thickening	Gravity thickening Flotation thickening Centrifugation Classification
Stabilization	Chlorine oxidation Lime stabilization Anaerobic digestion Aerobic digestion Heat treatment Pure-oxygen aerobic digestion
Disinfection	Disinfection
Conditioning	Chemical conditioning Elutriation
Dewatering	Centrifuge Vacuum filter Pressure filter Horizontal-belt filter Drying bed Lagoon
Drying	Dryer
Composting	Composting Co-composting
Thermal reduction	Multiple hearth incineration Fluidized-bed incineration Flash combustion Co-incineration Co-pyrolysis Pyrolysis Wet-air oxidation Recalcination
Ultimate disposal	Landfill Land application
Reuse	

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Table 5-3

IMPORTANT FACTORS THAT MUST BE CONSIDERED WHEN SELECTING AND EVALUATING UNIT OPERATIONS AND PROCESSES

Factor	Comment
1. Process Applicability	The applicability of a process is evaluated on the basis of past experience, data from full-scale plants, and pilot data from plant studies. If new or unusual conditions are encountered, pilot-plant studies are necessary.
2. Applicable flow range	The process should be matched to the expected flow range for Example, stabilization ponds are not suitable for extremely large flows.
3. Applicable flow variation	Most unit operations and processes work best with a constant flowrate, although some variation can be tolerated. If the flow variation is too great, flow equalization may be necessary.
4. Influent-wastewater characteristics	The characteristics of the influent affect the types of processes to be used (e.g. chemical or biological) and the requirements for their proper operation.
5. Inhibiting and unaffected constituents	What constituents are present that may be inhibitory, and under what conditions? What constituents are not affected during treatment?
6. Climatic constraints	Temperature affects the rate of reaction of most chemical and biological processes. Freezing conditions may affect the physical operation of the facilities.
7. Reaction kinetics and reactor selection	Reactor sizing is based on the governing reaction kinetics. Data for kinetic expressions usually are derived from experience, the literature, and the results of pilot-plant studies. The effect of reaction kinetics on reactor selection is considered in Sec.5.5
8. Performance	Performance is most often measured in terms of effluent quality, which must be consistent with the given effluent discharge requirements.
9. Treatment residuals	The types and amounts of solid, liquid, and gaseous residuals produced must be known or estimated. often pilot-plant studies are used to identify residuals properly.
10. Sludge-handling constraints	Are there any constraints that would make sludge handling expensive or infeasible? In many cases, a treatment method should be selected only after

Table 5.3 Cont'd.

Factor	Comment
11. Enironmental constraints	Nutrient requirements must be considered for biological treatment processes. Environmental factors, such as the prevailing winds and wind directions, may restrict the use of certain processes, especially where odors may be produced.
12. Chemical requirements	What resources and what amounts must be committed for a long period of time for the successful operation of the unit operation or process?
13. Energy requirements	The energy requirements, as well as probable future energy costs, must be known if cost-effective treatment systems are to be designed.
14. Other resource requirements	What, if any additional resources must be committed to the successful implementation of the proposed treatment system using the unit operation or process in question?
15. Reliability	What is the long-term record of the reliability of the unit operation or process under consideration? Is the operation process easily upset? Can it stand periodic shock loadings? If so, how do such occurrences affect the quality of the effluent?
16. Complexity	How complex is the process to operate under routine conditions and under emergency conditions such as shock loadings? What level of training must the operator have to operate the process?
17. Ancillary processes required	What support process are required? How do they affect the effluent quality, especially when they become inoperative?
18. Compatibility	Can the unit operation or process be used successfully with existing facilities? Can plant expansion be accomplished easily? Can the type of reactor be modified?

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Table 5.4.

ADVANCED WASTEWATER-TREATMENT OPERATIONS AND PROCESSES

Description	Type of wastewater treated	Principal or Major use	Waste for ultimate disposal
Physical unit operations			
Air stripping of ammonia	EST	Removal of ammonia nitrogen	None
Filtration:			
Multimedian	EST	Removal of suspended solids	Liquid and sludge
Diatomite bed	EST	Removal of suspended solids	Sludge
Microstrainers	EBT	Removal of suspended solids	Sludge
Distillation	EST Nitrified + Filtration	Removal of dissolved solids	Liquid
Electrodialysis	EST + filtration + carbon adsorption	Removal of dissolved solids	Liquid
Flotation	EPT, EST	Removal of suspended solids	Sludge
Foam Fractionation	EST	Removal of refractory organics, surfactants and metals	Liquid
Freezing	EST + Filtration	Removal of dissolved solids	Liquid
Gas-phase separation	EST	Removal of ammonia nitrogen	None
Land application	EPT, EST	Nitrification, denitrification, removal of ammonia nitrogen and phosphorus	
Reverse osmosis	EST + filtration	Removal of dissolved solids	Liquid
Sorption	EBT	DDIS	Liquid and sludge
Chemical unit processes			
Breakpoint chorination	EST (filtration	Removal of ammonia nitrogen	Liquid
Carbon adsorption	EPT, EST	Removal of dissolved organics, heavy metals, and chlorine	Liquid
Chemical precipitation	EBT	Phosphorus precipitation, removal of heavy metals, removal of colloidal solids	Sludge
Chemical precipitation in activated sludge	EST + filtration	Removal of ammonia and nitrate nitrogen	Liquid
Electrochemical untreated	Untreated	Removal of dissolved solids	Liquid and sludge
Oxidation	EST	Removal of refractory organics	None
Biological unit processes			
Bacterial assimilation	EPT	Removal of ammonia nitrogen	Sludge

Cont'd.. next page

Table 5.4. cont'd

Denitrification	Agricultural return water	Nitrate reduction	None
Harvesting of algae	EBT	Removal of ammonia nitrogen	Algae
Nitrification	EPT, EBT	Ammonia oxidation	
Nitrification-denitrification	EPT, EBT	Total nitrogen removal	Sludge

TABLE 5.5

Comparison of design features for alternative land-treatment processes

Feature	Irrigation	Rapid infiltration	Overland flow	Wetland application	Subsurface application
Application techniques	Sprinkler or surface	Usually surface	Sprinkler or surface	Sprinkler or surface	Subsurface piping
Annual application rate, m	0.6-6.0	6-120	3-20	1-30	2-25
Field area required, ha[b]	22-226	1-22	10-44	4-113	5-56
Typical weekly application rate, cm	2.5-10	10-210	6-15[c] 15-40[d]	2.5-60	5-50
Minimum preapplication treatment provided	Primary sedimentation[e]	Primary sedimentation	Screening and grit removal	Primary sedimentation	Primary sedimentation
Disposition of applied wastewater	Evaportranspiration and precolation	Mainly percolation	Surface runoff and evapotranspiration with some percolation	Evapotranspiration percolation, and runoff	Percolation with some evapotranspiration
need for vegetation	Required	Optional	Required	Required	Optional

[a]Includes ridge and furrow border strip.

[b]Field area in hectares not including buffer area, roads, or ditches for 0.044 m^3/s (1 Mgal/d) flow.

[c]Range for application of screened wastewater.

[d]Range for application of lagoon and secondary effluent.

[e]Depends on the use of the effluent and the type of crop.

Note: cm x 0.3937 = in

m x 3.2808 = ft

ha x 2.4711 = acre

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Treatment levels achievable with various operations and processes used for advanced wastewater treatment[a]

		Typical effluent quality						
Secondary treatment[b]	Additional treatment	Suspended solids, mg/L	BOD, mg/L	COD, mg/L	Total N, mg/L	PO_4 as P, mg/L	Turbidity mg/L	Color units,
Activated-sludge process (suspended-growth process)	None (secondary effluent)	20-30	15-25	40-80	20-60	6-15	5-15	15-80
	Granular-medium filtration	<5-10	<5-10	30-70	15-35	4-12	0.3-5	15-60
	Granular-medium filtration, carbon column	<3	<1	5-15	15-30	4-12	0.3-3	5
	Coagulation plus settling	<5	<5-10	40-70	15-30	1-2	<10	10-30
	Coagulation plus settling and granular-medium filtration	<1	<5	30-60	15-30	0.1-1.0[c]	0.1-1.0	10-30
	Coagulation, settling granular-medium filtration, ammonia stripping	<1	<5	30-60	2-10	0.1-1.0[c]	0.1-1.0	10-30

	Coagulation, settling, granular-medium filtration, ammonia stripping, carbon columns	<1	<1	1-15	2-10[d]	0.1-1.0[c]	0.1-1.0	<5
Land treatment	Irrigation[e]; rapid	<1	<2	....	3	0.3		
	infiltration[f];	2	2	....	10	3		
	overland flow[g]	10	10	....	3	12		
Trickling-filter process	None (secondary	20-40	15-35	40-100	20-60	6-15	5-15	15-30
Rotating biological contractor (attached-growth process)	effluent); granular-medium filtration	10-20	10-20	30-70	15-35	6-15	<10	15-60
	Aeration, settling, granular-medium filtration	<5-10	<5-10	30-60	15-35	4-12	0.5-5	15-60

[a] Adapted in part from Ref. 21.

[b] To meet U.S. Environmental Protection Agency effluent standards, the use of filters has now become accepted as standard practice and they are considered to be included in the definition of conventional secondary treatment.

[c] Reduction of PO_4 to this level will typically require 200 ppm of alum or 400 ppm of lime; if greater PO_4 concentrations can be tolerated, coagulant dosage is decreased.

[d] Requires elevating the pH to over 10.5 to convert nitrogen to ammonia.

[e] Percolation of primary of secondary effluent through 1.5m of soil.

[f] Percolation of primary or secondary effluent through 4.5m of soil.

[g] Runoff of comminuted municipal wastewater over about 45m of slope.

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DISCUSSIONS

In the present industrial effluents, which you have not covered much of disposal of toxic materials present a problem. The industries consider the modalities you suggested costly. Is there appropriate technology?

Answer: There are technologies of that kind. The problem is Economic. It might be appropriate for commercial group to establish recovery companies.

Comment: Sewage treatment organisms are highly versatile. Wastes that are toxic to biological organism can be dealt with but very often they are resistant to their environments. The critical question is the construction of a system that works and designed to work for the given set of waste organisms.

The variations should also be subjected to controls because the treatment systems are Sensitive to high variations. The biological systems must also be in proper balance.

Comment: Recovery of algal growth for other industries for chicken growth may sound rather far fetched for a system that is not controlled in the first place. The element of algal growth and recovery are possible where the system is properly controlled and the biomass is properly controlled.

Comment: Reuse of algal products and variations of sludge is good but some micro organisms are toxic and persistent so that their use as chicken feed for example might biccumulate in the animal tissues and cause long range problems.

Comment: Equalization of sewage before it is introduced into the biological treatment is good. But it is costly; besides, it requires sophisticated personnel and this is a critical bottleneck. Thus, it is not tne toxity of the wastes alone that is critical, rather the personnel qualified, committed and equipped to deal with the problem.

Comment: The coloured materials get out of the factories and the colouration have been nearly impossible to move from the liquid wastes. Then once in the water, the colour prevent aeration. Perhaps this can be handled by proper aerators as opposed to seeking mechanisms for removing the dye.

Comment: In some cases the aeration devices require change in the system and this could be costly.

Comment: Although the Ministry of Water Development has not issued any general discharge standards, the Sugar industry - Miwani, Muhoroni, and Chemelil have drawn up their own standards, and so has Nzoia.

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DESIGN AND MANAGEMENT OF WATER QUALITY MONITORING PROGRAMS

BY

DR F K PFAENDER

F K PFAENDER

What is monitoring?

Monitoring is the routine collection of information on health or environmental conditions, as well as the recording and transmission of this data in a form useful to decision makers.

Monitoring Concepts

1. Monitoring is part of a larger plan for the surveillance of the environment or health for possible changes or impacts. Seeking information of a type and in a form useful to decision makers.

2. This overall plan should:

   a. Characterize the state of the environment.
   b. Assess the effects of various practices and activities on the environment and health.
   c. Guide the development of programs for improving environmental quality, including the development of public policy, legislative and operational programs.
   d. Determine whether established limits or standards have been met or exceeded.

Monitoring Goals

The first question to consider is what the objective of a specific monitoring effort will be.

Ambient Monitoring: Broad based sampling of the environment to assess quality status and trends.

Compliance Monitoring To determine whether specific water quality standards, guidelines or effluent permits are being met

MONITORING CONCEPTS

1. MONITORING IS PART OF A LARGER PLAN FOR THE SURVEILLANCE OF THE ENVIRONMENT OR HEALTH FOR POSSIBLE CHANGES OR IMPACTS. IT SEEKS INFORMATION OF A TYPE AND IN A FORM USEFUL TO DECISION MAKERS.

2. THIS OVERALL PLAN SHOULD:

   A. CHARACTERIZE THE STATE OF THE ENVIRONMENT.
   B. ASSESS THE EFFECTS OF VARIOUS PRACTICES AND ACTIVITIES ON THE ENVIRONMENT OR HEALTH.
   C. GUIDE THE DEVELOPMENT OF PROGRAMS FOR IMPROVING ENVIRONMENTAL QUALITY, INCLUDING THE DEVELOPMENT OF PUBLIC POLICY, LEGISLATIVE PROGRAMS AND OPERATIONAL PROGRAMS.
   D. DETERMINE WHETHER ESTABLISHED LIMITS OR STANDARDS HAVE BEEN MET OR EXCEEDED.

MONITORING GOALS

WHAT DO YOU WANT TO KNOW?

AMBIENT MONITORING - BROAD SAMPLING OF THE ENVIRONMENT TO ASSESS THE QUALITY STATUS AND TRENDS.

COMPLIANCE MONITORING - TO DETERMINE WHETHER SPECIFIC WATER STANDARDS, GUIDELINES OR EFFLUENT PERMITS ARE BEING ADHERED TO.

SPECIAL STUDIES - DETAILED INVESTIGATION OF SPECIFIC PARAMETER OR AREA.

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Often Special Studies are part of monitoring programs - detailed investigation of specific parameters or topic.

Points to Consider in Monitoring Design

1. Identification of the type of information necessary for informed decision making.

2. Evaluation of possible parameters whose measurement can yield the type information you need.

3. Evaluation of sampling sites, methods, and frequency.

4. Evaluation of Analytical Methodology - want most precise and accurate methods practical given constraints of time, workload, resources and funding.

5. Development of data synthesis and reporting format.

6. Rationale for constant reevaluation and revision of monitoring program.

7. Quality Assurance Program also needs to be part of monitoring design.

Ambient Monitoring

- You want to assess overall trends in water quality. This can be random sampling of lake basin area, tributaries and lake itself. This allows evaluation of the status of the lake, evaluation of inputs, identification of trends as development occurs, and evaluation of pollution control programs.

- You need baseline or background information.
  1. Can come from previous information, prior monitoring
  2. Can come from intensive study

- Parameters and frequency - Table
- The next three tables are taken from the Global Environmental Monitoring book developed by the United Nations. These are suggested parameters for water quality monitoring.

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POINTS TO CONSIDER IN MONITORING DESIGN

1. IDENTIFICATION OF THE TYPES OF INFORMATION NECESSARY FOR INFORMED DECISION MAKING.
2. EVALUATION OF POSSIBLE PARAMETERS WHOSE MEASUREMENT CAN YIELD THE TYPE INFORMATION YOU NEED.
3. EVALUATION OF SAMPLING SITES, METHODS AND FREQUENCY.
4. EVALUATION OF ANALYTICAL METHODOLOGY.
5. DEVELOPMENT OF DATA SYNTHESIS AND REPORTING FORMAT.
6. RATIONALE FOR CONSTANT REEVALUATION AND REVISION OF MONITORING PROGRAMS.
7. QUALITY ASSURANCE PROGRAM.

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Table 2

Basic Water Monitoring Program 10/1/79 through 9/30/80

Parameter	Frequency Rivers & Streams	Lakes & Impoundments	Estuaries
Temperature	Monthly	Quarterly	Monthly
Dissolved Oxygen	Monthly	Quarterly	Monthly
pH	Monthly	Quarterly	Monthly
Alkalinity	Monthly	Quarterly	Monthly
Conductivity.	Monthly	Quarterly	Monthly
Secchi Disc	NA	Quarterly	Monthly
Salinity	NA	NA	Monthly
Turbidity	Monthly	Quarterly	Monthly
BODs	Monthly	Quarterly	Monthly
COD	Monthly	Quarterly	Monthly
Fecal Coliform	Monthly	Quarterly	Monthly
Nitrogen - Total	Monthly	Quarterly	Monthly
NO2 + NO3 and NH3	Monthly	Quarterly	Monthly
Total Kjeldahl Nitrogen	Monthly	Quarterly	Monthly
PO4	Monthly	Quarterly	Monthly
Total Phosphorus	Monthly	Quarterly	Monthly
Residue, Total	Monthly	Quarterly	Monthly
Volatile	Monthly	Quarterly	Monthly
Fixed	Monthly	Quarterly	Monthly
Metals, Cadmium	Quarterly	Quarterly	Quarterly
Chromium - Total	Quarterly	Quarterly	Quarterly
Cobalt	Quarterly	Quarterly	Quarterly
Copper	Quarterly	Quarterly	Quarterly
Iron	Quarterly	Quarterly	Quarterly
Lead	Quarterly	Quarterly	Quarterly
Magnesium	Quarterly	Quarterly	Quarterly
Zinc	Quarterly	Quarterly	Quarterly
Arsenic	Quarterly	Quarterly	Quarterly
Flow	Monthly	NA	NA
Biological	Annually	Annually	Annually

ANNEX III

LISTS OF DETERMINANDS FOR GEMS/WATER

The determinands in Lists I and III are to be measured (with certain exceptions, at all sampling locations: the determinands in List II should be measured as considered appropriate for particular locations. The absolute targets for accuracy of measurement are also given.

LIST I: Basic Determinands

Determinand	Determination for GEMS/WATER			Absolute Target for Accuracy
	Ground-Waters	Lakes	Rivers	
Temperature	-	+	+	0.5°C
pH	-	+	+	0.1
Electrical Conductivity	+	+	+	1.0, Sm^{-1} at 20°C
Dissolved Oxygen	+	+	+	0.2 $mg\ l^{-1}$ and 2% sat.
Chloride	-	+	+	1 $mg\ Cl^{-}l^{-1}$
Alkalinity, total	-	-	+	0.02meq l^{-1}
Suspended solids	-	-	+	2 $mg\ l^{-1}$
Nitrogen, ammonia (as N)*	-	+	+	0.1 $mg\ l^{-1}$ or 0.01 $mg\ l^{-1}$
Nitrogen, nitrate + nitrate (as N)*	-	+	+	0.1 $mg\ l^{-1}$ or 0.01 $mg\ l^{-1}$
B.O.D.	-	-	+	2 $mg\ l^{-1}$
Fluoride (as F)	+	-	-	0.1 $mg\ l^{-1}$
Phosphorus, ortho-phosphate (Soluble reactive, as P)*	-	+	+	0.02 $mg\ l^{-1}$ or 0.002 $mg\ l^{-1}$
Faecal Coliform bacteria	+	-	+	Not applicable

* The lower of the two targets applies when eutrophication is of interest.

N.B.

Special local circumstances and knowledge of the quality of a particular water may:

(a) allow certain of these determinands to be excluded;

(b) require inclusion of determinands shown above as not being required.

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ANNEX III
LIST II OPTIMAL DETERMINANDS

Determinand	Determination for GEMS/WATER			Absolute target for accuracy
	Ground-Waters	Lakes	Rivers	
TOC	+	+	+	1 mg l^{-1}
COD	+	+	+	20 mg l^{-1}
MBAS anionic tensides	+	+	+	0.1 mg l^{-1} Lauryl sulfate or its equivalent
Nonionic tensides	-	-	+	0.1 mg l^{-1} Lissapol X or its equivalent
Chromium, total	-	-	+	0.005 mg l^{-1}
Chromium, hexavalent	-	-	+	0.005 mg l^{-1}
Nickel	-	-	+	0.005 mg l^{-1}
Zinc	-	-	+	0.005 mg l^{-1}
Copper	-	-	+	0.005 mg l^{-1}
Arsenic	+	-	+	0.005 mg l^{-1}
Boron	+	-	+	0.1 mg l^{-1}
Cyanide	-	+	-	0.005 mg l^{-1}
Silica, reactive	-	+	-	0.1/0,01 mg l^{-1} *
Iron, total	+	+	+	0.01mg l^{-1}
Manganese	+	+	+	0.01 mg l^{-1}
Potassium	+	+	+	0.1 mg l^{-1}
Sodium	+	+	+	1 mg l^{-1}
Sulfate	+	+	+	2 mg l^{-1}
Nitrogen, Kjeldahl (as N)	-	+	+	0.1 mg l^{-1}
Phosphorus, total	-	+	+	0.2/0.002 mg l^{-1} *
Faecal streptococci	+	+	+	Not applicable
Phytoplankton genus and species counts	-	+	-	Not applicable
Primary productivity	-	+	-	**
Carbon dioxide,	+	+	-	1 mg l^{-1}
Permanganate value (as O_2)	+	-	+	2 mg l^{-1}
Solenium	+	+	+	0.001 mg l^{-1}
Hydrogen sulfide	+	+	+	0.0r mg l^{-1}
Barium	+	-	-	0.1 mg l^{-1}
Phenols	+	-	+	0.002 mg l^{-1}
Lithium	+	+	+	0.1 mg l^{-1}

Cont'd .....

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ANNEX III (CONT'D)

LIST II OPTIMAL DETERMINANDS

Determinand	Determination for GEMS/WATER			Absolute target for accuracy
	Ground-Waters	Lakes	Rivers	
Polycyclic aromatic hydrocarbons	+	+	+	Decided not to set target
Transparency	-	+	+	0.5 m
Calcium	+	+	+	
Magnesium	+	+	+	1 mg l^{-1}
Volatile suspended solids	-	-	+	2 mg l^{-1}
Chlorophyll a	-	+	-	0.0005 mg l^{-1}
Phytoplankton (Volume)	-	+	-	No target set.

* The lower of the two targets when eutrophication is being monitored.

** Detailed methodology (dark bottle and light bottle incubation) yet to be agreed -- involves determination of dissolved oxygen; target accuracy for each dissolved oxygen determination in the test be as for the determinand dissolved oxygen in List I of this Annex.

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LIST III : DETERMINANDS OF GLOBAL SIGNIFICANCE

To be measured at all sampling locations wherever the laboratory facilities allow for it.

Determinand	Absolute target for accuracy
1. Heavy metals:	
Cadmium	0.001 mg l^{-1}
Mercury	0.0001 mg l^{-1}
Lead	0.005 mg l^{-1}
2. Organochlorine compounds	Targets to be decided
DDT	
DDE	
DDD	
Dieldrin	
Aldrin	
Hexachlorocyclohexane isomers (BHC)	
PCBs	

N.B. Monitoring of 1 and 2 above includes:

(i) total content in water)
(ii) dissolved content in water) during present phase of the project

(iii) content in bottom sediment)
(iv) concentration in relevant biota) envisaged for subsequent phases of the project

The accuracy targets apply only to (i) and (ii) above.

Compliance Monitoring

- This type monitoring is usually much more specific. Usually only one or a few parameters are measured.
- The industry or municipality reports to government the nature of their effluents. The government evaluates and based on legislation, suspected effects, assimilative capacity or receiving water, etc., decides on permissible levels of effluent constituent. The industry receives a permit to release a certain amount of waste into the water. The industry must take whatever action necessary to meet the permitted amount of waste.

- It is necessary to monitor whether the industry is in compliance with their permit. There are two ways this monitoring is usually done.

  1. Self monitoring system
     - This is the approach the U.S. has taken for compliance monitoring of industrial effluents. There are guidelines for specific pollutants and for industrial categories, as well as for different types of receiving waters.
     - Flow diagram

  2. A less common system has the government doing the monitoring. The permit process is the same, as are the reactions to exceeding the permit. The only difference is that a central laboratory collects and analyzes the samples.

  3. There can be hybrid system with joint effort by government and industry to meet special circumstances or needs.

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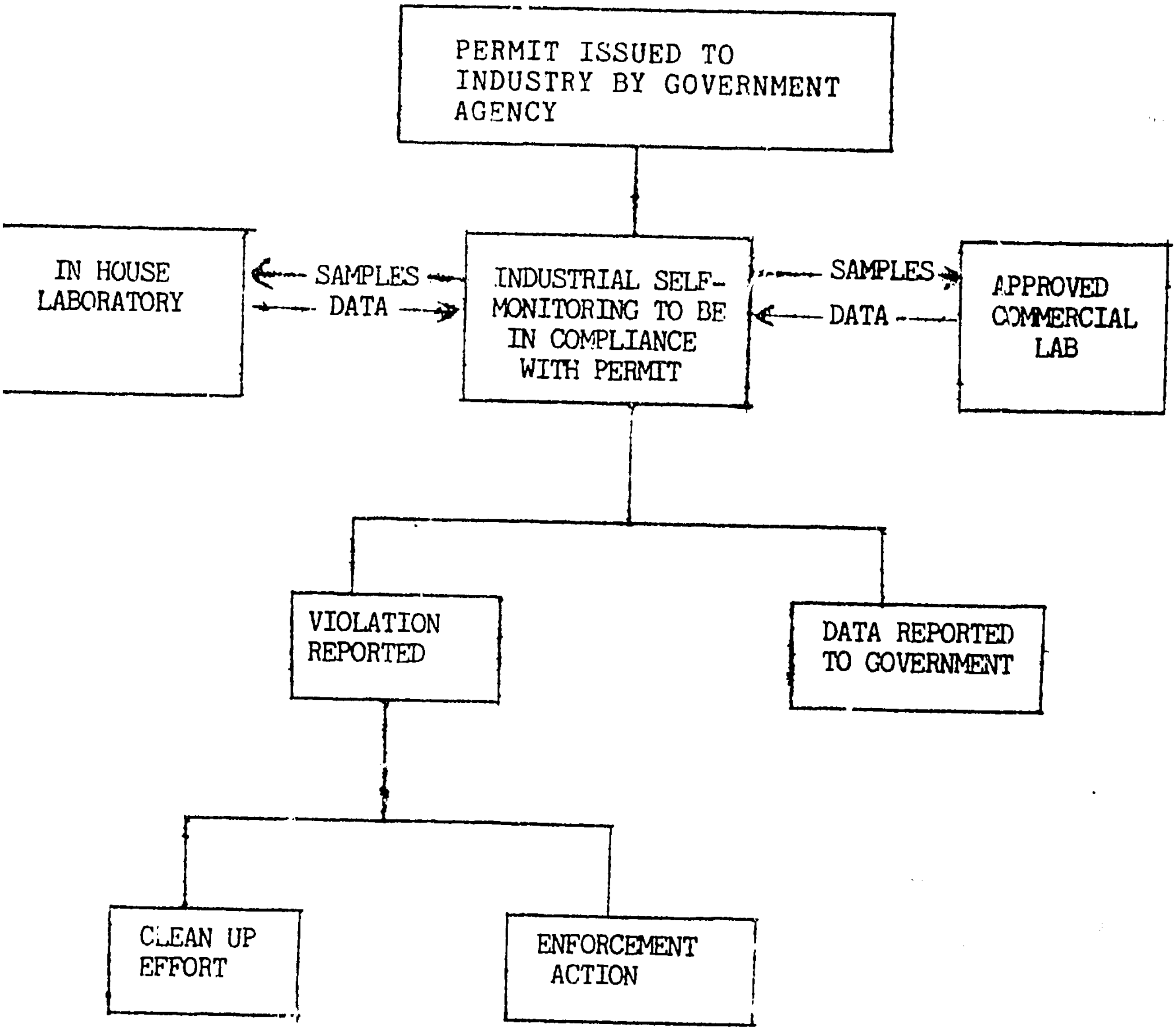
SELF MONITORING SYSTEM



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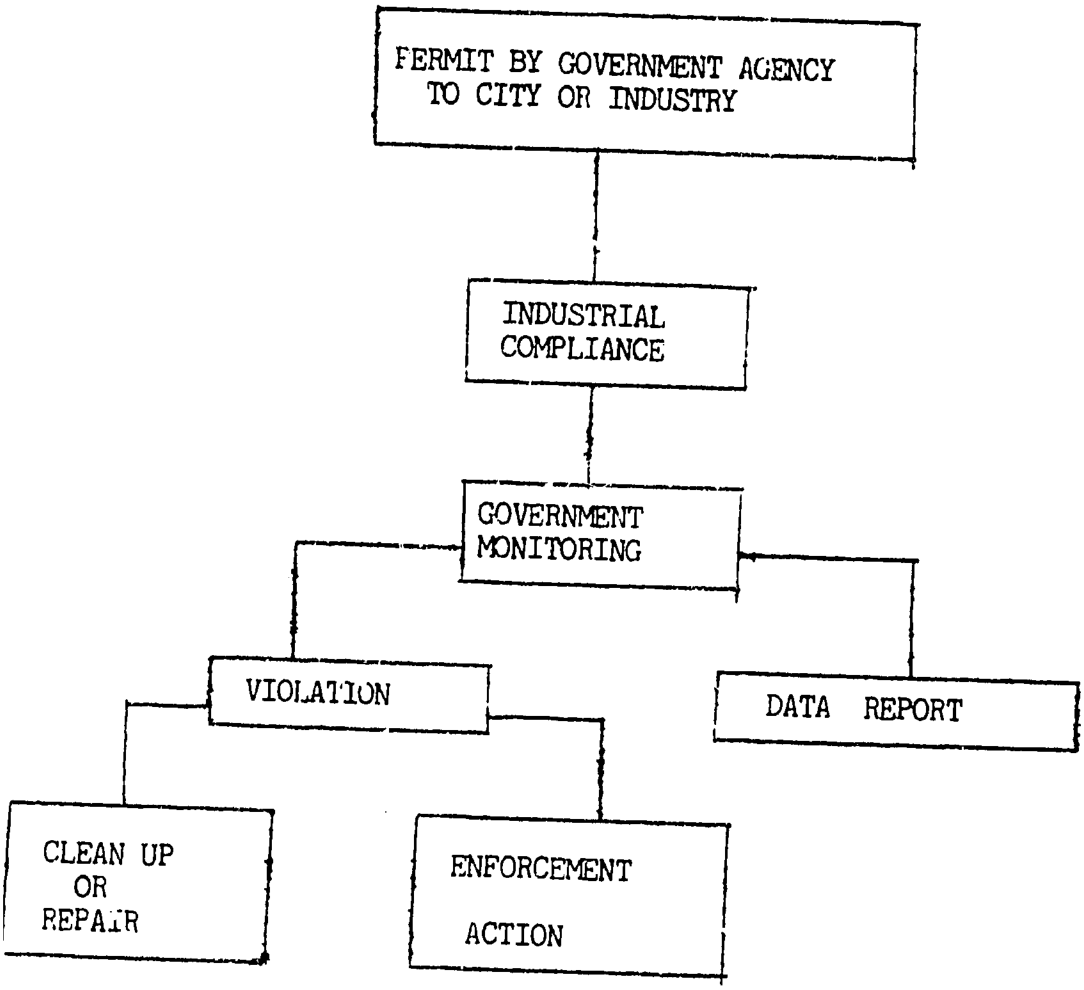
GOVERNMENT COMPLIANCE MONITORING



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PRINCIPLES OF WASTEWATER TREATMENT

BY

PHILIP C SINGER

1. CHARACTERISTICS OF WASTEWATER

A. Typical Composition of Raw Domestic Wastewater

Table I

TYPICAL COMPOSITION OF DOMESTIC SEWAGE
(All values except settleable solids are expressed in mg/liter)

Constituent	Concentration		
	Strong	Medium	Weak
Solids, total	1,200	700	350
Dissolved, total	850	500	250
Fixed	525	300	145
Volatile	325	200	105
Suspended, total	350	200	100
Fixed	75	50	30
Volatile	275	150	70
Settleable solids, (ml/liter)	20	10	5
Biochemical oxygen demand, 5-day 20^{o} (BOD_5 20^{o})	300	200	100
Total organic carbon (TOC)	300	200	100
Chemical oxygen demand (COD)	1,000	500	250
Nitrogen, (total as N)	85	40	20
Organic	35	15	8
Free ammonia	0	0	0
Nitrites	0	0	0
Nitrates	0	0	0
Phosphorus (total as P)	20	10	6
Organic	5	3	2
Inorganic	15	7	4
Chlorides *	100	50	30
Alkalinity (as CaCO)*	200	100	50
Grease	150	100	50

* Values should be increased by amount in carriage water.

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II. GENERAL TREATMENT CONSIDERATIONS

A. Primary Treatment

1) Sedimentation

a) OBJECTIVE: to separate settleable solids and floatable material (grease) from the wastewater

b) Approximately 60% removal of suspended solids and 40% removal of BOD can typically be achieved.

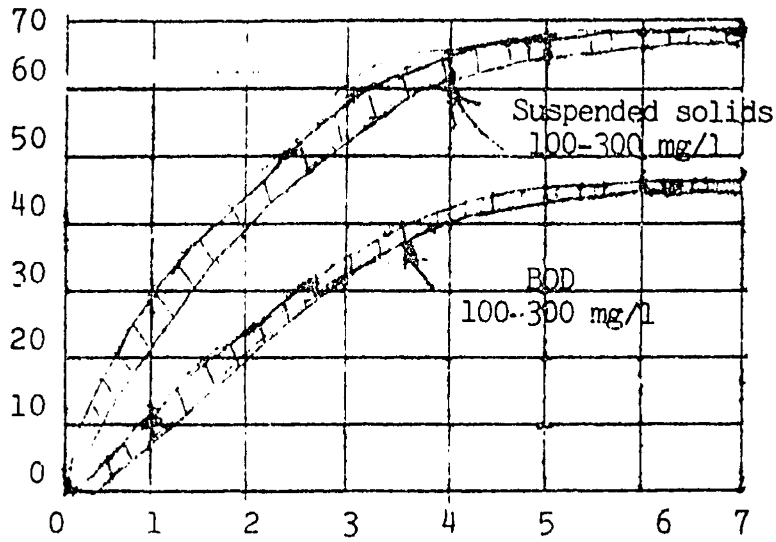

Fig. I Removal of suspended solids and biochemical oxygen demand from sewage by plain sedimentation in primary tanks.

B. Secondary Treatment

1) Bilogical treatment processes

a) OBJECTIVE: to biologically convert soluble and colloidal organic material (BOD) to CO_2 and settleable mircoorganisms (biomass). See Figure II.

b) Aerobic processes are typically utilized, e.g. stablization ponds, trickling filters, activated sludge. Anaerobic processes could also be used, however, frequently used for sludge digestion.

c) Pretreatment, e.g. pH neutralization, heavy metal coagulation, equalization, may be required in order to prevent upset of the biological system, especially where the influent wastewater

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III. PRINCIPLES OF SEDIMENTATION

1) To remove settleable portion of suspended solids from wastewater by gravitational forces.

2) Efficiency of removal is a function of particles size and density, and solution density and viscosity. The latter two are affected by temperature.

3) Stoke's Law $v_s = \frac{g}{18} \frac{p_s - p}{H} d^2$

4) Overflow rate

   a) The overflow rate of a sedimentation basin governs the effectiveness of the basin in removing suspended solids. The overflow rate, or surface loading rate, is

   $$v_o = Q/A_s$$

   and has units of gpd/ft^2.

   b) Primary settling tanks - 800 to 1000 gpd/ft^2 based on 24-hour average flow to obtain 50-60% SS removal.

   c) Secondary settling tanks -

      i) 500 to 700 gpd/ft^2 for trickling filter effluent.

      ii) 30 to 35 lbs/day/ft^2 for activated sludge effluent. Design is based on thickening requirements rather than settling requirements.

   d) Rectangular and circular horizontal flow basins are typically used. Circular tanks are usually used for thickening. See Figure III.

   e) Sludge concentrations -

      i) In primary tanks, solids concentration in sludge averages 2.5 to 5.0%; 3000 gal. of sludge is generated per million gal. of wastewater.

      ii) In secondary tanks following trickling filters, solids concentration averages 5 to 10%. Activated sludge typically thickens to only 1 to 2% solids.

      iii) Sludge needs to be destablized, dewatered, and ultimately disposed of. Anaerobic sludge digestion and sand drying beds are usually used for these purposes.

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IV. PRINCIPLES OF MICROBIAL GROWTH AND SUBSTRATE UTILIZATION

1) Organisms require energy for synthesis of biomass, i.e. new cells. See Figure IV.

2) Energy required for synthesis of biomass can come from a variety of sources.

   a) Sunlight, as in photosynthesis, by photoautotrophs such as algae.

   b) Oxidation of inorganic compounds, e.g. NH_4^+, by chemoautotrophos.

   c) Oxidation of organic compounds using O_2, by aerobic heterotrophs.

   d) Oxidation of organic compounds in the absence of O_2, by anaerobic heterotrophs.

3) Microorganisms couple energy-yielding reactions (oxidations) with energy-demanding reactions (synthesis) to carry out their metabolic activities.

   a) Aerobic oxidations of organic compounds yield more energy for syenthesis than anaerobic reactions. Hence, more biomass (wast sludge) is produced per unit amount of substrate degraded under aerobic conditions.

   b) Oxygen required for the aerobic oxidation of organic substances can be provided by algae (as in oxidation ponds and facultative waste stablization ponds) or by aeration devices (as in oxidation ditches and aerated lagoons).

4) Aerobic reactions are generally faster than anaeobic reactions.

5) Wastewater must be nutritionally balanced for biological treatment.

   a) Recommended nutrient requirements are 15 mg nitrogen and 1 mg phosphorus per 100 mg of BOD_5.

   b) Domestic wastewater typically has more than enough N and P to satisfy the needs of the microorganisms.

   c) Industrial wastewater or municipal wastewater with a significant industrial component may need N and/or P supplementation.

V. TYPES OF BIOLOGICAL TREATMENT PROCESSES

A. Waste Stabilization Ponds (see Table II)

1) Large, shallow basins, enclosed by earthen embankments, lined or unlined. Raw wastewater treated by natural processes involving algae and bacteria.

2) Rate of oxidation is slow; long hydraulic residence times (large areas of land) are required.

3) Particularly attractive wastewater treatment alternative where sufficient land is available and where temperature is favourable. Waste stabilization ponds have the least energy requirements and capital expenditures of other wastewater treatment alternatives.

4) Types of ponds (see Table III)

a) Oxidation ponds (unaerated aerobic ponds)

i) Shallow (3-4 ft), aerobic pond. Shallow depth essential for complete sunlight penetration.

ii) Dependent solely on photosynthetic production of oxygen by algae and other aquatic plants.

b) Facultative ponds (see Figures V and VI)

i) Among the most common types of waste stabilization ponds.

ii) Deeper ponds (3-8 ft.). Aerobic conditions exist in the upper layers due to algal photosythesis and natural surface re-aeration. The oxygen provided allows aerobic bacteria to oxidize organic material in the wastewater. The CO_2 released is used by the algae, along with sunlight and nutrients, to carry out photosynthesis and produce oxygen. Anaerobic conditions exist in the bottom layers where organic solids undergo anaerobic decomposition.

c) Aerated Ponds

i) Oxygen provided by mechanical aeration devices, e.g. surface aerators.

ii) May be aerobic (if completely mixed) or facultative (if only partially mixed). If only partially mixed, anaerobic decomposition of organic solids occurs in bottom layer.

d) Anaerobic ponds

i) Used only for partial treatment, usually for pretreatment of strong organic wastes such as those from industry; particularly useful

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for wastes with a high solids content.

ii) Balance needs to be maintained between acid -producing anaerobic microorganisms and methane-producing microorganisms.

iii) Effluent usually treated by a facultative pond following the pretreatment anaerobic pond.

e) Maturation Ponds

i) Used following facultative ponds for destruction of pathogenic microorganisms.

5) Design criteria for waste stabilization ponds.

a) See Tables IV,V,VI,VII.

6) References

a) Reed, SC and AB Hais, "Cost-Effective Use of Municipal Wastewater Treatment Ponds", pp 177-200 in Appropriate Technology in Water Supply and Waste Disposal, CG Gunnerson and JM Kalbermatten, eds.; American Society of Civil Engineers, New York (1979).

b) Mara, D, Sewage Treatment in Hot Climates, John Wiley and Sons, London (1976).

c) Wastewater Treatment Plant Design, American Society of Civil Engineers, New York (1977).

B. Trickling Filters

1) Relatively shallow (3-8 ft) circular or rectangular bed of rocks (1-3 in. in size) over which primary clarified wastewater is sprayed intermittently. (see Figure VII).

a) Biological slime grows on rocks, removing and oxidizing organic substances in wastewater as the water trickles over the rocks.

b) Air is drawn up through the bed of rocks and oxygen diffuses into the biological slime along with the organic substrate. (See Figure VIII).

c) Biological slime increases in thickness as substrate is utilized. Interior portion of slime eventually becomes anaerobic and decomposition of the microorganisms within the slime occurs. When the slime becomes too thick and too weak, it is sheared off the rock (sloughing) and passes into the effluent along with the treated wastewater.

d) Secondary clarifiers are required to collect the biomass which sloughs off the filters (humus).

e) Primary clarification is required to prevent clogging of the distributor or of the media.

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f) Waste sludge from secondary clarifiers needs to be disposed of.

2) Design of trickling filters is based on both hydraulic loading (MGAD)and organic loading (lbs BOD_5 per acre-ft.per day). See Table VIII.

a) Filters can be classified as low-rate or high-rate, depending upon the loading.

b) Nitrification occurs in low-rate trickling filters.

c) Recirculation of clarified effluent is employed in the design and operation of high-rate trickling filters. This serves to smooth out variable loads and dampen fluctuations in influent wastewater quality and quantity. (see Figure IX).

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IMPLEMENTATION OF MONITORING AND
ANALYTICAL PROGRAMS, MANPOWER DEVELOPMENT
AND TRAINING

BY

FREDERICK K PFAENDER

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F K PFAENDER

BASIC CONSIDERATIONS

A. Important to take available or potential resources into consideration when designing and implementing system.

B. Avoid fragmenting monitoring responsibility among several agencies.

C. Avoid following someone else's model too closely

D. As much as possible, use simple analytical procedures in the laboratory.

GOALS

- The people involved in the monitoring program need to be aware of both the overall goals of the monitoring effort, as well as the goals and objectives of their specific duties.

- There are several types of uses that water quality monitoring data can have (Figure 1). The program needs to address the needs of these users. These are important in setting the appropriate goals.

- These goals can be short term, intermediate and long term (Figure 2). A list of each type goal is provided. You can decide which are pertinent to your situation.

ORGANIZATION OF MONITORING PROGRAMS

1. The objective of this paper is not to suggest how you should design and implement your monitoring program, but to give some idea of how we have approached this problem. That is why we advance the examples referred to in the figures below.

2. North Carolina Water Quality Program.
   Flow Sheet - Figure 3

3. U.S. Environmental Protection Agency.
   Flow Sheet - Figure 4

4. Both programs are large organizations with many hundreds of people.

LABORATORY DESIGN

Several factors should be kept in mind when evaluating laboratory designs.

a. Remember that the baseline for your whole effort depends on your laboratory. It is important to have this part of program working well.

b. Centralized laboratory is most efficient for most small programs.

c. Better to expand existing laboratory than develop new facility, if possible.

d. Begin with minimal program and build up over several years.
   Figure 5 is example of Water Quality Monitoring Support Laboratories for U.S. Environmental Protection Agency.

MANPOWER DEVELOPMENT

The kinds of programs suggested above need people with range of specialities - hydrologists, biologists, chemists, geologists, planners. Two major areas of emphasis emerge.

1. Identification and recruitment of people with the training you need.

2. Training programs so you are not as dependent on others to provide your trained personnel.

BASIC CONSIDERATIONS

A. TAKE RESOURCES INTO CONSIDERATION DURING PLANNING OF MONITORING PROGRAMS.

B. AVOID FRAGMENTATION OF MONITORING RESPONSIBILITY WHERE POSSIBLE.

C. AVOID FOLLOWING SOME MODEL OF HOW OTHERS HAVE DONE MONITORING - DESIGN AND IMPLEMENT YOUR OWN SYSTEM.

D. USE SIMPLE ANALYTICAL TECHNIQUES AS MUCH AS POSSIBLE.

Training assistance can come in several forms:

1. Send people for generalized or specialized training to established institutions.

   a. Universities, Technical Schools, Governmental Agencies.

   b. Short courses offered by International organizations, WHO, ETMA, others.

2. Request specialized training programs for your particular needs:

   a. Seminars, workshops, short courses run by your institutions, or those of other African nations.

   b. Short courses - ETMA, UN, other donor countries.

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Figure 1. WATER QUALITY DATA USES

Receptor User Requirements

- Public interest:
  - Public Health
  - Aesthetics
  - Nuisance
  - Ecological balance
  - Conservation
  - Natural state preservation
  - Recreation
- Planning :
  - Water and related land use planning
  - Economic planning
  - Urban planning
- Regulation and Control:
  - Identification of sources
  - Fate of Pollutants
  - Description of present state of quality
  - Prediction of water quality
  - Evaluation of trends
  - Available control strategies and tactics
  - Measurement of progress in pollution abatement
  - Episodic effects
  - Non-degredation policy
  - Research
  - Legislation
  - Public hearings
  - User-oriented reports
- Data Interchange:

Figure 2. TIME-PHASED GOALS OF WATER QUALITY MONITORING IN REGULATION AND CONTROL

A. Short-term Goals

1. Monitor and investigate complaints
2. Identification of gross pollution and nuisance conditions
3. Prevention of water pollution emergencies or episodes; e.g. fish kills
4. Set, amend, or repeal water quality standards
5. Development of effluent standards
6. Issuance of discharge permits for significant waste sources
7. Enforcement of existing standards; investigation of the degree of compliance and frequency of violation
8. Establishment of priorities for the control of sources of pollution
9. Authorise and approve water pollution control and abatement plans for drainage basins.

B. Intermediate Goals

1. Determine the nature and extent of pollution in areas of interest.
2. Preparation of control strategies and time-staging of program
3. Develop integrated data system to meet receptor-user requirements
4. Development of water quality criteria and standards
5. Evaluation of the effectiveness of activities aimed at controlling water pollution as evidenced by general changes in water quality

C. Long-term Goals

1. Long-range program planning, policy, and land-use planning
2. Determination of origin and distribution of pollutants
3. Tracing of pathways and fate of pollutants
4. Understanding of the physical, chemical, and biological response of streams
5. Evaluation of various control strategies
6. Response of water quality to standards, permits, regulation, and enforcement.
7. Prediction of water quality
8. Evaluation of trends, determination of the background levels of pollution

The first requirement is to assess the type of monitoring you need to do. Assess the baseline date before the industry is established because it is part of planning, and will allow impact to be determined.

Monitoring itself is only a tool for decision makers and you must establish what you want to know. For instance,

a. Ambient monitoring is to assess overall quality and trends

b. Compliance monitoring is to ascertain whether given standards are met or exceeded

c. Special studies are detailed investigation of specific parameter or area.

In most situations these are handled by different agencies.

But whatever is the case, the purpose is related to the goals of the monitoring agencies. Water for fisheries require a set of standards and the agency concerned will do the relevant survey, for its decision-making.

POINTS TO CONSIDER IN MONITORING DESIGN ARE:

1. Identification of the types of information required.
2. Evaluation of sampling sites, methods and frequency.
3. Evaluation of possible parameters whose measurement can produce the types of information necessary.
4. Evaluation of analytical methodology.
5. Development of data synthesis and reporting format for the data.
6. Rationale for constant re-evaluation and revision of monitoring programmes.
7. Quality assurance programs.

Ambient and Compliance Monitoring

There are a variety of parameters that can be measured to produce information on the quality of the water. These are specified in the figures 2 and 3.

In the U.S., State Autnorities are often required to make basic assessment of the waters in their areas. But in most cases, they do not perform this ambient monitoring as well as might be desirable. This of course is a massive task.

Compliance monitoring is conducted to ascertain whether permits for discharge are being met or exceeded. For example, the U.S. Government and the country at large have enough laboratories and personnel to do all the monitoring work even though the cost is large. The same applied to the industries, however for limited sizes, the monitoring of wastes can be a significant burden. The U.S. has taken the approach of having the industry be responsible for doing monitoring of their own effluents and reporting the date to EPA.

BASIC CONSIDERATIONS FOR MONITORING

(A) Take resources into consideration during planning of monitoring programs

(B) Avoid fragmentation of monitoring responsibility where possible.

(C) Avoid following some model of how others have done monitoring - Design and Implement your own system.

(D) Use simple analytical techniques as much as possible.

In (B) for instance, have few laboratories in which you can have confidence rather than many that are neither competent nor credible. Strive for cost-effectiveness and a modality that allows for efficient and simple comparison of the data.

In (C) there is no substitute for persimony so long as it is rational because it enhances cost-effectiveness.

In terms of people: you need from the top of the agency to the one washing dishes in the laboratory to understand exactly why they do what they do.

There are other specific goals of monitoring.

Short-term Goals

1. Monitor and investigate complaints.
2. Identification of gross pollution
3. Prevention

Intermediate

Determine nature and extent of pollution
Prevention strategies
Development of intermediate standards
Develop integrated data system to meet receptor use
Develop quality

Long-term Goals

Long-range planning
Determination of origin and distribution
Determining pathways

In every case, the task is to determine both the man-power needs and the appropriate organization. This must be unique and geared to the techniques adopted for your purposes.

Along with the above is the laboratory design because it determines the efficiency of your organization. It can be one of the following:-

1. Centralised Laboratory - where resources are scarce.
2. Better to expand existing laboratory than to start new ones.
3. Begin with a small programme and expand over several years.

Training : Will automatically follow from the above. A number of approaches are necessary.

1. Bend people to established training programs.
   A. Universities technical schools.
   B. Government agencies

2. Specialised training provided for specific needs.
   A. Intra-African Programs
   B. Short courses - Donor countries

Those from outside East Africa can provide help. They can give trainers for the monitoring programs and associated policy questions. But one way of handling it is to expand training capabilities in African instutions.

DISCUSSIONS

Comment: The notion of a centralized laboratory in the Kenyan context has had problems. Samples were ferried to Nairobi. For example, it is important to note that for some of the problems samples must be examined immediately. Long delays change the characteristics of the sample. Distances and transportation problems increase the problem in Kenya.

Answer: The centralization must be relative and mean that the laboratories would be task - specific.

Comment: Kenya had one mobile laboratory but it had an accident and stopped. Besides, they are costly to purchase and worse to maintain.

ETMA is concerned with training and involves three institutions. Clark University, University of North Carolina, and the South Eastern Consortium involving 16 Universities in the US's South-East.

They will cater for any African institution that is interested and is prepared to sponsor the training. The kind of course given depend on the request. In the process of negotiation the finances are arranged and some of it can come from the U.S. sources.

It is a major goal of the ETMA to strengthen the capabilities of African institutions.

TRAINING NEEDS AND RESOURCES

A major need identified during the workshop was training at several levels and disciplines. At both the beginning and intermediate levels there needs to be technical, social policy, and educational training activities mounted within the Greater Lake Basin Area to provide the manpower necessary for reacting to area development. Among those subject areas identified as important were:

- Economic aspects of Basin Development
- Planning and Management of Development
- Water quality Monitoring - sampling and analysis
- Water quality monitoring - Data synthesis and use.
- Waste Treatment Plant Operator Training
- Public Education on Environmental Matters
- Waste and Water treatment engineering

This training should be readily available through several donor agencies including Environmental Training and Management in Africa (ETMA). The Lake Basin Development Authority could serve as a focus for these training activities in Western Kenya and other parts of the greater Lake Basin Area. Other donor agencies could include UNEP and the USAID, among others. Requests for ETMA training efforts should be directed to the ETMA representative for East Africa in the Office of the Environmental Secretariat, in Nairobi - currently Dr Richard Ford is the representative, but he will be returning to U.S. in August - his replacement will probably not be in place until October or November. In the interim requests can be addressed to:

Dr Earle N Buckley
South-East Consortium for International Development
400 Eastowne Drive
Chapel Hill NC 27514 USA

CHAPTER VIII

RECOMMENDATIONS AND ACTION PLAN

BY

THE PARTICIPANTS

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RECOMMENDATIONS AND PLAN OF ACTION PROPOSED

by

THE PARTICIPANTS

Working Groups, commencing during the afternoon session on 27th July 1982. There are four categories of tasks dealt with by the groups. I. Sewerage; II. Pollution Monitoring; III. Legislation and Enforcement; and Regional Co-operation.

The present participants worked in the groups as follows:-

I. SEWERAGE

1. V.M. Kariuki
2. P.C.Singer
3. C.K. Murigo
4. W.O. Orwenyo
5. J.G.C. Amolo
6. R.I.Katambani
7. C.C.N Suhudu

II. POLLUTION MONITORING

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2. O. Masongo
3. P.M. Olindo
4. I.M. Kilonzo
5. J.M. Nyamu
6. M.M.Kariuki
7. B.N. Shikony
8. D.M.S. Mosha
9. R. Nyaoro
10. T. de Souza
11. A. Getabu
12. Paul Andwana
13. Y.W.K Malinga

III. LEGISLATION

1. J.O. Rourke
2. D.N. Kinyanjui
3. J.K. Ingonga
4. M.J. Telewa
5. P.J. Madati
6. C. Ashibila
7. K. A. Ajode
8. J.B. Rasono
9. P.O. Sewe

IV. REGIONAL COOPERATION

1. A.O. Moshi
2. D.P.S. Wasawo
3. C. Bunane
4. J. Gaudet
5. F.W.B. Bugenyi
6. E. Berege
7. J.N. Bonuke
8. A. Asila
9. R. Nyakundi
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GROUP REPORTS

Group I - Sewerage

The present state of service offered by the sewerage systems in most urban centres in Lake Basin Area of Kenya and in other urban centres in East Africa was considered with specific reference to:

a) Adequacy

b) Maintenance

c) Sanitary Engineering and Design

d) Planning of Towns and Urban Centres.

Further discussions addressed the:

- Role of local, national and regional Authorities in Environmental Sanitation.
- Training and Research needs.
- Need for local code for monitoring effluent into the Rivers and Lakes.

ADEQUACY OF SEWERAGE SYSTEMS IN LAKE BASIN AREA OF KENYA

The adequacy of the systems should be looked at from the points of view of satisfactory service for the total number of residents of an urban centre as well as the satisfactory service which can be provided, taking into account the load handled by the system as a whole.

In almost all of the urban centres there is inadequate data to determine either quantitative or qualitative performance of the treatment systems. But generally it was found that the current sewerage systems are woefully inadequate.

The reasons for inadequacy are:-

(a) In most urban centres the sewerage systems were designed long ago and have not kept pace in terms of improvement or enlargement to measure up with the requirements for water supply and the populating growth. As a result, the existing treatment system is found to be inefficient and inadequate to cope with the current needs of the urban centres.

(b) In many towns a significant percentage of the residents live in areas not connected to the central sewerage systems because the slums in which they reside were not planned for the purpose and have no water-borne sanitation. The result is an urban sewerage system that does not cover some of the highest concentration of the population.

There is urgent need for alternative methods and appropriate technology for excreta disposal in these areas. As a matter of fact it is recognized that providing appropriate and satisfactory alternative to water borne central sewer system is particularly difficult in high density slum areas. Attention should be urgently directed at the slum areas because they pose public health problem to the resident population, a matter which is contrary to the development goals of the country. A healthy population is an indicator as well as a prerequisite of national development.

(c) Some of the personnel manning some of the sewerage works are inexperienced and not adequately trained.

Therefore they do not understand the strategic importance of their work nor yet are they competent to enhance or modify their performance to improve the sanitary conditions of their clients.

(d) Many of the town sewerage systems do not have adequate laboratory facilities to conduct full tests for industrial and domestic pollutants discharged in the receiving systems notably, the rivers and lakes. Thus, there is qualitative inadequacy in most sewerage systems.

MAINTENANCE

Proper installation and maintenance of the sewerage systems to ensure efficient and continuous service is the condition for achieving the goal of sanitation.

At present the level of maintenance is ineffective and inadequate for several reasons:

i) Lack of spare parts - some of the sewerage systems are old and machinery obsolete.

ii) Lack of initiative from the administration of the authorities responsible for maintaining the sewerages. Many administrators do not consider the urgency of repairing faults in time in the sewerage systems.

At times budgetary provisions are not made for sewer maintenance and even the revenue collected for sewerage maintenance from the residents is not used for the purpose of maintaining that system.

iii) There is inadequate maintenance staff; in many cases that staff is without adequate training.

SANITARY ENGINEERING AND APPROPRIATE TECHNOLOGY

There is general lack of qualified sanitary engineers to undertake planning and design of the sewerage works to suit the local conditions. Part of the reason for this is the peripheral emphasis laid on importance of proper sanitary engineering and need for evolution of appropriate technology for disposal of domestic wastes, including excreta, in rural communities and periurban and slum areas.

This goes hand in hand with lack and/or inadequacy of training programmes for sanitary engineers and sewerage inspectors and maintenance staff for the local Authorities.

TOWN AND URBAN PLANNING

Influx of the rural people into the towns makes towns and urban planning difficult. However, for the towns existing planning exercise is inco-ordinated and does not cover all aspects involved in human settlements. Sewerage planning, in particular, comes as an afterthought and even when it appears on the drawing board implementation takes secondary position. This shows lack of appreciation for sanitary conditions for the local population as a requirement for development.

TRAINING AND RESEARCH

There is general apathy around the area of training of personnel to look after environmental sanitation in urban areas and the high density settlement areas.

Lack of research and training programmes leave most sanitation workers rusty and out of date. Thus, where there is no manifest concern for improving their work the sanitation workers become apathetic.

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Data collection, analysis, and utilization is almost absent with the consequence that meaningful planning, which must be based on such data, become unfeasible.

NEED FOR LOCAL CODE FOR MONITORING SEWERAGE EFFLUENT

At present the analytical laboratories in the Lake Basin area use standards that may not be suited for the environment. WHO and WMO Standards are general and should really be modified or clearly articulated to allow proper monitoring under the local conditions.

THE ROLE OF THE AUTHORITIES

The primary responsibilities of sewerage, solid and industrial waste disposal lies with the Local Authorities.

Under the Public Health Act, the public health Authorities are responsible for problems of agricultural, domestic and municipal wastes which are likely to affect human health.

These authorities need sympathetic hearing and assistance on their sewerage, gabbage and industrial waste disposal financial needs. The Local Authorities referred to here include urban, town and Municipal Councils and the County Councils.

The Central Government need to assist the local authorities secure aid and qualified personnel for necessary service.

The Lake Basin Development Authority, with the role of co-ordinating planning and use of water resources, should develop a strong link with the local authorities in the Basin Area to ensure proper planning of the environmental sanitation and pollution control in relation to human settlements, industrial development, agricultural development and water use programmes. The Authority should act as an important liaison between the Local Authorities, other central Government Authorities and Foreign Aid Agencies to attract due attention and funding for such programmes.

The Central Government Ministries responsible for Environment, Water Development, Health, Industry have roles of varying degrees in the issue of sewerage and industrial waste disposal. This set up leaves room for inaction even where there is serious and urgent need because each expects others to take the necessary action.

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Accordingly, the Lake Basin Development Authority should act as a co-ordinator when execution of legislation is needed for sewerage and industrial waste control to prevent water pollution.

SEWERAGE

Recommendation

(1) It is recommended that planning and design of the town sewerages should be locally carried out.

(2) The Lake Basin Development Authority should participate in:-

a) Co-ordination of town and urban planning with a view to providing development master-plans to include sewerage treatment systems.

b) Initiating a move to establish training facilities for sanitary engineers, sewerage supervisors and maintenance personnel.

c) Establish Research Data Processing Units from the Monitoring Laboratories.

(3) Every sewerage system should have an in-built monitoring laboratory facility properly equipped and manned by trained personnel.

AID CHANNELS

The co-ordinating role of the Lake Basin Development Authority was considered to be very significant in the monitoring of pollutants in the Lake Victoria Catchment of Kenya and that the LBDA should work in collaboration with the relevant government Ministries and departments, e.g. Ministry of Water Development, Ministry of Health and Department of Fisheries. This type of institutional arrangement constitutes a functional mechanism through which donor agencies could assist the LBDA directly and participate in the monitoring, manpower development and training to enable the LBDA to strengthen the national monitoring machinery.

Other institutions corresponding to LBDA, in the countries riparian to the Lake Victoria should be considered for aid by the agencies to facilitate comprehensive quality management for the waters entering the Lake.

EQUIPMENT

The group recommends that in order to determine the most suitable equipment required to undertake effective pollution monitoring in the Lake Basin Area, a detailed survey be done as soon as possible under the co-ordination of the LBDA to ascertain what facilities exist, where they are located, and if these facilities are functional. It would be a central requirement for the survey team to determine how to resolve the short-comings of the existing systems. Apart from Kenya such a survey should be done in Tanzania, Uganda, Rwanda and Burundi.

MANPOWER

The survey under (d) would also cover the crucial issue of manpower development and training by establishing what manpower is available, at what levels of specialization and in what numbers as a basis of setting targets to be achieved. That UNEP and other competent organizations should be requested to assist the countries concerned to achieve these targets.

INSTITUTIONAL ARRANGEMENTS

With respect to Uganda and Tanzania who do not have institutional arrangements similar to the LBDA, it is recommended that the relevant Authorities give serious consideration to the possibility of creating similar institutions.

DISSERMINATION OF INFORMATION

The Group Recommends that as a matter of urgency, Hydromet disserminates as widely as possible all information available to it on the waters of the Lake Victoria Catchment, e.g. Libraries, Universities and Research Institutes located in the Lake Victoria basin. Within its coordinating role, the LBDA should make available all available information to relevant Institutions, information, reports and data available to it on the Lake Victoria Basin states to avoid the high cost of duplication of effort. The information so gathered should be used to establish regional water quality and discharge standards. The LBDA should take appropriate action to coordinate that action.

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FUNDING

The Group recommends that subsequent to the survey of available facilities, equipment and trained manpower the relevant Authorities in the greater Lake Victoria Catchment Area approach appropriate Institutions to establish formal training arrangements for technical and professional training and bilateral and multilateral donor agencies should be requested for fellowships as well as other financial resources to facilitate the training and acquisition of equipments to ensure effective monitoring of the water quality with immediate effect and for all future times.

COMPLIANCE WITH NATIONAL STANDARDS

The Group unanimously agreed that LBDA and the Specialized departments concerned with Monitoring (Health, Fisheries, Water etc.), should as a matter of urgency coordinate their efforts in formulating National Effluent Control guidelines and standards. The Local Authorities acting as water undertakers should adopt and enforce discharge standards against discharges in the areas of their jurisdiction.

GROUP III - LEGISLATION AND ENFORCEMENT

DISCUSSIONS

- It was noted that there were many legislations in Kenya, as well as Tanzania, Uganda, Ruanda and Burundi, pertaining to the environmental pollution control: These include:-

  - The Public Health Act
  - The Water Act
  - The Poisonous substances (and pharmacy) Act
  - The Pesticides Control Act
  - The Factory Act
  - The Forestry Act
  - The Fisheries Act
  - The Local Government Act
  - The Agriculture Act
  - The Bureau of Standards Act
  - The Industrial Research Organization Act
  - The Marine (Port or Harbour) Act
  - The Lake Basin Development Authority Act

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- The Tana and Athi River Development Authority Act
- The Kerio Valley Development Authority Act
- The Kagera River Basin Development Authority Act
- The Rufiji River Basin Development Authority Act

- These are among the Acts which either in whole or portions deal with some aspects of water resources management. In most cases the precise question of protection of the water resources from contamination is not dealt with at all or only obliquely implied. Most importantly the crucial question of monitoring and procedure for enforcement are scantily dealt with and this results in uncertainty which discourages positive action. The discharge standards, where they exist are often vague and inadequate and there is no system of applying, issuing or withdrawing industrial permits in urban and rural areas. There is no system for environmental impact assessment for planned major project before their implementation.

- For these and other reasons, this Group recommends the following:-

1 There is a need for streamlining umbrella law to charge the environmental departments in the Government with stronger and more coordination and enforcement powers to ensure adequate monitoring and law enforcement mechanisms.

2 The Lake Basin Development Authority should implement its enabling Act to that effect. It should work in conjunction with relevant local authorities and industries to establish reticulation of monitoring systems so as to identify the quantities and qualities of the effluents from the 3 major polluters: industrial, agricultural and municipal systems.

3 Once the streamlining Act to establish the environmental departments is promulgated, the department should issue general standards of effluents in form of subsidiary regulations to protect receiving waters as well as the atmosphere.

4 The proposed streamlined and overall legislation should provide for uniform industrial permit system applicable all over the countries.

5 The University and the Directorate of Personnel Management should initiate and expand teaching programmes in environmental and natural resources management law, so as to supply the personnel to enforce the law and its subsidiary regulations.

6 The LBDA should initiate and coordinate a comprehensive and up-to-date review of the status of natural resources and environmental law in each of the countries of the great Lake Victoria Catchment.

7 All ministries with laws relating to the management of natural resources should assess and review the efficiency of their enforcement mechanisms in view of the new problems wrought by changing technology and increasing demand on natural resources.

8 The Lake Basin Development Authority should liaise with relevant authorities in neighbouring countries riparian to the Lake Victoria to ensure that all the discharges into the lake comply with appropriate standards and initiate appropriate enforcement mechanisms.

9 The Lake Basin Development Authority and similar institutions in the Catchment area should establish their own capabilities to assess the impacts which any major industrial, agricultural or urban venture has on the environment, and recommend means of environmental pollution control and abatement.

10 The Central Governments in each of the states in the Lake Victoria Catchment area is urged to establish standards for discharge of gaseous emissions into the air and to promulgate legislations on air quality.

11 Every municipal/urban centre in the Lake Victoria Catchment area should promulgate its own comprehensive waste disposal and discharge ordinance to prescribe specifications in discharge agreements with emission on effluent standards as well as procedures for enforcement for all industries locating in its area of jurisdiction.

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GROUP IV - REGIONAL COOPERATION

By Regional Cooperation in this Section we mean the action or initiatives taken by all the countries within the Lake Victoria Catchment area either singly, or in conjunction with others to monitor or enforce water quality standards in the catchment area. It is recommended, as a general premise, that the Lake Basin Development Authority which took the initiative in this water quality workshop, should initiate contacts, as suggested below and work together with corresponding institutions.

1 There should be established regular monitoring institutions and outstations at key points, such as major estuaries around the Lake, as well as at Kisumu, Jinja, Port Bell, Entebbe, Bukoba, Mwanza and Musoma.

2 To educate local people on the actions being taken on the regional monitoring programmes.

3 To commence and maintain the exchange of data and monitoring activities, on a regional basis.

4 To commence and maintain a system of regional consultation on the situation as well as control of pollution of the waters of the Lake Victoria catchment generally and Lake Victoria in particular.

5 To facilitate training and the exchange of staff on regional basis and to unify the approach of such training among all the basin states.

6 To establish and apply water quality standards for monitoring in the catchment area.

7 To identify the priorities of the basin states in water resource utilization, as might be ascertained from the respective water master-plans and other sources.

8 There should be an assessment, through Remote Sensing, if possible, of major points of sediment influx into the Lake.

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9 On the basis of that assessment information should be fed into GEMS and then strategies worked out on how to prevent sediment loading within the whole basin.

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DRAFT PLAN OF ACTION

We, the PARTICIPANTS in the Workshop on the Quality of Water of the catchment area of Lake Victoria and who are involved in public policy work in our respective countries are aware of the present needs and priorities that should be immediately implemented for the socio-economic development of the people of our countries.

We recognize the significance of water and its resources for socio-economic development of the people of the region.

We believe that the availability of suitable water for human consumption, power generation, agriculture and industrial uses, is a prerequisite as well as an index of development.

We believe that the aquatic resources such as fish in these waters, must be preserved and maintained in a quality perfect for human consumption because they are a vital resource for nutritional needs of the people. This must be accepted as the highest priority for the development of the people.

We recognize that any plans for the use of water resources must take into account that once in the Lake, the water, its resources and any other suspended or dissolved loads, do not obey territorial boundaries and therefore require comprehensive and co-ordinated catchment-wide planning by all the countries in the area.

We recognize also that the long-range and comprehensive planning required under these circumstances necessitate significant investment in human and capital resources by the states in the catchment. These, we believe, must be done at an appropriate pace because we are aware that socio-economic development of our peoples, especially those in the rural areas, is declared high priority by all our governments in the region.

It is in that spirit that we have submitted the above general policy recommendations as well as the following specific plans for action with the request that respective authorities of the countries in the catchment area give them immediate attention.

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Therefore, we RESOLVE and URGE that in the interest of present and future development of the people, the states of the catchment area, namely: Burundi, Kenya, Rwanda, Tanzania and Uganda, take initial and sustained action as outlined in the specific plans below as well as in the attached general recommendations.

And we request and urge that in accordance with the stipulations in its constituent instrument the Lake Basin Development Authority should take the initial step to communicate these recommendations to the relevant institutions of the countries in the catchment area.

We request and urge further, that where action is required, the Lake Basin Development Authority should, in accordance with the stipulations in its constituent instrument, initiate consultations necessary to that end.

I. PLANNING

1 Each State should, as a matter of urgency, evolve a Water Master Plan stipulating its short-term and long-range policy on water resources management. Such a Master-Plan should deal with strategies for conservation and utilization of water resources in the Lake Victoria Catchment area, as a specific section.

2 The States should as a matter of urgency use the findings of Hydromet Survey and other available sources to assemble data relating to the water resources in the Lake Victoria Catchment Area and, where appropriate, exchange the information with one another.

3 The States should urgently establish, staff and equip documentation centres on water resources management in the Lake Victoria Catchment area to facilitate effective policy planning and implementation. To this effect, the Lake Basin Development Authority and the Organization for the Development of the Kagera Basin should urgently establish their centres and initiate exchange of information and documents.

4 The National Governments should evolve efficient and reliable communication systems between the researchers, the policy makers and the implementing agencies to facilitate effective use of research findings in water resources management.

5 The relevant bilateral and multilateral agencies should assist the countries of the Lake Victoria Catchment area to establish baseline data on the quality of water in the area and thereafter to monitor and assessany changes on a continuing basis.

6 The States within the Lake Victoria Catchment area should, as a matter of urgency, conduct studies on the strategies for comprehensive and integrated management of the waters of the basin for the development of the area.

II - EDUCATION AND TRAINING

1 The Governments of the States in the Lake Victoria catchment areas should, with the assistance of relevant bilateral and multilateral agencies, urgently establish short-term and long-term training programmes for technical and scientific staff at all levels to enhance the local capabilities in water resources management.

2 Lake Basin Development Authority and other similar organizations in the Lake Victoria Catchment Area should, in cooperation with the Local Authorities in the area, establish training programmes to develop cadre of staff competent in water quality control and enforcement of appropriate discharge standards.

3 Agencies responsible for water resources management in the catchment area, such as the Lake Basin Development Authority, should organize co-ordinated training seminars on techniques of water quality control to ensure a high standard of monitoring of water quality is maintained.

4 Each of the States in the catchment area should launch intensive educational programmes to enlighten the industrialists and Local Authorities as well as the general public on the rationale and techniques for prevention of pollution of water resources.

III - EFFLUENT MONITORING AND POLLUTION CONTROL

1 The Governments of the States in the Lake Victoria Catchment area should, with the assistance from relevant bilateral and multilateral agencies, establish and properly equip laboratories and field stations for water resources research to facilitate control and maintenance of good water quality as well as assessment of other management questions. These laboratories established at national level should preferably be located within the Lake Basin Area.

2 Each of the States should initiate establishment of monitoring system for each indigenous activities whose effects reach the rivers or ground water in the catchment area to determine the content of their pollution load and thereafter a follow-up programme to trace specific polluting substances in the environment.

3 National institutions dealing with water resources in the Lake Victoria catchment area should immediately establish a system for exchange of staff and sharing of facilities in the field of water quality monitoring and assessment to enhance efficient and economical maintenance of water quality in the area.

4 Each of the States in the catchment area should prepare an analytical review of legislations relating to water and environmental quality standards with a view to enhance the link between scientific information on quality standards and legislation.

5 Each of the States in the Lake Victoria Catchment area should, as a matter of urgency, conduct complete review of the equipments and manpower presently available to the Local Authorities located in the catchment area for monitoring of sewerage and industrial effluents discharged into the drainage system. The purpose of the survey is to determine the precise level of the present capabilities and thus ascertain the level of needs for equipments and manpower.

6 The States are urged to ensure that the existing legislations relating to water quality, especially under the Water, Public Health and Factories Acts, are rigorously and conscientiously enforced while the review and promulgation of new related environmental legislations are under way.

IV - CATCHMENT CONSERVATION AND MANAGEMENT

1 Each of the States in the Basin should immediately conduct studies of the drainage and river profiles in their jurisdiction with a view to planning appropriate conservation strategies including afforestation and soil conservation.

2 Each of the States should develop comprehensive catchment conservation programmes to ensure adequate water source and low silt load as a priority measure.

3 Each of the States should study the pattern and frequency of drought and floods as well as their effects on the environment, then to design and implement effective control strategies.

V - REGIONAL CO-OPERATION

1 The Governments of Burundi, Kenya, Rwanda, Tanzania and Uganda as well as the Organization for Management and Development of the Kagera River Basin should establish a framework for technical consultation and exchange of information on rational management of the water resources of Lake Victoria Catchment area.

2 The States in the Lake Victoria Catchment area should collaborate in standardization of analytical methods and presentation of data. Thereafter, they should conduct frequent joint seminars and consultations for exchange of information on how to promote efficient enforcement of the standards.

3 The States in the Lake Victoria catchment area should evolve, as a matter of urgency a uniform and/or harmonized policy and code for industrial siting to include requirements for adequate waste water treatment plants.

4 The States should co-operate in an urgent effort to evolve a uniform policy to arrest the irrational use of pesticides and fertilizers in the Lake Victoria Catchment area.

5 The States within the Lake Victoria Catchment area should, as a matter of urgency commence negotiations toward a framework treaty governing consumptive utilization of the waters of the catchment area. Such a framework agreement should specify general conditions for development organizations for various parts of the catchment area.

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