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SEWAGE STABILIZATION PONDS IN AFRICA

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Report by Mr. Arthur E. Williamson, B.S., M.S., on a visit to five countries in Africa under the auspices of International Cooperation Administration

Salisbury
August 17, 1960

ICA/Washington
February 14, 1961

Mr. Arthur E. Williamson is the Director of the Division of Environmental Sanitation of the State of Wyoming. In view of Mr. Williamson's experience in the field of Stabilization Ponds, it was arranged that he should undertake an assignment with the Northern Rhodesia Government to consult and advise on the application, construction and operation of Stabilization Ponds for the disposal of sewage. This project was arranged under the auspices of International Cooperation Administration.

During Mr. Williamson's itinerary in Africa, the opportunity was taken for brief consultations with authorities other than the Northern Rhodesia Government. These consultations include the following:

Brazzaville (Congo Republic)

Consultations with officials of the World Health Organization - 3 days.

Pretoria (Union of South Africa)

Inspection of installations and experimental work in progress, with a representative of the Northern Rhodesia Government, at the establishments of the Council for Scientific and Industrial Research - 10 days.

Salisbury (Southern Rhodesia)

Consultations with officials of:

International Cooperation Administration
Federal Ministry of Health
Southern Rhodesia Government
Salisbury Municipality
Marandellas Town Management Board
Civil Engineers - 8 days.

Zomba (Nyasaland)

Consultations with officials of:

Public Works Department
Federal Ministry of Health
Blantyre/Limbe Municipality - 2 days.

Time in Northern Rhodesia was from May 26th to August 14th, 1960.

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INTRODUCTION - STABILIZATION PONDS

Definition

1. A stabilization pond is an engineered structure to utilize natural processes, under controlled conditions, for the stabilization of organic wastes.

2. The units are known by several names, i.e., sewage lagoons, oxidation ponds and stabilization ponds. The trend has been to accept the last nomenclature as the most fitting to the process.

Natural Processes Involved

3. The stabilization pond utilizes the symbiotic relationship of Bacteria and Algae in the breakdown of organic matter.

4. Bacteria are responsible for the decomposition of the organic compounds. As long as this decomposition takes place in the presence of oxygen, the end products are odorless. In this natural cycle the algae produce the required oxygen as a by-product of their growth.

5. The cycle then might be briefly described as: Bacteria consume organic matter and require a readily available source of oxygen, with end products of Carbon Dioxide, Ammonia, water, etc. The algae require Carbon Dioxide and Ammonia as a nutrient for growth and give off oxygen as a by-product. Thus we have two groups of organisms which supply the needs of each other and in the meantime stabilize the organic matter.

6. Time and temperature are the governing factors in the bacteriological cycle that determine the rate and extent of stabilization of organic matter.

7. In the algae cycle, solar radiation governs the process of photosynthesis and the conversion of organic matter.

Historical

8. Stabilization ponds in one form or another have been used in the United States and other countries for quite some time. In the Southwest portion of the U.S. they have been in use for many years as a form of secondary treatment for sewage. The original conception in that area was for the conservation of water for irrigation - however, the additional treatment was recognized.

9. The recent interest in stabilization ponds was brought about by the realization that raw sewage could be treated by such methods and the considerable savings that could be accomplished.

10. The first stabilization pond, designed to handle raw sewage, was constructed at Maddock, North Dakota, in 1949. This unit was designed as a complete retention pond as no defined drainage ways exist in that area. Final disposal had to be accomplished through evaporation and absorption. The

results observed from the first few installations proved that the ponds could be designed as a "flow through" unit and the effluent could be discharged to water courses.

11. Although the original idea of using a raw sewage stabilization pond was conceived by a consulting engineer, the further study, design and criteria were developed by state and federal health authorities. This has assured that the public health and water pollution aspects have been given primary consideration.

12. From the original installation in North Dakota, the use of raw sewage stabilization ponds spread rapidly throughout the Missouri Basin and into other areas of the United States.

13. At the present, there are over 800 municipal installations in the United States. A total of 430 installations in 36 states have been approved for federal aid grants under the present Water Pollution Control Program. (This figure covers the period July, 1956 - April, 1960).

14. Operating installations in the United States range in size from a fraction of an acre to a total of 135 acres. The units serve populations up to 17,000. An installation in North Dakota under construction will serve approximately 45,000 people. The only limitation to the size of a pond installation is the availability of suitable land.

Design Criteria Features

15. Similarly to any biological process, the design criteria is based upon the B.O.D. (Biochemical Oxygen Demand) loading per unit of area or volume. In the case of the stabilization pond the design value is pounds of B.O.D. per acre per day. This is a relative measure of the organic load that can be expected to be stabilized by the pond.

16. In the United States the normal range of design has been 20 to 50 lbs. of B.O.D./acre/day. Experimental and temporary units have been satisfactorily operated under much heavier loadings during ice free periods.

17. In the United States the winter conditions where heavy ice formation is expected, is the governing factor in our design. In Northern Rhodesia, design can be based upon ice free conditions and maximum efficiency obtained.

18. Since a stabilization pond is essentially an earth structure, the construction is of a simple nature and is reflected in the lower cost.

19. The desirable shape for a pond is square or round, however they can be shaped to fit the topography with no ill effect. Extremely narrow bays or land projections should be avoided.

20. The earthen embankments are constructed on slopes to resist the erosion to be expected. No form of living or bank protection has been used in the United States construction.

21. Ponds in the United States have been designed to operate through the depth range of 3 to 5 feet. This variation in depth is necessary for winter operation (under ice) and quick recovery in the springtime.

22. Under ice free conditions, a constant depth of 3 feet is recommended. This depth is sufficient to prevent the growth of aquatic vegetation, as sunlight will not penetrate to the bottom due to heavy algae growths.

23. In normal construction, the inlet to the pond is on the bottom and somewhere near the center of the unit. This introduces the solid material near the bottom and allows wave action to distribute the material uniformly over the area.

24. The outlet structure can be any simple overflow structure to handle the expected volumes.

Degree of Treatment

25. Experience in the United States has shown that the stabilization pond will give treatment equivalent to conventional treatment plants and for most periods of the year the effluent will be better than from conventional treatment methods. The stabilization of organic matter is in the range of 80 to 95%. The removal of coliform bacteria, which can be considered a measure of removal of disease producing bacteria, is of the magnitude of 99.9%.

26. Generally, the effluent from a stabilization pond can be discharged into any water way, regardless of dilution, without causing nuisance conditions.

27. Many questions arise as to the possibility of ponds being a breeding place for flies and mosquitoes. In a normal operating pond, there is no visible solid material so there is no material for flies to breed upon. Ponds in the United States have been checked frequently for mosquito breeding, but only isolated incidence of larvae has been found. The general conditions within the pond are not conductive to mosquito breeding.

Use of Ponds

28. The stabilization pond can be used to treat any organic waste that can normally be treated by biological methods. As long as the design is within acceptable loading limits the normal process of stabilization should occur.

29. Because of the flexibility of this unit, it can be fitted into practically all schemes of sanitation. It can be used to treat overflow from aqua privies or septic tanks and can be expanded to handle raw sewage, should a full water borne system be installed.

Costs

30. One of the main reasons for the rapid growth in the use of stabilization ponds has been the low initial cost and the absence of operating costs. This has enabled many communities to install sewerage systems that could not otherwise afford them.

31. Experience in the United States has shown that the capital cost for a stabilization pond to be in the range of 1/4 or 1/3 of the cost of conventional treatment plants. With the higher design loadings that can be used in this area, the cost ratio can be further reduced.

32. Since no manpower or mechanical equipment is necessary for the operation of a pond, the operational cost is negligible. Operational costs of conventional plants are considerable as they often require power and trained personnel for their operation.

Use in Africa

33. The climatological conditions in Africa favor the use of stabilization ponds for sewage treatment. High intensities of sunshine prevail and the temperatures are above freezing. These conditions will allow design to utilize the maximum efficiency of the unit.

34. In designing the initial units, loadings in the range of 100 to 150 lbs. B.O.D./acre/day should be used. Future loadings could be increased, depending upon the results observed after a period of operation.

35. Certain information must be obtained to assist in the design and evaluation of stabilization ponds in this area; particularly in respect to sewage from African areas. It is essential to know:

(a) The per capita contribution of B.O.D. (lbs. B.O.D./cap/day) for raw sewage, aqua privy effluent, etc.

(b) Sewage flows to be expected from various types of development.

The accumulation of this data will necessitate a program of testing sewage strengths and measuring sewage flows.

36. The low sewage flows found in typical African areas create some problems in design. It is necessary to adjust loading (i.e., area) to flow so that evaporation will not deplete the water level. However, it appears that this problem will be overcome by the use of higher loading factors and the flexibility of the pond method of treatment.

37. All public health authorities recognize the shortcomings of sewage disp[illegible] schemes that depend upon pit disposal or soakaway systems. It would appear tha[illegible] the pond system for the disposal of liquid wastes is capable of handling and

improving present methods of sewage disposal and can be expanded to the ultimately desirable, full waterborne sewage system.

38. The cost of the stabilization pond system is low enough and the degree of treatment high enough that is can be utilized in conjunction with all types of sanitation schemes.

39. The treatment of sewage by the use of stabilization ponds has been recognized by both Health and Sanitary Engineering Authorities in the United States as a satisfactory and practical method. Its use should be considered as another possible method of solving our sanitation problems and should never be considered as a second class alternate to conventional methods.

(This portion of the report was prepared as a Preliminary Report to the Northern Rhodesia African Housing Board and presented at the 39th Meeting of the Board on June 30, 1960.)

THE PROBLEM

40. Whenever people are brought together in organized communities and mass housing is produced, good sanitation schemes become essential for the protection of the health of the inhabitants. In general, the lower the standard of living in a community, the more essential it becomes to have a good and simple sanitation scheme.

41. Many attempts have been made to utilize sewage disposal methods, developed for isolated residences, in mass housing programs. Invariably these methods have failed when used on a community-wide basis as they frequently create nuisances and health hazards. Experience has shown that the only reliable method of maintaining good saniation within a community under all conditions is to collect all liquid wastes in a common sewer system and provide treatment of the waste to insure safe final disposal.

42. As the object of the Housing Program is to provide acceptable housing at a minimum cost so that it will be within financial reach of the African, then it follows that any sanitation scheme must also be constructed at minimum cost. However, it must still meet the criteria for an acceptable system which can be given as:

(a) The collection system must contain the solid and liquid wastes, transport them from the community to a central disposal point without creating a nuisance or health hazard.

(b) Final disposal and treatment of the waste must be such that:

(i) it does not create a health hazard;
(ii) it does not create a nuisance;
(iii) it does not cause pollution of the receiving waters.

43. When a sewerage system and sewage disposal works are designed on conventional standards developed for European systems, the cost of such a scheme becomes out of proportion with the cost of the African house.

44. These two facts then appear to create a direct conflict when considered on the basis of need and cost. However, it is possible to design a system that will fulfill the acceptable criteria, if the engineer is allowed to use his ingenuity and design for existing conditions and not be limited by arbitrary standards that do not necessarily apply to African housing conditions. Available information in literature indicates that the use of stabilization ponds might be the answer to low cost sewage treatment. Experimental units were installed at Kafue and Chingola and additional information was available from operating units at Marandellas and in the Union of South Africa. Information from these projects proved that a system utilizing stabilization ponds for final treatment could be constructed at a minimum cost that was realistic in relation to the cost of the house.

45. The designing engineer frequently encounters official difficulties when designing a sewerage system based upon criteria and conditions. This difficulty is brought about by the fact that the official Health Agencies do not utilize sanitary engineers within their organization. Consequently, the approving official must rely upon inflexible standards of design which in the case of African housing are not compatible with existing conditions.

46. Examples of fixed standards encountered are:

(a) Fixed standard for B.O.D. of plant effluent, regardless of the nature of the receiving water or nature of material in the effluent.

(b) Fixed grade for sewers of given size regardless of nature of fluid carried or slope of land.

(c) Venting of aqua privy tanks even when effluents discharged to a receiving sewer.

47. It must be pointed out that systems designed upon a basis of criteria and conditions are in no way inferior to a system based upon standards. The criteria for acceptable sewage disposal is constant, regardless of living standard, and only conditions which are influenced by living standards and economic factors affect design. Likewise, it should be stressed that the use of stabilization ponds for final treatment of sewage is not a substitute or inferior method for conventional treatment plants. The use of stabilization

ponds must be considered as a possible method of sewage treatment, equal in every respect to conventional treatment plants, but in nature being much more economical both in initial investment and operating costs.

WHAT HAS BEEN DONE

48. The acitivites during the tour in Africa can be classed under two general headings:

(a) "Selling" the idea to Health Agencies, Engineers, Housing Boards, etc. that stabilization ponds are a recognized method of sewage treatment, and that they will produce the degree of treatment required at a minimum cost.

(b) Dissemination of technical information pertaining to the theory, design, operation and evaluation of stabilization ponds to the engineering staff of the African Housing Board and to other engineers and persons interested in this aspect.

49. The above activities have been accomplished through many group meetings and individual conferences with the persons involved in the complete field of African housing. Daily work with the staff of the Northern Rhodesia African Housing Board has made it possible to transmit technical information and theory on a working basis.

50. The "selling" of the idea appears to have been successful. There has been a general acceptance by Health Officers, engineers and local Housing Authorities of the idea to use stabilization ponds. Several sewage schemes in the final design stage have been revised to use stabilization ponds in place of conventional treatment plants. Among these are Mufulira, Chingola and Ndola. Active planning is in process to use stabilization ponds in African Housing projects at Matero, Chunga, Choma, and other sites. The Bancroft Mine must replace its existing treatment plant and present planning is to use stabilization ponds. The Public Works Department is designing pond installations for Samfya and Kasama. In Nyasaland, the consulting engineer has recommended ponds for the system at Limbe and the Public Works Department has asked the engineer to consider ponds for the Zomba project. This is not a complete list of the projects under active consideration at this time, but it does point out the general acceptance of the process.

51. The design and theory of stabilization ponds has been covered thoroughly with the engineering staff of the Northern Rhodesia African Housing Board. Reference and research material that was available has been provided. With this background, the engineers are capable of designing stabilization ponds for the various conditions that may arise. Likewise, an accurate interpretation of analytical results can be made.

RECOMMENDATIONS

52. Although the use of stabilization ponds appears to be generally accepted at this time, there will be a continuing need to keep the interest alive. Several larger operating installations will prove to be a big aid in the promotion and use of ponds. The initial ponds should be designed with a conservative loading in the range of 100 to 150 pounds of B.O.D. per acre per day. There is little doubt that the ultimate capacity for ponds will be considerably higher than this figure. It is felt that it would be prudent to approach the maximum design loadings after the initial ponds have been generally accepted.

53. It is essential that basic data in regard to sewage flows and sewage strengths be accumulated. This information is necessary to verify actual loadings on ponds that are constructed. Likewise, it is necessary to determine daily per capita contributions both in flow and B.O.D. so that valid criteria can be developed and used for later design.

54. Minimum laboratory analyses should be carried out on operating ponds. This information will provide operating efficiencies and a continuous record of proof in case the installation is unjustly accused of polluting a waterway. In conjunction, it would be well to have similar analyses of any small streams prior to the discharge of effluent from stabilization ponds.

55. Staff members of the Northern Rhodesia Housing Board are competent to carry out the necessary field and laboratory analyses. The primary need at this time is to furnish and equip an adequate laboratory. Plans are under way at this time to have a small laboratory constructed on the grounds of Charter House, the present location of the African Housing Board. It appears that laboratory facilities will be avaiable through the Municipality of Chingola, in which work in the Copperbelt area could be carried out. As sanitary chemistry is quite specialized, it is best to have analyses performed by the engineering staff so that design, operating conditions, and analytical results can be accurately correlated and interpreted.

56. There is a need for a "meeting of the minds" between the Health Agencies and designing engineers in regard to the matter of rigid standards. Minimum standards should be used as a guide to design rather than a mandatory value. Unless the engineer is free to do design based upon sound engineering principles, it becomes impossible to design for prevailing conditions and produce the most economic scheme. The Health Agencies would find that Sanitary Engineering personnel on their staff would be of value in the handling of water supply and sewage disposal schemes. Such personnel could also be utilized in working out operating problems often encountered in the field.

57. The engineering staff of the Northern Rhodesia African Housing Board is adequately informed to carry on the design and promotion of the use of stabilization ponds. However, there will be increasing requests for information on this subject as the program continues. Perhaps additional technical personnel from ICA would be of value in carrying the program through the initial period.

REPORT ON VISIT TO NATIONAL INSTITUTE FOR WATER RESEARCH, PRETORIA, UNION OF SOUTH AFRICA

By Arthur E. Williamson

The Institute for Water Research is part of the Council for Scientific and Industrial Research, located at Pretoria, South Africa. The Council is responsible for all scientific and industrial research in South Africa, and because of this became quite involved in water problems at an early date. These actions led to the establishment of a fully-fledged National Institute for Water Research in April 1958.

Since the Union of South Africa, because of climatological conditions, has very limited water resources, it has become necessary to protect and utilize this resource to the highest degree possible. A good water supply is essential to the industrial and economic development of a country. The main activities of the Water Research Institute can be listed as follows:

(1) Water Resources and River Studies

This activity is to catalogue the water resource in regard to quantity and quality. Where pollution exists its nature and origin are determined and corrective actions indicated.

(2) Purification of Water

Fundamental studies are carried out in both the treatment of sewage and production of potable water supplies. The main efforts are directed at additional biological treatment for sewage, so that the quality is good enough for unlimited re-use.

(3) Industrial Effluents

The Institute acts as technical adviser to the Department of Water Affairs in regard to large scale water use and discharge of trade waste effluents. This has brought about control of water pollution from this source. This action has necessitated considerable study in regard to treatment of industrial wastes and often development of new processes.

(4) Assistance to Municipalities

The Institute assists the municipalities with problems encountered in public water supply and sewage treatment.

(5) Re-use of Organic Wastes

Studies are being carried on to determine methods of utilizing sewage sludge and refuse as organic fertilizer. This will help in the problems of disposal as well as providing needed organic material for the soil.

To carry out the responsibilities of the Institute it is organized into the following Divisions:

1. Hydrobiology Division
2. Bacteriology Division
3. Chemistry Division
4. Technology Division

A review of technical literature on stabilization ponds aroused the interest of the Water Research Center as to the possibility of this method being of value in water conservation as well as sewage treatment. Results observed on several small initial installations were sufficiently good to indicate the need for further research.

Since the use of stabilization ponds showed great promise for both water conservation and high degree of treatment, as well as reduced capital investment, the Institute started a detailed program of basic research covering their operation.

To carry out the necessary research, the Institute was constructing four small stabilization ponds of approximately half an acre each, and twelve pilot scale units at the Pretoria sewage works.

Each Division will carry on detailed research on these units in an attempt to identify and explain the basic reactions taking place in the purification process. This research will fill a large gap in the general knowledge of the process. Also, from this information, it should be possible to develop accurate design criteria for stabilization ponds and therefore realize maximum economy of construction.

Recent information in regard to the research project indicates exceptional results. The data obtained has been of sufficient quality that a preliminary paper will be presented within the next month (September) setting forth tentative design criteria. It appears that a loading of 250 lbs. Biochemical Oxygen Demand per acre per day will be confirmed.

During the stay at Pretoria, one full day was spent with Mr. Henry van Eck, coordinator for the research projects at the Institute. The complete field of operation, design and research covering stabilization ponds in the United States was discussed with him. This discussion was certainly of mutual value, as I was able to obtain some information on actual operation of ponds in Africa. It was felt that the information which I was able to supply, particularly in regard to operating observations, would help materially in their research project.

Sufficient time was spent with the head of each Division to completely review the proposed program for research in that field. It was possible to point out certain problems that had been observed in United States operation and particular study directed at these conditions should they be observed here.

During the visit, Mr. Gert Marais, the engineer employed by the Northern Rhodesia African Housing Board to do the supervision and analysis of stabilization ponds, spent as much time as possible with me in the discussion periods so as to take advantage of the information exchanged.

While in Pretoria, it was arranged for me to give a two-hour Seminar for the graduate Civil Engineering students at the Johannesburg University. It was felt that this was a worthwhile project, in that most of the graduate students are either working or will be working with consulting engineering firms. This was a chance to acquaint them with stabilization ponds and their possible use in the future. Some time was spent at the University with Professor Jennings, who occupies the chair of Civil Engineering, as he was helping Mr. Marais lay out the necessary laboratory equipment and procedures for Northern Rhodesia.

Many problems of water conservation, water quality, etc., were also discussed with personnel at the Institute as the water problems of South Africa are very similar to the ones encountered in the arid portions of Western United States.

Attached to this report is a brochure covering the National Institute for Water Research. Additional copies of this booklet can be obtained from "The South African Council for Scientific and Industrial Research", Pretoria, Union of South Africa.

Salisbury
August 17, 1960.