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Industrial Waste Management in Egypt:

Principal Research Findings of the Science and Technology Project

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INTRODUCTION

This report covers the achievements of the Science and Technology Cooperation Project (STC) in the field of industrial waste management. It is one of a series of reports documenting the key areas of work undertaken by STC researchers in the fields of computer-aided manufacturing, biotechnology and genetic engineering, industrial waste management, and municipal waste management.

STC is a project funded by a grant from the U.S. Agency for International Development which is supplemented by in-cash and in-kind contributions from the Government of Egypt and the end-users. The goals of STC are improving the productivity and welfare of the Egyptian people by applying technology to specific development problems and building science and technology research capacity in selected fields. To this end, STC has funded 81 research subprojects.

Section I of this report represents a synthesis and analysis of key findings and conclusions from 17 STC research subprojects. The Principal Investigator for this effort was Dr. Ahmed Hamza. Section II of this report comprises summaries of the 17 research subprojects that formed the basis for section I. These summaries were prepared by a PRIDE team led by Dr. Walid Gamaledin. Members of the team included Ms. Naglaa El Bialy, Dr. Farida El Dars, and Dr. Dina El Naggar. This team was assisted by Ms. Nivene El Koshairi and Ms. Hala Rafik. The subproject summaries were based on reports issued by subproject research teams, interviews with Principal Investigators, and site visits. Gretchen Mikeska graciously provided expert comments on an early draft of this report.

The views expressed in this report do not necessarily reflect those of the Project in Development and the Environment or USAID.

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SECTION I
INDUSTRIAL ENVIRONMENTAL MANAGEMENT: SYNTHESIS AND ANALYSIS

A. Introduction

Industrial development in Egypt suffers from intense polarization as manufacturing facilities tend to concentrate in urban settlements where demand and growth rates are highest. At the same time, use of relatively old technologies that generate appreciable pollution is predominant in Egyptian industry.

Since the early 1950s, the pattern of developing the manufacturing industry has been typified by establishing a large production industry to feed another large manufacturing facility, which in turn supplies feed stock to a third large plant in the same location. Such a pattern of industrial development often contributed to formation of pockets of intensive pollution, which led to severe degradation of city environments and overloading of public infrastructure.

As a result of this chaotic situation, the environment has been afflicted with severe problems; the most important of which result in deterioration of natural resources, impairment of agricultural productivity, and serious threats to public health.

In addition, environmental degradation resulting from industrial development has been aggravated due to the: (a) vast increase of industrial emissions owing to the steady expansion of existing manufacturing plants and the establishment of new industries; (b) improper end-of-pipe treatment of liquid and gaseous emissions and unacceptable disposal practices of hazardous residues; (c) difficulties in monitoring industrial emissions owing to the lack of instruments and trained personnel; (d) reluctance on the part of most dischargers to invest money in pollution abatement; (e) lack of professional management and readily available trained personnel for operation of plant waste treatment facilities; (f) lack of pollution-control equipment; (g) inadequate design of facilities for management of liquid and solid wastes management systems; (h) lack of industrial responsibility; and (i) lack of strategic planning for long-term control of industrial emissions.

In response to the emerging environmental concerns, industry has initially reacted to the mounting public pressure by adopting a strategy of pollution control through waste treatment. However, in most instances, the end-of-pipe approach faced serious operational problems, and transferred pollutants from one receiving medium to another; leading industries to look for other viable options to solve their pollution problems.

At present, industry recognizes the need to avoid or minimize waste generation through introduction of modern processing technologies, effective management of production inputs, reuse of secondary materials, efficient packaging of final products, and conservation of water and energy. This trend is further strengthened as government subsidies for energy, water, and raw materials are gradually lifted and manufacturers are charged the actual costs of production inputs.

The government, in an effort to relocate industry away from the congested urban centers, has opted to establish new industrial cities across the country. Manufacturing enterprises in these industrial cities are relatively modern and rapidly growing; their annual investments are large in relation to existing stocks, and pollution-prevention measures can be easily adopted during the course of industrial development in these new cities. However, most facilities in older cities

represent an aging industry, with limited investment available for improving or expanding existing operations. In these aging industries, the cost of pollution prevention is usually higher per unit output than at the new enterprises.

So far, the public sector industries are unable to provide sufficient resources for retrofitting their out-dated facilities, or adding new cleaner production units. Moreover, it has proven difficult to adopt drastic measures for upgrading manufacturing technologies, particularly if they affect employment or cause basic changes in the traditional management practices. Despite these problems, it is encouraging to note that liberalization of industry and improvement of management capability in recent years have progressively led to improvement in productivity and product quality, resulting in reduced manufacturing wastes and industrial emissions.

In the long term, most public industries with mature but aging facilities allocate significant investments for either modernizing or replacing existing production equipment. However, this move toward modernization is presently facing numerous technological, social, and financial difficulties and cannot be expected to gain a large momentum in the near future.

B. Cleaner Production in Egypt: Concepts and Prospects

As awareness of the serious effects of industrial pollution on environmental quality has increased in Egypt, so has the realization that manufacturing enterprises must switch to cleaner production technologies.

Where competition exists among manufacturing enterprises, cleaner production alternatives usually receive more attention. These alternatives include: proper design and operation of production units to reduce generation of wastes; process changes to maximize utilization of energy and materials; improved product quality and service-life; and operation of central facilities for recovery and reprocessing of the used or off-specification products. (1)

Unfortunately, little consistent information is presently available to manufacturers regarding the cost-effectiveness of adopting cleaner production alternatives; this is mostly attributed to: (a) lack of unified procedures for assessing intangible benefits when comparing various technology alternatives; (b) the dynamic nature of costs as new technologies are continuously introduced to improve production processes and to enhance environmental-compatibility of products; and (c) specificity of information describing cleaner technologies that are applicable to a particular industry.

Other major constraints to adoption of cleaner production arise from: (a) lack of integration in the production processes; (b) inadequacy of industrial infrastructure; (c) scarcity of expertise familiar with cleaner production technologies; and (d) prevailing attitudes by management against expenditures on cleaner production measures, particularly those with long pay-back periods. (2)

Industrial environmental management involves corrective (such as end-of-pipe treatment, containment of hazardous residues, control of air emissions), preventive (such as low waste technology, recycling of resources, process control), and resources conservation (such as effective management of production inputs, reuse of secondary materials, energy conservation) measures that are interdependent. With budget restrictions for environmental protection, industries must decide whether to allocate funds to treat industrial wastes or to invest in new production technologies with the aim of waste minimization.

A preventive industrial strategy will include resources conservation, economic efficiency, and environmental protection. Conversely, waste treatment technologies more often than not transfer pollutants from one environmental medium to another, consuming resources out of proportion to the accrued benefits. Moreover, conventional controls only deal with the problem of first-generation pollution, which is created in the manufacturing process and regulated by legislation, while ignoring the problem of second-generation pollution emanating from waste treatment such as sludge handling or containment of concentrated hazardous emissions. Therefore, Cleaner Technology (CT), comprised of both preventive and resources-conservation measures, is usually preferable to corrective measures from both an economic and an environmental perspective. (1)

Past experience has indicated a strong tendency for industrial planners to consider a narrow range of alternatives, with respect to both processing technology and waste treatment. Innovative alternatives should include a broad range of reuse, beneficial recycling/reclamation alternatives, and energy conservation and recovery opportunities, as well as the specific methods or technologies of treatment.

Conceptually, innovative CT may embody a number of recycle/reclamation or reuse opportunities depending on the particular industrial activity. Maximum consideration should be given to the identification of all potential conceptual approaches that could be implemented at a specific manufacturing plant, especially those modifications incorporating alternative technologies that exhibit significant recycle, reclamation, energy recovery, or revenue-generating potential.

Although it is difficult to explicitly define the boundaries of an innovative CT program, it is possible to prescribe "potentially applicable options" based on the experience of similar manufacturing activities in both developed and developing countries. Innovative CT consists of various alternatives, the most common of which are listed below:

- Toxic use reduction through substitution of hazardous process inputs with less-hazardous raw materials;
- Greater integration and rational use of process inputs;
- Installation of new equipment or modification (retrofitting) of existing equipment;
- Modification, adaptation or improvement of production processes;
- Improved production efficiency resulting in reduction of waste generation, including off-specification products, resulting in improved process efficiency;
- Adoption of proven processes or equipment originally developed for another industry in a different manufacturing activity;
- Unique combinations of processes and techniques that recognize and maximize inter-process compatibility or synergistic effects; and
- Internal or external reuse/reprocessing of process by-products.

The above elements of innovative CT are not inclusive, nor are the elements completely exclusive of one another. To further clarify the concept of CT, it is appropriate to define its major components (3):

- Waste minimization means the elimination or reduction, to the extent feasible, of a waste that is generated and would otherwise be subsequently treated, stored, or disposed of. It includes any source reduction or recycling activity undertaken by a generator that results in either: (1) the reduction of total volume or quantity of the waste; or (2) the reduction of toxicity of the waste, or both, so long as such changes result in the goal of minimizing present and future threats to human health and the environment.

- Sources reduction is any activity that eliminates or reduces the generation of wastes within the process.

- Recycling implies reuse or reclamation of secondary materials. A material is reused if it is either (1) employed as an ingredient (including its use as an intermediate) to make a product; however, a material will not satisfy this condition if distinct components of the material are recovered as separate end-products (as when metals are recovered from metal containing secondary materials), or (2) employed in a particular function as an effective substitute for a commercial product. A material is "reclaimed" if it is processed to recover a useful product or if it is regenerated. Examples include the recovery of lead values from spent batteries and the regeneration of spent solvents.

Process alteration represents the most prominent component of a CT program. A product can sometimes be manufactured by two or more distinct processes. Certain processes, such as the diaphragm process for producing chlorine, generate considerably less waste than the alternative mercury cell process. Unfortunately, modification of existing facilities involves research and development and capital investments, and may require a lengthy implementation period.

Inefficient chemical reactions in a process are a major source of increased waste generation. Improving the efficiency of the process through modification of catalysts, reactor design, and operating parameters has been shown to reduce significantly the quantity of waste generated. For example, in the production of acrylonitrile by the catalytic oxidation of propylene, switching from an antimony-uranium catalyst to a ferrobismuth phosphomoylbdate catalyst has boasted the conversion of acrylonitrile by 35 percent. Attaining zero waste generation, however, is currently beyond the technical capabilities of most manufacturers.

Modification of equipment is another way to reduce waste generation. The invention of mechanical wipers to scrape the sides of paint tanks, for example, reduces the exposed volume of waste paint that would otherwise produce fugitive volatile organic compound (VOC) emissions. Similarly, process automation, which helps optimize product yields by automatically adjusting process parameters, has in many cases minimized operator error, reduced the likelihood of spills, and discouraged the production of off-specification materials. These off-specification materials can be highly toxic, albeit, their generation is often in small amounts.

Water conservation can also result in significant waste reduction. Efficient product washing results in reduced sludge generation by minimizing the amount of product lost to the wash water and the quantity of wastewater that is generated.

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Technology modification and development of low waste production systems is currently a central focus of CT. Generally these changes are most cost-effective when implemented during a plant's planning or design period or when a plant is retooling and replacing worn out equipment. Retrofitting plants that have already been in operation is often expensive but may be necessary to reduce pollution and enhance environmental quality.

Good operating and housekeeping practices involve the alteration of existing procedural, organizational, or institutional aspects of a manufacturing process. The goal is to limit unnecessary generation of waste attributable to human intervention. Employee training, inventory control, waste stream segregation, improvements in materials handling, spill and leak prevention, and preventive maintenance are all examples of good operating practices. Others include the scheduling of batch operations to limit the frequency of equipment cleaning and, consequently, waste generation; the segregation of hazardous wastes from non-hazardous wastes to minimize the volume of contaminated wastes; and the reduction of overspray and runoff from spraying by the paint booth operator during paint application.

Replacement of an original product with a different product that is intended for the identical use can be an effective method of source reduction. For example, integrated pest management, an alternative to pesticide use in certain applications, reduces pesticide production, and, in turn, the waste generated during pesticide production and application. Substitution of less toxic solvents, such as petroleum solvents for more toxic solvents such as perchloroethylene or trichloroethylene, generates a spent solvent waste that is less toxic. (4)

In evaluating the costs and benefits of CT, the potential value of most projects has been established on the basis of savings in the following areas:

- Raw materials costs;
- Utilities, labor, and maintenance costs; and
- Enhanced revenues through creation of marketable by-products.

However, waste reduction also creates savings due to elimination or reduction of waste generation costs that were previously affected but not taken into consideration such as:

- Disposal fees;
- Fees/taxes on generators per unit of waste;
- Transportation costs;
- On-site waste storage and handling costs; and
- Predisposal treatment costs.

The application of CT is yet to achieve the desired level in the country. Many industrial sectors have not been able to benefit from the advances in CT due to lack of research and development, inadequacy of information on opportunities for waste minimization and their costs and benefits, lack of innovative policy measures for implementation, and lack of data quantifying cost savings to specific industries. In addition, the reactive environmental policies, legislation,

and administrative structures, along with piecemeal planning, are not conducive to waste minimization in Egyptian industry. Effective implementation of CT will require informational, legal, economic, and institutional measures that are substantially different from those presently in place.

Environmentally sound industrial production, to be pursued effectively, requires major research and development efforts through indigenous initiatives for CT applications and transfer of technology through bilateral assistance.

The first step in this direction is the establishment of background information on existing production practices, sources of wastes, potentials for waste minimization, and practical applications of CT. The research in CT should, therefore, be encouraged to assess environmental benefits and techno-economic viability of CT, both at the micro and macro level.

C. Institutional Mechanisms for Industrial Environmental Management

A major handicap in achieving effective industrial environmental management in Egypt has been the fragmentation of decisions in terms of both geographic boundaries and allocation among various uses. The interactions between industrial development, urban growth, and infrastructural support services have not received systematic attention from the multiplicity of agencies involved. Thus wholly unrelated decisions on development of industry in a specific region inevitably produce negative impacts on environment and other development activities.

To overcome these problems, a greater control should be gained over industrial development in order to restrict unnecessary damage due to irrational siting or uncontrolled pollution in the longer term. The underlying conditions for effective management appear to include an institutional structure which enables: (a) coordination of activities of public agencies involved; (b) an increased role in decision-making for those most affected by industrial development (local communities, workers, businesses); (c) adoption of a unified industrial permit system to enable efficiency in allocation and resolution of use conflicts; and (d) determination of the threshold level of damage incurred by industrial pollution that is unacceptable to society regardless of the short-term benefits that may accrue.

Although the need to strengthen coordination at the planning and execution levels is apparent, this should not lead to consolidation of functions in few organizations; rather, it should link existing agencies in such a way that their collective accomplishments will be greater than if they act separately. The fact that a number of national agencies are engaged in activities directly related to industrial development in each country may be a source of strength. The various agencies have specialized management knowledge and a diversity of ideas and approaches. However, the individual efforts of different organizations should add up to a coherent and integrated management structure.

Environmental management in industry is affected by a variety of institutions and factors. Major players that affect decisions concerning adoption of cleaner production include manufacturing and service industries, governments, and environmental advocacy groups. (5)

Manufacturing enterprises can adopt proper pollution-prevention measures through eliminating or reducing wastes generated during production; encouraging full cycle product/waste management services, such as used solvents collection and redistillation, re-refining of exhausted lubricating oil, and cardboard packaging and recycling services; funding research and

development out of profits; conducting in-house total quality control and employees' awareness and training programs to encourage waste minimization and pollution prevention; employing environmental audits as a systematic procedure to identify opportunities for waste reduction and to undertake proper actions to overcome operational problems; and focusing on cost-effective cleaner production alternatives that may not impair process/product performance or reduce production rate.

Service industries represent a fast-growing business in Egypt. They usually provide specialized services or lease products rather than sell them. They are, therefore, responsible for taking products after use for reconditioning before being offered for reuse. As such they contribute to the extension of products' life cycle. Service industries such as auto repair and maintenance of household appliances can extend the serviceable life of capital goods far beyond their designed useful-life. Product-life extension is a strategy widely adopted by the service-oriented economy of Egypt; the focus in this case is directed to developing skills for provision of services rather than promoting manufacture and sale of new products. In essence, service industries is serving the same purpose of the cleaner production which aim to conserve resources and increase products' useful life. (2)

The government has recently started to promote pollution prevention through instituting relevant legislative instruments (the environmental law 4/1994), providing technical assistance, and offering economic incentives. Most industrialized countries have passed laws that require industries to produce environmentally safe products and to employ environmentally sound technologies in their production. Assistance of some of these countries is provided to Egypt for research and development (R&D) to encourage integration of cleaner technologies in industry; economic measures are being considered through offering incentives such as tax exemptions on imported cleaner production equipment and disincentives such as penalties on polluting industries or withdrawing subsidies on infrastructural services.

The Academy of Scientific Research and Technology through it Science and Technology Cooperation Program (STC), is supporting industrial demonstration projects for pollution prevention with emphasis on application of cleaner production and waste recycling. Multimedia pollution prevention concepts are being examined to assess the potentials of product-life extension and the validity of applying "cradle-to-grave liability" in industry. Governments are also exercising pressure to promote cleaner production through the vast purchasing powers of their central and local institutions.

Box 1
Cooperation among Industry, Government, and International Donors to Adopt Pollution Prevention in the Egyptian Manufacturing Industry

The Miser Chemical Industries (MCI) chloralkali plant in Alexandria is Egypt's primary source of caustic soda and chlorine. The plant was built in the 1950s and comprises two mercury-amalgam electrolysis units. The release to the sea of about 12 tons mercury/year with the process effluents (7.5 mg/l compared with a maximum allowable limit of 0.05 mg/l) has caused serious human and environmental risks. As a result of over 40 years of operation, mercury contamination has reached alarming levels with hot-spots around the distillation/recovery unit, all over the cell houses, in soil and wastewater trenches with levels 10 to 100 folds higher than the maximum allowable mercury levels. (4)

MCI has launched, in cooperation with the German government, a major pollution-prevention effort comprising two undertakings: (1) the mercury decontamination and demolition of the existing electrolysis facilities, and (2) construction on the existing premises of new electrolysis units using mercury-free membrane technology. MCI has been recently privatized and will share the cost of shifting to cleaner production of about US $100 million with the German Bank KfW.

Desilication of the General Company for Paper Industry (RAKTA) black liquor would allow recovery and reuse of over 10,000 tons/year caustic soda and elimination of a major source of pollution to the sea. The IE/UNEP is leading an international effort to solicit financial assistance of about US $40 million to build a full-scale desilication facility. An extensive cleaner production plan is presently under way to shift to save-all system for white water, replacing chlorine with oxygen bleaching and recycling water in straw washing. These self-financed efforts, with government support in research and development (R&D), will eventually lead to 10-fold reduction in water consumption, significant recovery of lost fibers, and reduction of a chronic industrial pollution problem in Egypt. (6)

The U.S. Agency for International Development provided financial support to an STC research and development cleaner production program since 1993 to help industry in introducing low-cost innovative measures to minimize waste and improve production efficiency. Projects include chromium recovery in leather tanning, reutilization of tire manufacturing wastes, reuse of wooden wastes from match production as soil conditioner and in paper manufacture, recovery of urea from the fertilizers effluents, production of environmentally safe reactive dyes to replace direct dyes presently derived from the carcinogenic benzidine, and waste recovery in textile finishing.

The Egyptian Environmental Affairs Agency (EEAA), in a drive to coordinate international and local cleaner production activities, has established a comprehensive program for pollution prevention in Egypt. The program objectives include development of a long-term plan of action on pollution prevention, implementation of industrial audits and demonstration projects in cooperation with international donors, and dissemination of information on cleaner production.

Environmental advocacy groups are gradually gaining credence in Egypt. They have been able to exert some pressure on industry to shift their operation toward cleaner production. Some environmental groups (the Egyptian Society for Industry and Environment) are considering launching voluntary certification "eco-labeling" programs to identify clean products. Nevertheless, most consumers in the country are still basing their purchasing decisions on prices and personal preference rather than on environmental considerations. In addition, legal constraints impede efforts of consumer groups to publicize environmental risks emanating from polluting industries.

Box 2
Innovative Approaches to Cleaner Production in the Petroleum Industry (7)

Oil refining and downstream industries have expanded rapidly in recent years. At the same time, there has been a noticeable tendency toward integration of production facilities and introducing cleaner technologies. This trend was dictated by the economic pressures to improve cost-effectiveness and competition of all sectors of the oil industry. The growing public demand to reduce pollution emanating from oil processing has also forced the industry to invest heavily in retrofitting older production facilities to improve efficiency and minimize wastes.

The oil industry has to cope with two other problems: namely, the growing scarcity of water supplies in Egypt, and the high cost of wastewater treatment before discharge to water resources; this is mandated in the laws 48/1982 and 4/1994 in order to maintain proper quality of water resources. Both problems have shifted emphasis from end-of-pipe treatment to preventive solutions involving greater integration and rational use of process inputs, improvement of production processes, and reduction of waste generation to the maximum practical extent.

At present, most refineries in the country employ total recirculating systems for cooling applications and multiple-reuse of process water; water use is further minimized by reducing the volume of make-up water used to accommodate for process and evaporation losses and discharges to blow-downs. Through various desulphurization processes, dramatic reduction has been achieved in recycling the sulphur content of the crude oil. In refining and downstream industries, gaseous emissions have been brought to acceptable levels due to recovery of particulate matter and recycling of the emitted gases.

Other cleaner technology measures that have been adopted as standard practice include replacing barometric condensers with surface ones; increasing the efficiency of drying, sweetening, and finishing processes to minimize generation of spent caustic, acids, and clays; installing sour water strippers to reduce the sulphide, ammonia, and phenolic concentrations and recycling of stripped condensate to the desalter; and improving Claus conversion of sulphide gases to sulphur by selective gas sweetening through adsorption or by catalytic hydrolysis of carbon disulphide. Most urea fertilizer plants employ wet scrubbing of prill tower emissions; and have installed a cryogenic system for the separation of hydrogen in the ammonia production, in order to permit better ammonia recovery from the purge gases and reduce nitrogen oxide emissions.

D. Recycling of Industrial Residues: Innovative Approaches

Industrial residues are those end-products of primary production that have not been reused, recycled, or salvaged. They are the non-product flows of raw materials whose economic values are less than the cost of collection and recovery for reuse, and, therefore, are discharged as wastes. These residues could be considered as secondary products if there were appropriate technological means for converting them into usable materials and if the value of the subsequent products were to exceed the costs of reprocessing.

Residues in this case cannot be regarded as wastes but become an additional resource to augment existing natural materials. Recycling, reprocessing, and eventual utilization of industrial residues offer potential of returning these secondary materials to beneficial uses rather than their discharge to the environment which generally causes detrimental effects on man and his amenities. Successful residue utilization involves: (a) rendering recovered products suitable for beneficial use; (b) promoting marketability to ensure profitable operating; (c) employing

appropriate reprocessing technology; and (d) creating an overall enterprise that is acceptable and economically feasible.

D1.Opportunities and Constraints of Waste Recycling in Egypt (8)

The present attitude which favors the use of virgin materials in Egypt is a consequence of economic and technical policies that developed during abundance of energy and natural resources. If effective utilization of residues is to occur, these "consumptive policies" should be reconsidered to encourage the generating industry or specialized secondary industry to utilize the residues. Efforts are needed to develop new technologies and to institute suitable measures to promote waste reclamation; this can only be achieved if residues are considered as complementary resources rather than as undesirable wastes.

Uncontrolled discharge of industrial residues has contributed to appreciable environmental deterioration, which is manifested by the following:

- Increased eutrophication due to excessive discharge of nutrients;
- Microbial contamination that may impair quality of the receiving water bodies;
- Depletion of dissolved oxygen in surface water, fish kills, and septic conditions;
- Offensive odors due to anaerobic decomposition of organic residues; and
- Unsightly conditions in waste-storage and land-disposal sites.

Management of industrial residues has been generally tackled in a piecemeal manner, and was rarely considered within the context of a comprehensive resources conservation scheme. Constraints that hamper effective reuse of residues include: (a) lack of economic incentives and government subsidization; (b) scarcity of managerial and technical skills needed for effective waste utilization; (c) shortage of capital for investment in residue reprocessing; (d) unreliable information concerning marketability of the processed residues; and (e) unfavorable consumer attitude.

When assessing the economics of residue utilization schemes in the industrialized world, the higher labor costs required for reprocessing compared with the relatively cheaper costs of primary production frequently hinder reprocessing of residues. In the less-developed regions, such as Egypt, the situation is reversed, because most residue recovery schemes are cost-effective due to availability of manpower and better marketability of the reprocessed materials.

Despite the fact that residue utilization has not been promoted in Egypt on the basis of resources conservation or concern for environmental protection, the economic incentive should favor acts for the development of successful reutilization systems.

D2. Socio-economic Implications of Residue Utilization

Utilization of industrial residues is influenced by economic feasibility, level of technology, and community attitude. When assessing the economic viability of reclaiming residues, the following factors should be considered:

- Concentration and form of residue;
- Degree and nature of contamination by other industrial residues;
- Cost and availability of virgin raw materials;
- Regulatory incentives and disincentives for residue reclamation; and
- Waste disposal costs.

Residue reprocessing involves technical difficulties because of the variability in residue composition, particle size, and moisture content and concentration. As such, management must be able to direct complex process operations while remaining flexible enough to incorporate technological changes as the industry evolves and more "know how" becomes available from industrialized countries.

The attitude of residue producers, and users of the recovered materials, is crucial for the success of any residue-utilization scheme. Generators of industrial residues often want to get rid of their wastes as quickly and cheaply as possible without seriously considering the possibility of recovery, unless compelling regulations force them to resort to such action. Economic factors such as reduced taxes, subsides, and higher costs of primary materials may encourage investment in residue recovery and utilization.

The unacceptability of reclaimed materials by users is considered an obstacle to effective residue utilization. A variety of subjective reasons, such as less nutritional value, contamination, and lower keeping quality, are given by consumers for rejecting reclaimed residues. Such prejudices are bound to diminish when products involve price differentials for comparable specifications.

Although most residues generated from industry are not toxic in nature, they can cause intense pollution problems when accumulated in large amounts for extended periods. In this case, reliance on residue recovery could help to alleviate pollution problems.

Evidence indicated that production of secondary materials from residues will continue to grow in the foreseeable future due to increased public pressure to control pollution and the growing demand for these products by the extensive programs for agriculture and animal production in the country. It is, therefore, essential to recognize that the need to recycle industrial residues will become inevitable as the cost of virgin products continues to increase in the future. Appreciation of the inevitability of this change is necessary to enable planning ahead for new resources to supplement the shortages of conventional products.

D3. Reclamation of Industrial Residues: Selected Examples (8)

Reprocessing technologies are applied in Egypt for recovery of waste paper, glass, plastics, food processing residues, and metal scraps. While modern technologies are yet to be employed in reprocessing plants, present technologies are, by and large, efficient and cost-effective. Flow charts of selected production processes and sources of residues are shown in Figure1. Examples of new waste reprocessing technologies are presented below:

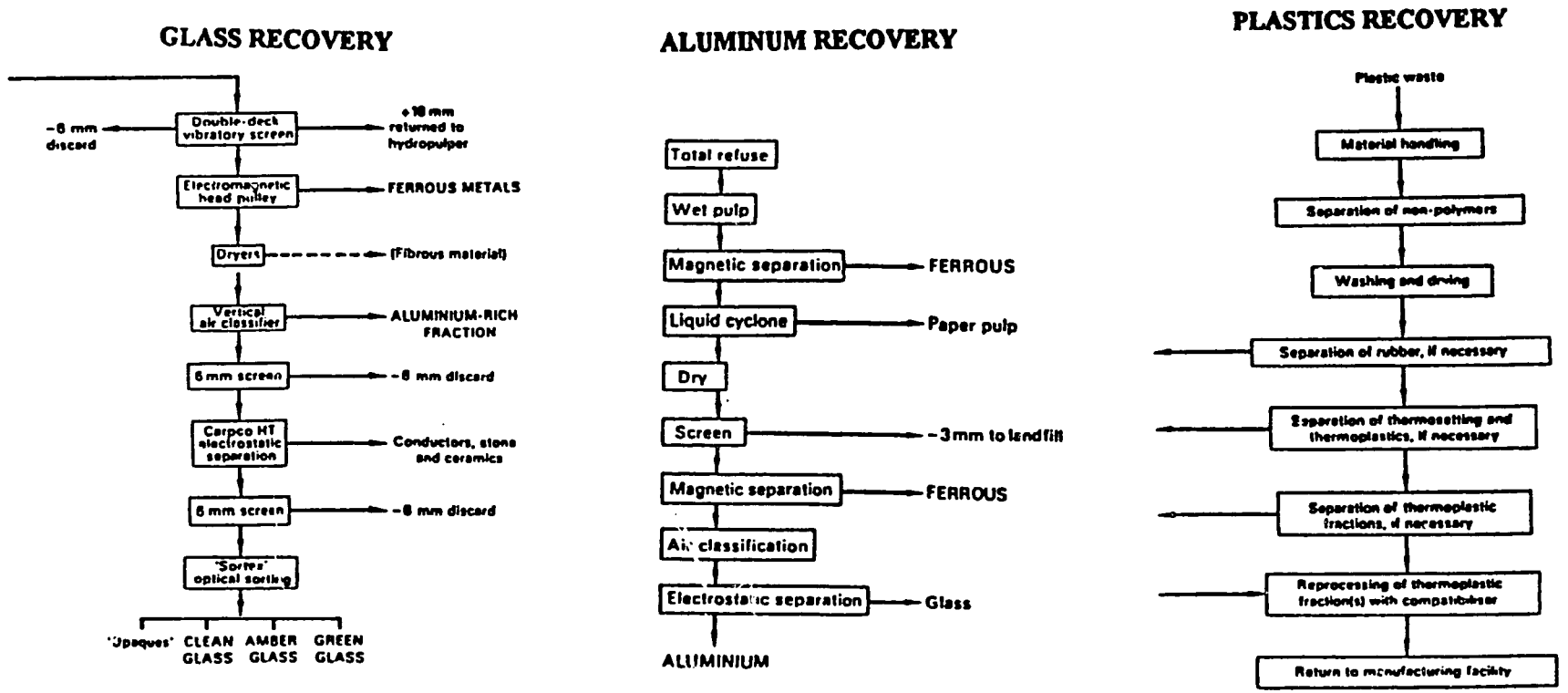

Figure (1): Production Processes for Recycling of Selected Waste Materials

Whey utilization: Dairy processing generates heavy loads of polluted effluents that contain dilutions of whole milk, separated milk, whey, and sanitizers used in the Clean-In-Place (CIP) system. White cheese processing consists of mixing skimmed and dry milk, heating, adding salts and rennet, and then letting the mixture separate. The separated whey is commonly discharged to the sewer without pretreatment, thereby increasing production losses and aggravating pollution problems. The dried whey can be blended with basic food materials to produce less-expensive foods such as fruit sherbets, custards, and bakery goods. Reverse osmosis has been applied on a limited scale in some dairy plants in Egypt to produce a protein supplement and recyclable water; the technical and economic aspects of full-scale application of this advanced treatment remain to be evaluated.

Starch residues: Wastewater originates mainly from the stepping process in which clean, broken rice seeds are macerated in caustic soda for dissolution of proteinaceous matter; protein recovery from starch wastes is being practiced by multi-stage evaporation and the recovered protein is utilized as a basic ingredient in animal feed production. A novel system is currently under investigation for successive acidification and neutralization of starch wastes to remove suspended solids and soluble organics prior to activated sludge treatment. The recovered sludge is dried for subsequent use as animal feed.

Canning residues: Processing of fruits and vegetables generates large amounts of wastes in the range of 25-50 percent of the raw materials; they include spoiled raw materials, peels, pith, and trimmed parts. Solid waste generated from the canning industry is occasionally sold as animal feed. However, the lack of an organized collection and proper storage systems result in residue putrefaction. This often renders the accumulated residues unsuitable for feeding formulae.

Edible oil wastes: In a field demonstration project sponsored by STC, a continuous-flow unit has been designed for the treatment of oil wastes using a system comprised of diffused air flotation. Removal of oil and suspended residues was effectively accomplished by air flotation in conjunction with chemical coagulation. The recovered oil is successfully used for the production of low-quality soaps.

Brewing wastes: The beer slops are normally discharged to the sewer system, which causes serious problems to the sewerage network. The residue of malt filtration is sold as animal feed or as soil conditioner. In the brewing process, hops are added to give the characteristic aroma. Fermentation is performed using a pure culture of saccharomyces cerevisiae. Part of the residue can be recycled with fresh culture for fermentation of subsequent batches. It is also possible to utilize brewing residues as an organic fertilizer. The feasibility of this approach is influenced by two important factors: (1) the economics of land application of residues, and (2) the ability to estimate the capacity of the land to assimilate the residues.

Spent clays: Diatomaceous earth is widely used as a filter aid in food processing and as a bleaching agent in oil refining. Considerable amounts of spent clay are presently discarded, which poses a serious environmental problem. Residual oil in the spent clay may reach 40 percent. A field demonstration project for reactivation of spent clay demonstrated that caustic treatment can recover over 70 percent of the entrained oil, while solvent extraction is capable of recovering about 90 percent of the lost oil. The remaining clay can then be burned under controlled conditions to produce reactivated clay with more or less similar bleaching power to that of the imported clays. Application of this technique in a centralized unit would be cost-effective because of the high demand for the recovered oil and the regenerated clays. Regeneration will also alleviate the disposal problems of the spent clay.

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Straw pulping: The escalating prices of imported pulp and the concomitant increased demand for paper have contributed to the recent increases in wastepaper reuse in Egypt. Reprocessing practices involve cutting of straw, separation of foreign matter, and semi-chemical digestion in an alkaline medium. The waste paper is sorted and subjected to screening and homogenization with the digested straw before feeding to the paper machine. Development of efficient collection techniques for straw and other agricultural residues will increase the stocks of cellulosic fibers and permit increased usage of local raw materials for paper processing.

Reuse of other cellulosic residues: About 50 percent of the municipal refuse contains cellulose; added to this are agro-industrial residues from canning, drying, and extraction processes. The most acceptable method for breaking cellulosic residues into simple sugars is enzymatic hydrolysis; the process applied for residue recovery in sugar processing is depicted in Figure 2.

D4. Centralized Treatment of Industrial Emissions

The industry has made great strides in recent years to provide the needs of consumer products while simultaneously adopting necessary measures to control pollution. However, wastewaters and solid residues discharged from various processing operation remains a potential problem to both public health and the ecosystem. Discharge of untreated effluents, for instance, can kill fish and cause appreciable degradation of water resources. Wastes may also cause health risks as they harbor pathogenic organisms such as those causing infectious hepatitis or myxoboliases.

Some industries are treating their wastes "on-site" before release to the environment. The disadvantages of such treatment are high capital and operating costs, low-volume operating levels, and unavailability of expertise to operate individual treatment units. With the magnitude of waste disposal problems facing many cities today, efforts must be directed toward achieving maximum reduction of pollutants at minimum cost. This can be attained by centralized waste treatment to promoting process efficiency, economy of scale, better response to future expansions, flexibility to meet the needs of seasonal operations, and possible recovery of materials and reuse of renovated water.

Waste management generally benefits from regionalization, where industrial residues from separate but compatible sources can be brought to a centralized facility for treatment. Demonstrations and pilot-scale studies are among the most effective means for introducing new methods and technologies for waste recovery and utilization.

The following factors are normally considered when developing specific programs for centralized reclamation and treatment of industrial residues:

- Availability, seasonability, and presence of storage facilities;
- Waste convertibility, transportation, and ease of handling;
- Marketability, storability, and seasonability of end product use (if any); and

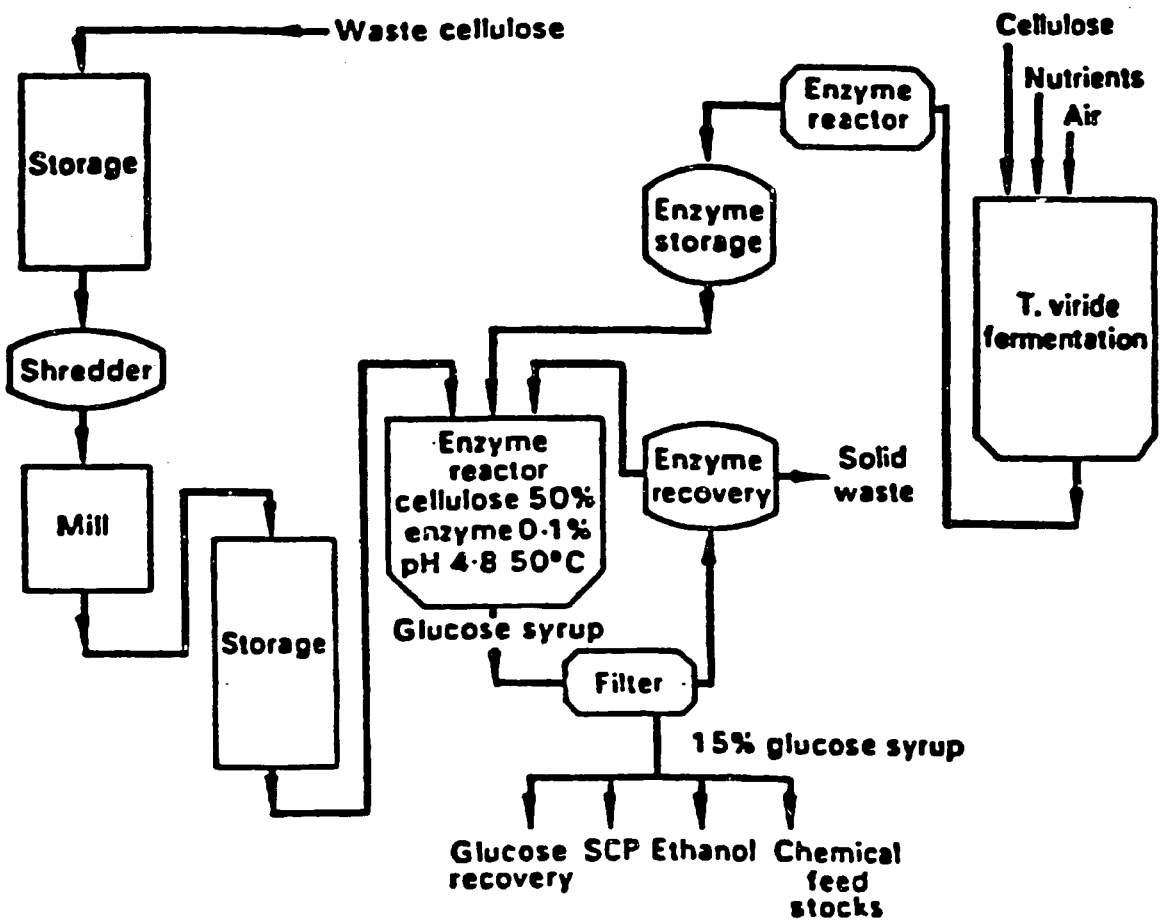

Figure (2): Enzymatic Conversion of Waste Cellulose

- Socio-economic aspects, regarding end products, such as limitation on use, consumer acceptance, and incentives.

For example, the centralized plants may treat pretreated process effluents to remove soluble volatiles by aeration, trace constituents by carbon adsorption, soluble organic matter by biological treatment, and so forth. The bacterial mass formed by biosynthesis can be further utilized as a feed additive. This biomass is characterized by high convertible energy content, high protein and vitamin content, low levels of trace metals, absence of carcinogenic and teratogenic substances, and suitability for storage.

Utilizing biomass with other residues for the production of animal feed provides the following benefits:

- Production of digestible feed-stuff without the addition of natural supplements;
- Alleviation of disposal problems of the generated biomass;
- Increased fodder production; and
- Lower costs of waste treatment.

Centralized recovery of valuable substances from solid residues can be achieved by various methods. Decisions concerning a proper recovery scheme cannot be made on an economic basis alone, as ecological and technological factors must also be considered in selecting methods for recovery and reutilization of residues.

Centralized treatment facilities should be located close to the production sites to minimize transportation costs. In all cases, a fee would be collected from the generators, depending upon the quantity and quality of residues and the type of treatment needed. Implementation of such centralized schemes address two particular problems: (a) the unavailability of land space, endemic to Egypt, preventing installation of waste-treatment facilities at production sites; and (b) the small-size industries, which cannot afford to implement sophisticated and expensive on-site residue recovery systems. An example centralized system for the agro-industry is illustrated in Figure 3.

E. Water Recycling in Industry

Despite its great potential, water recycling in the manufacturing industry has barely been tapped. As processing wastewaters must be treated to an acceptable quality to meet environmental regulations, recycling treated effluents within an industrial plant becomes, in most instances, more economical than paying the high surcharges imposed on polluted effluents. In the future, pollution control standards will be more stringent, which offer more incentive for on-site reclamation and recycling. (9)

In deciding how much to recycle, the industry has to compare the costs of getting water and treating it prior to disposal with those of treating wastewater for reuse within the plant. In most instances, recycling offsets its costs by recovering valuable materials such as nickel and chromium

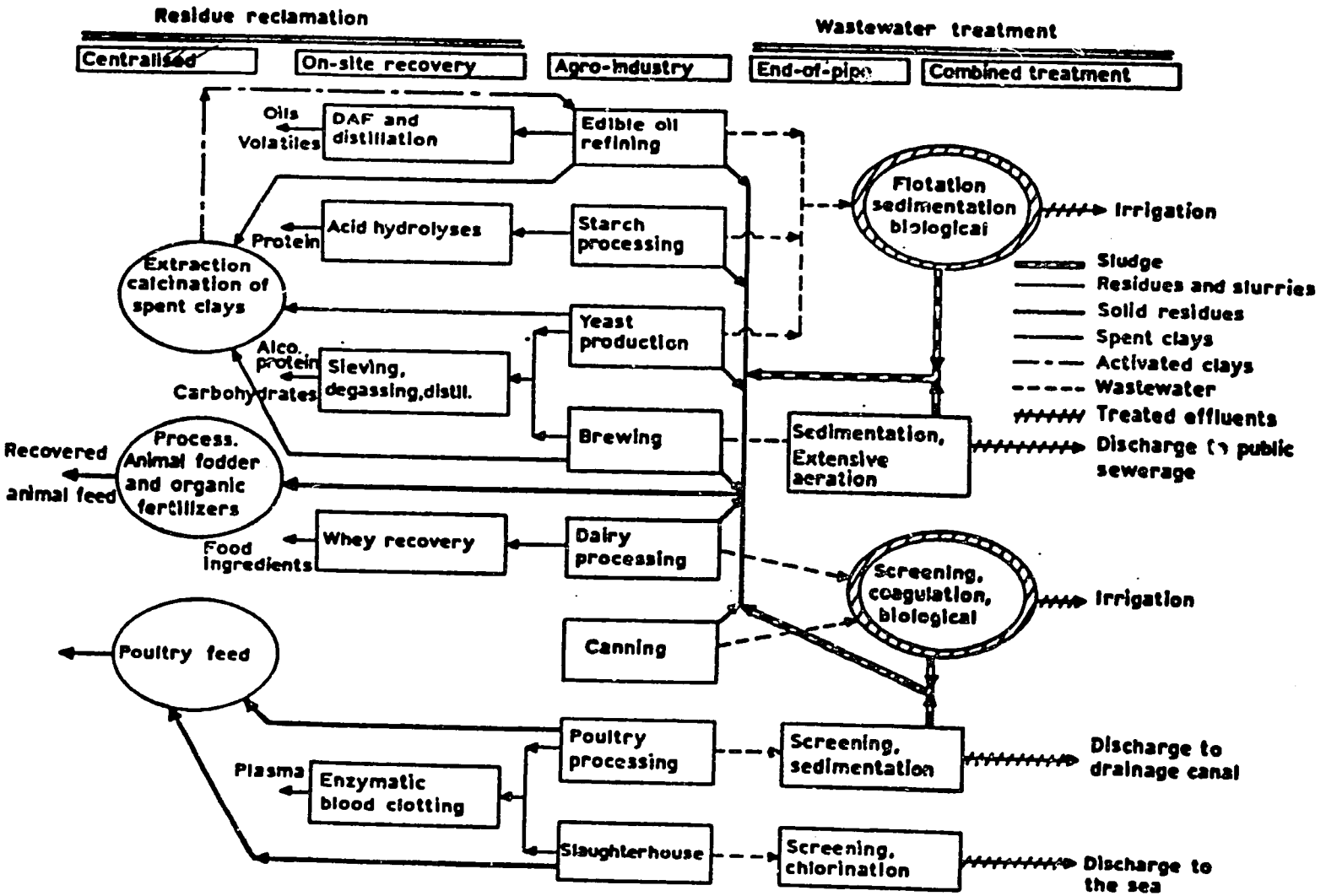

Figure (3): An Integrated Scheme for Reclamation of Solid Residues and Liquid Effluents of Agro-Industries.

from plating operations, silver from photographic processing, and fiber from paper-making. As water and wastewater treatment costs rise, recycling will become more attractive.

In the water-scarce areas, particularly in some new industrial cities, expansion of in-plant water recycling has been motivated by the shortage of adequate water supplies, rising costs of municipal water, and enforcement of stringent industrial effluent discharge standards. In some instances, where the water shortage is acute, industry has resorted to use of effluents from wastewater treatment plants for non-contact processes. This trend has received acceptance, particularly when the treated effluent water quality meets the industry's water quality specifications.

While there are a range of industrial water uses, most manufacturing facilities are still limiting water reuse to closed-system cooling make-up, wash-down operations, site irrigation, fire protection, and dust control. The following subsections describe reclaimed water quality requirements for cooling and process water in various industries.

E1. Cooling Water

Cooling tower make-up water represents a significant water use for industries such as power generation, oil refining, and chemicals and metal manufacturing. In these industries, one-quarter to more than one-half of a facility's water use may be cooling tower make-up. Because a cooling tower normally operates as a closed-loop system isolated from the process, it is commonly regarded as a separate water system with its own specific requirements which are largely independent of the process water requirements.

The buildup of impurities such as calcium, magnesium, sodium, chlorine, phosphate, and organics in a cooling system is controlled by bleeding of a portion of the cooling water and replenishment by make-up reclaimed water. If the concentration of impurities become too high, scale deposits will form on heat-exchanger surfaces. This lowers the heat transfer capacity of the equipment and eventually requires shutdown and cleaning.

While scaling is the most prevalent problem in cooling systems, excessive impurity concentrations may also cause accelerated corrosion, sliming, or plugging problems from accumulated suspended matter. Chemical additives are used in cooling water systems to control scale, slime, and corrosion. The type of chemical additives needed depend on the character of the make-up water. However, chemical additives also have limitations and cannot eliminate the need for blowdown.

E2. Process Water

Quality requirements for water used in industrial processes are highly dependent on the particular industry involved. Even within a single industry, process water quality requirements vary from plant to plant depending on the particular products involved. For this reason, it is not possible to generalize on the quality requirements for industrial process water.

Water quality requirements for paper and allied products are quite variable, depending on the process involved and the desired quality of the finished product. Generally, it is desirable to minimize suspended solids in the water since they may adversely affect both the color and brightness of the product. Other constituents that must be controlled, include silica, aluminum,

hardness (to prevent corrosion or scaling of process equipment), and microorganisms (to avoid slime growths, and paper staining).

Water quality requirements in the chemical industry vary according to the nature of the process and the type of products. In general, water is required that is moderately soft and relatively low in silica, suspended solids, and color. The TDS and chloride content of the water is generally not as critical.

Water quality requirements for petroleum and coal products are moderate. The process water should be in the pH range of 6 to 9 and be fairly low in suspended solids. However, many constituents, such as SiO2, sodium, potassium, and bicarbonates, are acceptable as received and will not cause processing difficulties. Non-staining water is mandatory in most textile mill operations. Hence, the water should be as free as possible of turbidity, color, iron, and manganese. Hardness can adversely affect the soaps used in various operations. Hardness may also increase the breakage of silk during reeling.

F. Industrial Pollution Control: Concepts and Applications (10, 11)

F1. Environmental and Economic Implications of Industrial Pollution Control

F1a. Primary Benefits

- Savings due to reuse of treated effluent instead of fresh water in non-contact processes;
- Savings resulting from compliance with regulatory agencies, i.e., avoidance of legal and expert fees and time of management involved in court cases; and
- Savings from increased production efficiency, made possible by improved knowledge of the waste-producing processes and practices.

F1b. Secondary Benefits

- Savings to downstream consumers from improved water quality and, hence, lowered costs for operations of water treatment plant and damages;
- Increase in employment of labor force used in construction and operation of waste-treatment facilities;
- Increased economic growth of area with more clean water available for additional industrial operations, and potential for expansion at the existing plants;
- Increased value of adjacent properties as a result of a cleaner, more desirable, receiving stream;
- Increased population potential for the area since cleaner water will be available at a lower cost; the limiting factors of water cost and quantity have been pushed back further into the future;
- Increased recreational uses, such as fishing, boating, swimming, as a result of increased purity of water; recreational opportunities previously eliminated are available again; and

- Increased commercial activities.

F1c. Intangible benefits

- Good public relations and an improved industrial image after installation of pollution abatement devices;
- Improved health of citizens in the area confident of having adequate waste treatment and clean waters;
- Improved conservation practices, which will eventually yield payoffs in the form of more clean water for more people for more years;
- Residential development potential for land areas nearby adjacent to clean recreational waters;
- Elimination of relocation costs (of persons, groups, and establishments) because of impure waters;
- Removal of potential physical health hazards of using polluted water for recreation;
- Industrial capital investment assures permanence of the plant in the area thus lending confidence to other firms and citizens depending on the output produced by the industry;
- Technological progress, resulting from the conception, design, construction, and operation of waste treatment facilities throughout the Egyptian industrial sector; and
- Formation of technical exchange industrial associations, resulting in the adoption of pollution prevention and pollution control strategies at other industrial facilities.

The negative impacts of uncontrolled discharge of industrial emissions on city environment are numerous. The case study given in Box 3 on the following page is typical of the harmful effects of industrial effluents on human settlements.

Box 3
Environmontal Degradation Due to Discharge of Untreated Effluents in Industry-intensive Cities: Case Study of Alexandria, Egypt (12,13)

Industrial development in Alexandria Metropolitan Area (AMA), has grown significantly during the last three decades to benefit from inter-industry linkages and the supporting infrastructure in this prime industrial center. While industrialization is encouraged to advance economic growth and to improve standards of living in AMA, the rate of change accentuates the impacts on public health and water resources.

Manufacturing industry in AMA accounts for about 40 percent of Egypt's industrial activities. Environmental degradation is manifested in deteriorated water resources, unsightly overgrowth of weeds, decreased fish catches and adverse public health conditions. The estimated flow of untreated industrial effluents discharged into the city sewer system, or directly into the sea, drainage canals, or Lake Maruit, is 1.7 million m^3 per day; pollutants include chromium wastes from tanneries, mercury from chloralkali and electronics industries, oil from petroleum and edible oil refining, black liquor from pulp and paper mills, and hazardous chemicals from dyestuffs and textile finishing plants. Solid wastes of various industrial activities amount to about 1.63 million tons per year. Despite successful reclamation schemes for some industrial residues; several recyclable materials are being disposed of incorrectly giving rise to serious environmental problems, in addition to loss of potentially marketable products.

In a drive to overcome unemployment problems, the local government is encouraging development of labor-intensive industries, which generate considerable pollution. At the same time, there is a high growth of small-scale industries due to adoption of policies promoting small enterprises to increase private investment in industry. Small enterprises generate excessive pollution which is difficult to manage.

Hazardous residues from manufacturing industries in AMA that are discharged into the air, water and on or into the soil cause severe environmental degradation. The short and long-term effects are far more serious than those caused by municipal wastes. While the latter is more readily biodegradable, most synthesized industrial residues are toxic, persistent, biomagnifiable and tend to accumulate in the receiving environments. The prevailing malnutrition, inferior socio-economic standards and hypersensitivity of city dwellers in AMA lessen their tolerance exposure limits of most toxic substances, a grim fact that adds to the misery of most industrial workers inhabiting the squatter areas around the city.

Hazardous waste problems in AMA are compounded by: (a) the vast increase of industrial emissions owing to the steady expansion of existing plants and the establishment of new industries; (b) improper end-of-pipe treatment of liquid wastes and unacceptable disposal practices regarding hazardous residues; (c) difficulties in monitoring industrial emissions owing to the lack of instruments and trained personnel; and (d) reluctance on the part of most dischargers to invest money in pollution abatement.

Liquid effluents from industrial sources are not pretreated on-site before discharge to public sewers. Since more than 75 percent of industrial establishments in AMA are still state-owned, it is difficult to enforce the emission laws due to mounting economic, and political constraints.

F2. Control of Air Emissions in Industry

Strategies for conservation of air quality in industry-intensive regions focus primarily on emission control at sources of industrial pollution. While source control efforts should continue to receive attention, all development activities must be scrutinized to ensure the ability of the air resources to assimilate the emitted pollutants in the receiving atmosphere.

Within the scope of an integrated area-wide environmental management plan, it is also important to direct regional planning efforts toward reducing sources of air pollution from transportation, stationary sources of fuel combustion, open-air solid waste burning as well as those emanating from industrial facilities in the region.

An integrated air quality management program may encompass a combination of measures to achieve the aggregate reduction of emissions necessary for attainment and maintenance of local guidelines and/or national standards. This implies adoption of measures for reduction of the amount of emissions presently generated from stationary and moving sources, modification of residuals after generation (i.e., retrofitting of vehicles), and better use of air modeling that estimates the assimilative capacity of the local environment, resulting in more careful siting of new sources in order to minimize their impact on regional air quality.

Locating sources to take advantage of the natural assimilative capacity is considered the least-cost alternative to source control and may not face as many economic constraints, as compared with industrial modification necessary to meet a practical abatement strategy, but this emphasis should not preclude consideration of less-costly alternatives.

Local initiatives may include: (a) devising and operating a regionwide air quality monitoring program; (b) controlling emissions through industry density regulation to dilute pollution loads, air zoning to prohibit hazardous air emissions, special use permits to apply regulations beyond general zoning, and planned unit development regulations to provide open space and buffers; (c) providing inducements as differential property taxes, emission feed, and utility extension policies; and (d) utilizing urban renewal to either eliminate pollution generators or improve spatial patterns.

The plan for an air quality assessment in an industrial region may include the following components:

- Developing emission guidelines for existing sources, and proposing a timetable for compliance with the guidelines and/or national standards; and

- Proposing a review system prior to construction or modification of industrial facilities, possibly as a component of a comprehensive environmental impact assessment system, locating new sources to which a standard of performance will apply, and prohibiting construction if it will hinder attainment of an acceptable air quality criteria.

F2a. Industrial Sources of Air Pollution

Industrial sources of air pollution are the most noticeable, because emissions are usually discharged through a single stack or duct. Where a particular industrial contaminant is the major objectionable pollutant in a community, it may be traced to its origin by a knowledge of the industrial processes being used. In these cases, corrective measures are frequently easy to implement.

The following describes common industrial contaminants likely encountered in air pollution problems.

- Nitrogen oxides (NOx) are produced by any high-temperature combustion operation. Process sources include plants for manufacturing fertilizer and explosives.

- Sulfur oxides (SOx) are emitted primarily as SO_2 from the combustion of fuel oil and coal at stationary sources. Sulfur is usually removed from natural gas at the well so that the gas can be used in domestic applications. A very small amount of SOx is emitted from the combustion of gasoline and diesel fuels. Combustion sources also emit small quantities of SO_3. The refining of sulfide ores generates very large quantities of SO_2. Oil refineries are also important sources of SO_2. The sulfur oxides react with atmospheric water to form H_2SO_4 within hours.

- Hydrogen sulfide may be emitted in large quantities from paper plants, natural gas cleaning and processing plants, oil refineries, and some plants manufacturing synthetic fibers, for example, rayon. The H_2S reacts in hours in the atmosphere, oxidizing to SO_2 and H_2O.

- Carbon monoxide may be released at high concentrations in the production of cast iron and other metallurgical processes where it is desirable to minimize the presence of oxygen. It is released at extremely low concentrations at stationary fuel-burning installations, but the quantities generated are still quite substantial because of the amount of fuel burned.

- Hydrocarbons are released in large quantities from a host of industrial processes usually related to the petroleum and natural gas industries or industries that use their products. They may be in the form of vapor, liquid, or tar-like particles, as in the case of asphalt paving operations. The hydrocarbon releases from the paint, roofing, and cleaning industries have already been noted. Hydrocarbons are also released at plants manufacturing plastics, most of which use petroleum or natural gas derivatives as base products, and at rubber or synthetic manufacturing or processing facilities.

- Particulates may be liquid or solid. The chemical and physical nature of the particles is extremely important in assessing the significance of the emissions. Metallic oxides from spray painting and the coating industries; catalyst dusts from refineries; asbestos fibers from the insulation, cloth, and pipe industries; and special chemical releases such as barium, beryllium, boron, and arsenic from the metals processing or manufacturing industries are designated as hazardous particles because they are highly toxic or carcinogenic and are in the respirable-size range. The largest in size of industrial particulates are ash from combustion of coal, oil, and refuse; and carbon particles from quarrying and mining and their associated industries.

F2b. Reduction of Air Emissions

The best way to control air pollution is not to produce pollutants in the first place (i.e., source reduction). For example, lead emissions from automobiles are eliminated by burning nonleaded fuels, and nitrogen oxide emissions have been significantly reduced by redesigning engines. Legislating the allowable quantity of ash and sulfur in fuels is a way of reducing these emissions and their by-products.

Other solutions include reducing emissions by using "add-on" devices. In the case of the automobile, carbon canisters are used to adsorb hydrocarbon vapors emitted from the carburetor and the gas tank. The vapors are subsequently returned to the engine for burning.

Planned dispersion may be used to control local air quality where emissions are not controllable by other techniques. Emissions from tall stacks have more time to disperse in the atmosphere before reaching the ground where they impact on humans, materials, and in residential areas to tall stacks at remote locations.

Add-on devices routinely used for air pollution control are described below.

Particle emission control. Particulate removal equipment must be designed to remove solid and liquid particles ranging from smaller than 1μm to larger than 100 μm in diameter. Smaller particulates are far more difficult to collect. Collectors are broadly categorized according to the physics of the collecting mechanism.

Gravitational settling chambers. Gravitational settling chambers are simple, inexpensive collectors where gravitational forces dominate vertical particle motions. They are essentially simple expansions in a duct in which the horizontal velocity of the particles is reduced to allow time for the particles to settle out by gravity.

Scrubbers. Scrubbers, or wet collectors, are designed to increase particle sizes using water or slurry droplets, because larger particles are easier to collect. Not every collision of a water droplet and a particle results in collection, because of the surface tension of the droplets and particle wetability characteristics. Chemicals are sometimes introduced to reduce the surface tension of the droplet or to improve the ability of the droplets to absorb gases selectively in addition to collecting particles. The liquid containing the particles is collected at the bottom of the tower and pumped to a settling basin or filtration device, where the particles are removed. The liquid may be recirculated with or without chemical treatment, resulting in a zero-discharge system and reduced makeup water requirements.

Scrubbers collect solid or liquid particles. They can be designed to reduce corrosion, and they can be operated at relatively high temperatures as long as the liquid used does not boil and excessive evaporation losses can be prevented. For these reasons, venturi scrubbers are frequently used to collect the small particles generated in steel-making or smelting operations. Operating costs are relatively high for high-pressure loss scrubbers, but capital cost is low compared with other collectors of equivalent performance.

Baghouses (fabric and fibrous mat collectors). Baghouses or fabric collectors are similar to a vacuum cleaner on a grand scale. They are used to remove dry particles from dry, low-temperature gas streams. Cloth socks are suspended in a chamber, and air forced through the sock discharges through the fabric. The fabric may be woven or made of felt, but woven cloth is by far the most common. Fabric materials include cotton, synthetics, and fiberglass, each having different adaptability to gas and particle temperature and physical and chemical characteristics.

Small particles are collected using the filter cake on the cloth surface as the filtration medium. As the thickness of the filter cake build up, the pressure loss through the baghouse, and hence power costs, increase. If the porous filter cake becomes too thick, the pressure on the upstream side of the cake may collapse the cake into a more compact mass, and the pressure loss through the cake will then increase dramatically. If the pores in the filter become filled with liquid, a similar action occurs; hence, baghouses are limited to dry particle collection, and special precautions must be taken to prevent excessive condensation from the gas stream.

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Electrostatic precipitators. The voltage difference (field strength) between the electrode and the collector plates is maintained at as high a level as possible, but below the field strength at which spark-over occurs. Electrons are released at the elected in a corona discharge and attach themselves to particles, thus charging the particles. The charged particles or molecules (ions) of the same polarity as the electrode migrate toward the grounded surfaces due to electrostatic forces. Positive or negatively charged electrodes may be used. The negative corona generates a slightly greater quantity of O3 and is slightly more effective for industrial operation.

Migrating ions collide with liquid or solid particles in the gas stream, giving the particles a charge which results in particle motion toward the collector plates. When particles touch the plates, they stick there. In time, a layer of particles that acts as an insulating blanket will collect on the plates, and the blanket surface charge may actually approach the particle layer. By washing them with liquids, the particle layer slides downward, or, if the particles collected are liquid, they will run down the plate surfaces much like condensation on a window. The particles falling off the bottom of the plate are collected in hoppers for disposal.

Gas Emission Control

There are four fundamental ways to reduce emission of undesirable gases:

- Reduce or eliminate the production of the undesirable gases;
- Induce the gases to react after production in chemical processes to produce different, less objectionable emissions;
- Selectively remove the undesirable product from a gas stream by absorption, which is the transfer of gas molecules into a liquid; and
- Selectively remove the undesirable gas by adsorption, which is the deposition of gas molecules on a solid surface.

Where the gas is recovered from the absorbing liquid or the adsorbing solid, the process is called regenerative because the liquid or solid is used repeatedly in the same process. In these cases the gas is most frequently processed further, making it a salable by-product from which part or all of the collection costs can be recovered.

F3. Management of Industrial Effluents

F3a. Effect of Industrial Pollution on Water Resources

The specific responses to a given pollutant depend on its load and the characteristics of the receiving water. Pollutants may cause a toxic action, an aesthetic insult or blanketing effect that hinders photosynthesis and limits the process of self- purification. The most common pollution parameters in effluents from various major industries are given in Table 1.

Table (1): Common Pollution Parameters

Industry \ Water Quality Parameters	BOD	TSS	pH	Fecal Coliforms	Oil and Grease	Temperature	COD	Color	Elemental Phosphorus	Total Phosphorus	Ammonia (as N)	Organic Nitrogen (as N)	Nitrate	Flow	Phenols	Sulfide	Total Cr	Cr VI	Chrome	Copper	Nickel	Zinc	Zinc A*	Cn Total	Cn A**	Fluoride	Free Available Cl	Residual Cl	Cadmium	Lead	Iron	Tin	Silver	Gold	Iridium	Osmium	Paladium	Platinum	Rhodium	Ruthenium	Mercury	TOC	Aluminum	Arsenic	Selenium
Offshore Oil & Gas Extraction																																													
Dairy Products																																													
Grain Mills																																													
Canned Fruits & Vegetables																																													
Canned & Preserved Seafood																																													
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Plastics & Synthetics																																													
Soap & Detergents																																													
Fertilizer Manufacturing																																													
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Phosphate Manufacturing																																													
Steam Electric Power Generating																																													
Ferro Alloy Manufacturing																																													
Leather Tanning & Finishing																																													
Glass Manufacturing																																													
Asbestos Manufacturing																																													
Rubber Processing																																													
Timber Products																																													
Pulp, Paper, & Paperboard																																													
Builder's Paper & Board Mills																																													
Meat Products																																													
Paving & Roofing Materials																																													

Color may substantially decrease light penetration and hence prevent photosynthetic oxygen production and increase turbidity and bacterial slimes which are aesthetically unacceptable and also cause detrimental effects on water quality.

Industrial effluents containing concentrations of heavy metals and other micro-pollutants either individually or in combination may pose hazards to human health and aquatic organisms. Fish kills are often the result of acute toxicity due to dumping of sludges or accidental release of highly toxic matter. Chronic toxicity due to steady release of low-level toxic pollutants results in changing the entire aquatic population balance through destroying susceptible species and allowing the less desirable but more tolerant species to flourish; diminishing algal and invertebrate food supply; and reducing reproductive potential as eggs are more susceptible to sub-lethal concentrations of toxicants than are the adults.

Toxic substances also pose detrimental health effects; cyanides are extremely toxic as they inhibit the phosphorylative oxidation reactions which permit cellular respiration. Mercury and its compounds, especially methyl mercury, have been associated with a number of episodes characterized by impaired hearing, vision, and muscular coordination, and in some outbreaks, by high mortality. Lead, which is considered a global pollutant, can produce a variety of serious effects, including neurological disorders.

Eutrophication due to enrichment of water by nutrients discharged with industrial effluents, notably phosphates and nitrates bearing wastes, may cause accelerated formation of objectionable algal growth.

Many organic materials may be biologically degraded in water streams, thereby causing excessive demands of oxygen. Examples of wastes generated in industrial processes include: urea-formaldehyde used in paint manufacture, and organic wastes from food, paper, textile, yeast, and chemical industries. These substances constitute a considerable pollution load on water resources. Similarly, chemical oxygen demand (COD) as in the case of iron-pickling discharge, would have a de-oxygenating effect on the stream. Oils, by floating on water surface impose a barrier. Detergents interfere with the uptake of atmospheric oxygen in water.

Complete exhaustion of dissolved oxygen in a polluted stream would render the water incapable of supporting fish-life; and in the absence of dissolved oxygen, some of the microorganisms would use the oxygen combined in certain materials such as sulphates, thereby creating malodor and nuisance. Some materials, such as phenols, may produce taste and odor problems in the water, all in addition to a delayed oxygen demand.

In the stream stretches that are anaerobic, the variety of species decreases compared with that in cleaner ones, often to 10 percent or less of the clean-zone number. The relatively few species that dominate in this case include organisms such as the rat-tailed maggot, sludge worm, blood worm, and sow bug. All are bottom feeders, adapted to anaerobic conditions.

The depreciation of property for residential uses and recreational development is a tangible resource loss due to gross industrial pollution of water bodies. In addition, in some urban centers of the Arab region stretches of rivers and reaches of lakes have been written off as large open industrial sewers. Pockets of industrial pollution forces dwellers in the adjacent areas to move out, which involves additional expenditures to build and run new infrastructure.

Measurable economic losses in such cases can be estimated when they represent direct costs such as loss of materials, cost of treatment, or decreased value of marketable fish. However, intangible costs such as impact on health, loss to tourism and employment, and aesthetic damages are extremely difficult to quantify in monetary terms.

It should be also noted that the value of the water to downstream users cannot be underestimated. Industry as a whole has an interest in protecting the quality of its water inputs as deterioration of water supplies result in added costs of water treatment, which may represent unbearable economic burden.

F3b. Industrial Wastewater Treatment (11)

The primary objective of wastewater treatment is to remove or modify those contaminants detrimental to human or environmental health or the water, land, and air environment. Land disposal, evaporation from ponds and deep-well injection are occasional options, but usually the only practical outlets for the disposal of treated (or untreated) wastewater are streams, rivers, lakes, and oceans. To protect these water resources, the discharge of pollutants into them must be controlled. Alternatives available for industrial wastewater treatment and discharge options are illustrated in Figure 4.

The suspended, colloidal, and dissolved contaminants (both organic and inorganic) in wastewater may be removed physically, converted biologically, or changed chemically. Contaminants are generally removed from wastewater in order of increasing difficulty. First, rags, sticks, and a miscellaneous array of large objects are retained on coarse screens when necessary to protect small pumps. Then grit, the materials that wears out equipment, is removed in grit tanks or chambers. At this point most of the small solids are still in suspension, and the settleable portion of these can be removed and concentrated in the primary gravity setting tanks. The concentrated solids, are pumped to an anaerobic digester for biological decomposition and the clarified primary tank effluent flows to the secondary treatment units. These consist of (a) a biological oxidation section where the dissolved and colloidal matter in the wastewater provides food for microorganisms which then convert the organics to CO_2 and H_2O; and (b) a final gravity setting tank where the microorganisms are settled out. Part of this concentrated biological sludge is returned to "reseed" the oxidation section but most, after further thickening, goes to the anaerobic digester..

The following is a description of the common processes used for treatment of industrial wastewater:

Physical processes. Gravity setting is the most common physical process for removing suspended solids from wastewater.

- Removal of grit (defined as sand particles of 0.2 mm diameter or greater);
- Clarification of raw effluents and concentrating the settled solids;
- Clarification of biological suspensions and concentrating the settled floc;
- Gravity thickening of primary or secondary sludges;

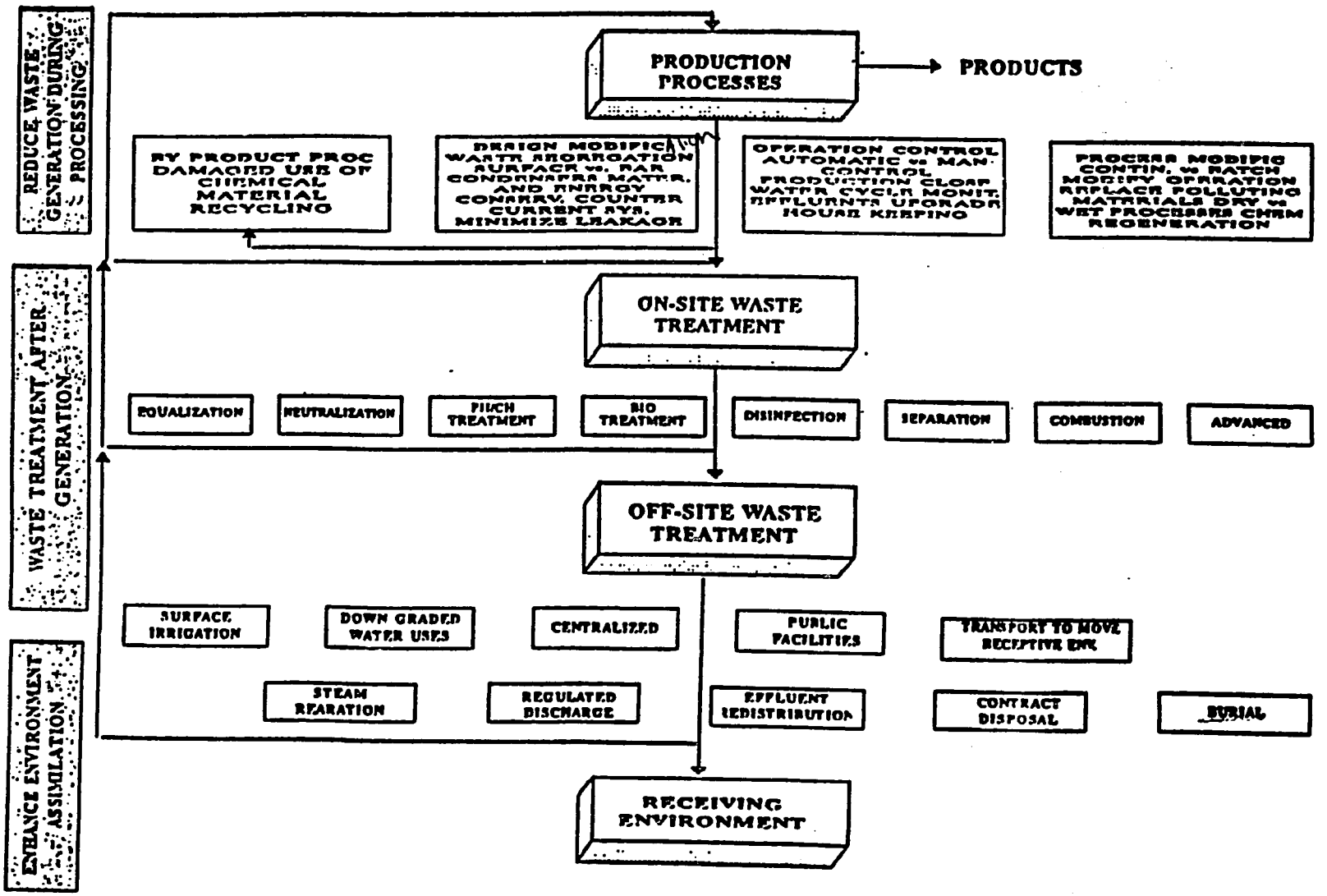

Figure (4): Options for In-plantControl, and Wastewater Treatment of Industrial Effluents

- Screening to remove large objects and perhaps grinding to reduce particle size;
- Granular media filtration (by gravity or pressure) to remove effluent SS; and
- Flotation or centrifugation to thicken sludges.

Biological processes. Most of the organic constituents in wastewater can serve as food (substrate) to provide energy for microbial growth. This is the principle used in biological waste treatment, where organic substrate is converted by microorganisms, mainly bacteria (with the help of protozoa), to carbon dioxide, water, and more new cells. The microorganisms may be aerobic (requiring free oxygen), anaerobic (not requiring free oxygen), or facultative (growing with or without oxygen). Processes in which microorganisms use bound oxygen (from NO_3 for denitrification, for example) are often called anoxic rather than anaerobic. The microbial population may be maintained in the liquid as suspended grow

Aerobic/anoxic processes. In aerobic processes (i.e., molecular oxygen is present, heterotrophic bacteria (those obtaining carbon from organic compounds) oxidize about one-third of the colloidal and dissolved organic matter to stable end products (CO_2 + H_2O) and convert the remaining two-thirds into new microbial cells that can be removed from the wastewater by settling.

Ever since the importance of wastewater treatment became recognized, industries have relied almost exclusively on aerobic rather than anaerobic biological processes for treating their liquid organic wastes. Aerobic treatment has predominated because of its simplicity, stability, efficient and rapid conversion of organic contaminants to microbial cells, and relatively odor-free operation. Although all aerobic biological oxidation processes use microorganisms to convert organic contaminants, the methods for accomplishing this conversion are varied and numerous.

Anaerobic processes. In anaerobic biological processes (i.e., no oxygen is present), two groups of heterotrophic bacteria, in a two-step liquefaction/gasification process, convert over 90 percent of the organic matter present, initially to intermediates (partially stabilized end products including organic acids and alcohols), and then to methane and carbon dioxide gas. The process is used universally in heated digesters, where primary and biological sludges are retained for approximately 30 days to reduce their volume by about 30 percent and their putrescibility, and thus simplify their disposal.

Two major advantages of anaerobic processes over aerobic ones are that they provide useful energy in the form of methane and that sludge production is only about 10 percent of that from aerobic processes for converting the same amount of organic matter. This is advantageous in the treatment of high-strength yeasts, where the handling of large volumes of sludge would be a problem.

Chemical processes. Oxidation, reduction, precipitation, and neutralization, are commonly used for industrial wastewater treatment. Chemical treatment alone or with other processes is frequently necessary for industrial wastes that are not amenable to treatment by biological means. The oxidation of toxic cyanide to manageable cyanate (with SO_2) or of hexavalent chromium to the nontoxic trivalent form in the disposal of plating wastes are examples.

F3c. Joint Treatment of Industrial and Municipal Wastewater

It is often possible and advisable for an industry to discharge its waste directly to a municipal treatment plant, where a certain portion of the pollution can be removed. A municipal sewage-treatment plant, if designed and operated properly, can handle almost any type and quantity of industrial waste. There are many advantages to be gained from such a joint venture:

- The cooperative spirit between industry and municipality is increased, particularly if division of costs is mutually satisfactory.
- Even if identical equipment is required, construction costs are less for a single plant than two or more. Furthermore, municipalities can apply for state and/or federal aid for plant construction, which private industry is not eligible to receive.
- The land required for plant construction and for disposal of waste products is obtained more easily by the municipality.
- Operating costs are lower, since more waste is treated at a lower rate per unit of volume.
- Possible costs advantages resulting from lower municipal financing costs, federal grants, and municipal operation can be passed on to the users and may permit higher degrees of treatment at a cost to each participant no lower removal levels.
- Some wastes may add valuable nutrients for biological activity to counteract other industrial wastes that are nutrient-deficient. For example, bacteria in the sewage are added to organic industrial wastes as seeding material.
- Acceptance of the joint treatment project and relinquishment of individual allocation would give the municipality full control of a river's resources, enabling the municipality to use the capacity of a river to the best advantage for the public at large. The municipality has greater assurance for closer monitoring of effluent quality.

Among the many problems arising from combined treatment, the most important is the character of the industrial wastewater reaching the treatment plant. Equalization and regulation of discharge of industrial wastes are sometimes necessary to prevent rapid change in wastewater quality necessary for maintaining the microbiological population to ensure ample chemical dosage in coagulating basins, and to ensure adequate chlorination to kill harmful bacteria before the effluent is discharged to a stream.

If the industrial waste characteristics are such that the waste can be treated safely and effectively in the municipal sewage plant, there still remain two major considerations: a municipal ordinance that protects the treatment plant from any individual or industrial violation and sewer-rental charges that enable the municipality to defray the increased costs of construction and operation resulting from acceptance of the industrial wastes.

F4. Management of Industrial Solid Wastes (14)

In most industrial areas in the country, solid waste materials are disposed of without taking the necessary precautions required for segregation of hazardous and non-hazardous wastes.

Industrial facilities are not normally provided with restricted storage areas for transit collection and storage of hazardous wastes.

F4a. Sources and Nature of Recyclable Solid Wastes

Large amounts of potentially recyclable materials are landfilled or stockpiled. These include:

- Off-specification products;
- Products whose date for appropriate use has expired;
- Materials spilled, lost, or having undergone other mishap including any materials, equipment, and so forth contaminated as a result of the mishap;
- Materials contaminated or soiled as a result of planned actions (e.g., residues from cleaning operations, packing materials, containers);
- Unusable parts (e.g., exhausted catalyst);
- Substances which no longer perform satisfactorily (e.g., contaminated acids, contaminated solvents);
- Residues of industrial processes (e.g., still bottoms);
- Residues from pollution abatement processes (e.g., scrubber sludges, baghouse dusts, spent filters);
- Machining/finishing residues (e.g., lathe turnings, mill scales); and
- Residues from raw materials processing.

The hazardous constituents in the form of liquid, sludge, or solid materials may include:

- Residue from substances employed as solvents;
- Halogenated organic substances not employed as solvents;
- Tempering salts containing cyanide;
- Mineral oils and oily substances (e.g., cutting sludges);
- Oil/water, hydrocarbon/water mixtures, emulsions;
- Substances containing PCBs and/or PCTs;
- Inks, dyes, pigments, paints, lacquers, varnish;
- Resins, latex, plasticizer, glues/adhesives;

- Pytotechnics and other explosive materials;
- Non-halogenated organic substances not employed as solvents;
- Inorganic substances without metals;
- Ashes and/or cinders;
- Non-cyanidic tempering salts;
- Metallic dust, powder;
- Spent catalyst materials;
- Liquids or sludges containing metals;
- Residue from cleaning of tanks and/or equipment; and
- Contaminated containers (e.g., packaging, gas cylinders, and so forth).

The following are identified as potential operations for resource recovery, recycling, reclamation, and direct reuse of industrial wastes (secondary materials). Some of these operations may not be economical when handled by the individual generators. However, their treatment in a centralized facility may prove profitable

- Use as a fuel or other means to generate energy;
- Solvent reclamation/regeneration;
- Recycling/reclamation of organic substances which are not used as solvents;
- Recycling/reclamation of metals and metal compounds;
- Recycling/reclamation of other inorganic materials;
- Regeneration of acids or bases;
- Recovery of components from catalysts; and
- Oil re-refining or other reuses of oil.

In view of the unacceptable practices for handling of hazardous wastes in industrial areas in Egypt, it is necessary to establish an integrated system for proper management of these wastes. The broad objectives of the system should encompass:

- Encouraging reuse: recycle-resource recovery whenever technically and economically feasible;
- Emphasizing waste-exchange to enable effective waste reuse;

- Discouraging incineration of waste to alleviate air pollution problems in the region; and
- Promoting private investment in waste reclamation.

F4b. Treatment of Industrial Hazardous Wastes (15)

Physical treatment: Physical treatment methods usually encountered in hazardous waste treatment include various methods of phase separation and solidification, whereby the hazardous waste is fixed in an inert, impervious matrix. At the most basic level, phase separation encompasses the widely used techniques of lagooning, sludge drying in beds, and prolonged storage in tanks. All three depend on gravitational settlement, and the first two also allow the removal of liquid by decanting, drainage, and evaporation. Lagooning and tank storage are widely used to separate oil and water from mixed wastes, sometimes following preliminary treatment with emulsion-breaking agents and occasionally, in the case of tank storage, combined with heating. A development of this last method is the burning of the recovered oil to produce process steam for tank heating.

Other, more-sophisticated methods are also used, such as air flotation and various filtration and centrifugation techniques such as adsorption/desorption, vacuum, extractive, and azeotropic distillation, particularly in the recovery of valuable chemicals from process residues.

Solidification or fixation processes, which convert the waste into an insoluble, rock-hard material, are generally used as pretreatment prior to landfill disposal. The conversion is achieved by blending the waste with various reactants to produce a cement-like product. Other techniques employ organic polymerization reactions or the mixing of the waste with organic binders such as bitumen.

Chemical treatment: Chemical treatment methods are used both to effect the complete breakdown of hazardous waste into nontoxic gases and, more usually, to modify the chemical properties of the waste, e.g., to reduce water solubility or to neutralize acidity or alkalinity. These methods also include cyanide oxidation, heavy metal precipitation, and chromium reductions.

Biological treatment: Hazardous waste is occasionally amenable to biological treatment, even though the concentrations of toxic materials present are often lethal to microorganisms. However, the in-plant biological treatment of dilute aqueous effluents is well established, and microorganisms have been developed to selectively degrade specific toxic chemicals. The natural microbiological activity in topsoil is also used in farming for degrading some organic chemicals, notably oily waste. Composting may also be useful for certain organic chemical products.

G. Preparedness for Industrial Emergencies

The complex nature of emergencies and the multiplicity of their causes calls for an integrated approach comprising proper risk-evaluation, developing tailor-made crisis management procedures, training personnel, and promoting community involvement and awareness.

While the primary responsibility for prevention of accidents rests with industry and civil defense authorities, the circle involved with preparedness for emergencies is broad. It includes manufacturers and users of hazardous chemicals, labor unions, government bodies concerned with protection of health and environment, and the general public.

While setting priorities on the basis of the potential risks should be the core of the emergency preparedness plan, it may be impossible to devote resources to meet all types of emergency situations. Proper planning should therefore address the worst problems first; establishing an adequate information base is also necessary for prioritization of these problems.

Data on performance of production technology can be compiled from industrial studies. However, impacts of accidents and the associated costs are still difficult to determine. The tasks of hazard management are commonly assigned to various institutions: health insurance (workers' health), manpower (occupational safety), civil defense (confirmation with codes of fire prevention), industry (safe operation of equipment and storage facilities), and Environmental Protection Agency (limitations on release of hazardous emissions).

The procedures for control of sources of hazards administered by these institutions concentrate on specific activities such as licensing and monitoring compliance with safety codes and regulations. This fragmented approach has tended to compartmentalize and hinder integration of efforts within a comprehensive scheme for management of hazards during emergency situations.

Accident prevention programs should be strengthened through improving existing practices for control at source, licensing, and permitting emergency response, zoning, and employing economic banalities to encourage compliance.

Control of the work environment, which is limited in most instances to satisfying safety requirements in construction and operation of manufacturing facilities, should be broadened to ensure safety of the surrounding population. Effective management of occupational safety programs should also promote community awareness of chemical risks and public preparedness in case of industrial or transport emergencies.

The industrial permitting system is often non-homogeneous and suffers from administrative barriers and inconsistent enforcement. The authorization system should be compulsory for all hazardous facilities to enable enforcement of strict licensing conditions. The installations subject to licensing are those classified as dangerous, noxious, or potentially harmful. In addition to common licensing requirements, priority dangerous installations should be also requested to submit safety analysis to describe the nature of hazard, the probability of accidents, and the anticipated damage should they occur. Such analysis usually encompasses characteristics of site area, nature of flow of all hazardous substances, evaluation of the possible risks and their potentiality, interactions with the surrounding environment and neighboring installations, and evaluation of the consequences of an accident.

Licensing storage facilities for hazardous chemicals should be based on examining characteristics (ignitability, corrosivity, toxicity, mutagenicity, or infectiousness), quantity, storage location (topographic and soil characteristics, hydrological data including impacts on water resources), and storage procedures (dikes, transfer areas, impoundments, tanks).

A regionwide contingency plan for industrial and chemical emergencies must be developed for industry-intensive areas in the country. This will enable the safeguarding of workers on-site and the neighboring population and will minimize dangers to the environment.

In major industrial areas, a local emergency preparedness committee should be established with broad representations of industry and agencies concerned with occupational safety, public

health, transportation, and civil defense. The functions of the committee may encompass identification of hazardous facilities, development of emergency and notification response procedures, identification of resources to combat disasters, and designation of coordinators from local departments and manufacturing plants. An integrated emergency preparedness scheme may embrace:

- Undertaking surveys to identify potential hazardous areas in manufacturing facilities and hazards associated with raw materials, intermediates, and products. A fault sequence analysis will be applied in which a particular hazard (fire, explosion, etc.) is defined as the eventual result of a series of circumstances leading to build up of hazardous conditions.

- The risk that a hazardous event might occur will be determined as well as the probability of the event having dangerous consequences (fatalities, injuries, damage to property or the environment). Sequence models will be employed to assess the effect of accidental release of flammable or toxic material to the atmosphere.

- Based on the findings of the above activities, in-situ measures may be implemented such as the modification of layout, application of additional safety devices, change in process and equipment, and/or use of less hazardous materials. Off-site measures may include zoning, early warning of the neighboring community, and evacuation exercises. A plan involving combination of these measures will be developed to enable safe production while maintaining security to adjacent population.

The approach for examining high-risk situations may involve consideration of potential accident scenarios, including those with the worst effects. The suggested scenarios for high-risk events subject to investigation in high-risk industrial areas include:

- Risks linked to liquefied combustible gas facilities (boiling liquid expanding vapor explosion and unconfined vapor cloud explosion);

- Risks linked to containers of liquefied or non-toxic gases which risk breaking during handling or after internal explosions or external shocks (total instantaneous loss of confinement);

- Risks linked to toxic gas facilities (instantaneous breakage of the largest pipe leading to the highest weight flow);

- Risks linked to high-capacity storage of inflammable liquids (fire in the largest tank, fireball, and projection of ignited product by boil over); and

- Risks linked to the use of explosive products (explosion of the largest mass of products present or which can be produced by reaction).

H. Economic Implications of Industrial Environmental Management (16, 17)

Most public sector facilities in Egypt are manufacturing goods for the local markets. Such industries suffer from acute pollution problems instigated by appreciable material losses and lower production efficiency. In most instances, these industries encounter severe shortage of cash flow to sustain their marginal operations, while at the same time they are requested to direct

substantial investment to pollution prevention. As most of these aging industries occupy strategic positions in the national economy, the government occasionally provides financial assistance for these industries to adjust to the requirements of environmental protection.

H1. Economic Benefits of Cleaner Production

Introduction of cleaner processes in large-scale industries rely, in the most part, on imported technologies and machinery. Therefore, availability of foreign exchange is crucial for financing modernization and cleaner technologies programs in public enterprises. In addition, the ability to purchase spare parts and imported feedstocks of acceptable quality is essential to ensure proper operation, waste minimization, and abatement of pollution.

An approach to overcome the economic and environmental burdens of public industries is being implemented at present. The government has devised a new financial mechanism including packages of loans and grants according to the specific needs of each facility among a national list of priority pollution industries. Financial assistance will be provided through an Egyptian Pollution Abatement Fund (EPAF). Candidate facilities should demonstrate financial viability and reasonable return on investment in new cleaner production technologies. The free-market policy pursued since the early 1980s has enabled possession of substantial foreign reserve, while the trend toward privatization of public enterprises and the establishment of autonomous business conglomerates (holding companies) permitted pooling financial resources among the affiliated companies, and subsequently allocating adequate funds for investment in cleaner production, particularly in units that experience temporary cash-shortage but exhibit potential for overcoming this constraint in the future.

Emphasizing the fact that considerable investments may be required for retroffiting aging industry or for adopting imported cleaner technologies in large-scale industries does not necessarily imply that cleaner production is always costly with no or low return on investment. Far from that, most industries, large and small, can achieve remarkable success by no-cost measures such as changing workers' attitudes toward housekeeping, introducing effective operational controls, and introducing minor modifications to maximize use of feedstocks and enable recycling of energy and process waters. Such profitable management options are liable, in most instances, to immediate implementation without causing negative effects on the productivity and product quality.

Improving production efficiency should, therefore, be perceived as an essential component of cleaner production. This may lead to overall reductions in the use of raw materials, water, and energy, which in turn can result in significant reduction of production costs. Other obvious benefits include improving work environments by better material handling, reducing environmental emissions, and avoiding costly remedial measures where releases have caused serious environmental damage.

H2. Economic Disincentives and Yheir Impact on Industrial Pollution Control

Institution of a system of charges to be levied on polluters may provide a vital source of funds to supplement those of the government budget allocated for pollution control. These funds may enable investing in pollution-control facilities, where no other source of finance currently exists. However, levying charges should not imply the right to pollute, since emission standards would remain enforceable; the charges should merely provide a "supportive mechanism" to ensure compliance with the standards. The financial resources generated through the charges will

also enable strict enforcement of emission standards, and additional financing of the centralized treatment facilities

The application of the "polluters pay principal (3Ps)" is not widely accepted by industry in Egypt at present. However, the 3Ps implies that costs for the prevention or control of pollution caused by industry must be paid by the individuals responsible for the emission of pollutants. Putting 3Ps in practice involves imposition of pollution charges which represent payment by industry for use of the assimilative capacity of the environment, or to benefit from the municipal sewage treatment services. Proposed economic sanctions, and regulatory instruments such as standards limiting maximum emissions can complement each other for effective control of pollution emanating from manufacturing industries.

A pollution charge should be based on effluent flow and concentration of pollutants (waste load). Methods of cost allocation and recovery include:

- **User's charge:** This system is based on the use of, or benefit from, the municipal sewerage services where various industrial wastes are combined and treated together. The unit-user charge is expressed as cost/unit waste. The total charge for a given contributor is the sum of the unit user charges multiplied by their corresponding loads. This system is appropriate for industries connected to municipal sewerage networks.

Surcharge costs are typically calculated according to the following formula:

$$Cost = Q\,[C1 + C2\,(BOD - X\,1) + C3\,(SS - X2) + C4\,(N - X3) + C\,5\,TX].$$

Where:	Q	=	Annual average flow.
	C1	=	Unit cost of flow to treatment works.
	C2, C3, C4	=	Treatment cost of BOD, suspended solids (SS) and nitrogen (N), respectively.
	X1, X2, X3	=	Non-chargeable BOD, SS, N, respectively.
	C5, TX	=	Concentration and cost of treatment of toxic constituents such as cyanide, phenol, etc.

- **Negotiated contracts:** In cases where there are several small industrial contributors to the municipal system, the sewerage authority can negotiate individual contracts taking into account the special nature of each effluent. Contracts are also useful in planning of a new industry, as it may be charged the capital costs for that portion of the design capacity allocated to its use.

- **Property taxes:** Though this system of taxation is convenient and commonly applied for other purposes, it may be inefficient and inequitable for paying pollution charges. The system encourages excessive generation of waste loads, as there is no incentive for industry to reduce pollution. Inequities would occur as non-polluters are forced to bear a share of the total cost which should be paid by the polluting industries only.

Service charges when enforced as stipulated in the environmental law 4/1994 will encourage polluters to comply with effluent limitations. Charges are the most direct way of internalizing the costs of pollution to a polluter. Money may be paid to the local government or the environmental protection entity (local office of EEAA) in proportion to the amount of

pollution. The government or EEAA may then use the money to finance central pollution control facilities.

The obvious advantage of a service charge is that it is the polluter who pays for the costs of polluting. The system rewards those industries that are clean and efficiently run and penalizes those that are dirty and wasteful. Also, it does not encourage increases in polluting activity, as a subsidy system might. Finally, the administration of such a system is relatively easy, requiring only the monitoring of discharges.

The disadvantages are that production and operating costs for the industries connected may rise. If the service charges are nominal, industries may find it less expensive to simply continue polluting. If the charges are high enough to force an industry to stop or severely restrict its effluent discharges, the industry may close down. In any event, industries will have different capabilities and costs related to controlling its wastes, and a uniform service charge could upset the economic balance between competing industries.

I. Legislation and Enforcement of Emission Regulations (18)

Industrial environmental management should aim to maintain or improve the quality of the surrounding environment. Ambient standards are determined for a number of different characteristics or pollutants within a medium such as air or water. These standards are designed to minimize risks to the health of humans, animals, or the environment. The components for which these ambient standards are set must be quantifiable and scientifically measurable. In water and air, criteria are set for allowable concentrations of a variety of pollutants. Furthermore, the pollutants for which ambient standards are set must be related to their sources. The EEAA can set ambient standards and monitor ambient conditions, but it cannot control or manage conditions except by controlling the sources of the pollutants which affect the ambient conditions.

Effluent standards are more useful for control of industrial pollution than ambient standards because they can be monitored and controlled at the sources of generation. Even though the ambient quality is what is needed to conserve, this is normally achieved by controlling effluent quality and quantity.

There are two major instruments available for control of industrial pollution, namely direct regulation, and/or polluter subsidies. They represent means of controlling effluents or discharges of pollutants, and they work to internalize pollution costs to the polluter. They can be applied independently, but are usually applied in combination. Each of these instruments appears in a variety of forms. The following is a brief review of the common forms in which they are applied:

I1. Direct Regulation

Through direct legislative action, the quantity, quality, and location of discharges of pollutants can be regulated. The main forms of direct regulation are zoning; prohibition, or zero discharge; and effluent standards.

Zoning. Zoning regulations are one of the simplest and oldest forms of pollution control and are still a part of almost every pollution control strategy. Zoning results in variable ambient quality. In areas where pollutants are discharged, quality of the environment is appreciably degraded. The government may choose to divide the country into regions with different expected ambient standards and therefore different allowable effluent standards. Polluters would then

determine for themselves the trade-off in abatement costs and location or relocation costs. People could also choose the level of environmental quality they wished to live in. However, the disadvantages of such a scheme are many. For example, industries might be forced to locate far from their markets, thus increasing the cost of goods.

Prohibition, or Zero Discharge. Another form of direct regulation of pollution is prohibition, also known as zero discharge. The advantages of such a concept are obvious. First and foremost, there would be no change in environmental quality. Moreover, all resources would have to be completely converted into useful products or stored indefinitely. And the legislation would appear to be equitable, since the same regulation would apply to everyone. Such a concept, however, is normally impossible to realize. A simple materials balance shows that any resource taken from the environment, including energy, must be returned in some form. Even if it were conceivable to recycle all wastes into new products, there would still be a large energy requirement to achieve this. For most activities, zero discharge would be expensive if not impossible to achieve.

Effluent Standards. Effluent discharge standards are the most common and the most useful form of direct regulation. They can be across-the-board requiring that effluents of all polluters meet the same criteria, or they may be individually developed for each polluter. The advantages of an across-the-board type of approach are that it is easy to administer, it appears fair to all polluters, and it provides the most rigid control over environmental quality. The disadvantages are that it may be uneconomical, and therefore impractical, to insist that all polluters meet the same effluent standards. Some polluters may easily meet standards that others will be unable to meet at all, or only at a very high cost.

The different assimilative capacities of the environment in different locations can be taken into account only on a case-by-case basis. For example, a large, fast-moving river can accept a much larger amount of organic pollution than a small canal, and therefore pollutant concentrations from point-source discharges could be much higher before river quality is seriously affected. Nevertheless, most jurisdictions prefer to set common effluent discharge guidelines, which must be met unless the contributor is specifically exempted.

Static regulations (law 93/1962 on disposal of industrial effluents in sewer systems and the implementing decree 643/1962, law 48/1982 on effluent discharge in fresh water bodies and the implementing decree 8/1983, solid waste law 38/1976 and the implementing decree 134/1968, industrial toxics law 137/1981 and the implementing decree, and so forth) have gradually lost their effectiveness which subsequently led to aggravation of pollution problems. The weakening and erosion of existing legislation is contributed to by several inter-related factors including: (1) dynamic evolution of polluting activities, industry in particular; (2) increased complexity of developmental activities; (3) loop-holes and vagueness in regulations which enable violations; (4) transfer and evasion of pollution via other form or media (discharge of polluted water in drainage canals and its ultimate disposal in fresh waterways); and (5) inflation and monetary erosion which render charges ludicrous.

It is, therefore, recommended to revise and amend the existing national legislation at reasonable periods of time (decree 643/1962 has been revised in 1994). Permits issued for discharge to water bodies should also be subjected to periodic review to ensure continued compliance with the conditions granted in the initial permits. Fairness and firmness in enforcing regulations should be imposed on all concerns to ensure equity and respect for the law.

Furthermore, to make sure that national legislation becomes a more effective tool for environmental protection, the concerned monitoring and enforcement bodies should see to it that regulations are available for a larger range of sectors and parameters and provisional criteria are instituted for pollutants with potential but not confirmed health risks.

To account for the diverse range of composition of industrial materials and manufactured products in Egypt, pollution-control regulations should seek to impose: (1) a strict requirement to forbid use of any imported material banned in the country of origin (this concept is being adopted in some Arab countries; however, illegal entry of uncertified products undermine control efforts; (2) requirement to provide detailed qualitative and quantitative descriptions of all chemical constituents of an imported product (refusal of submission of information on polyelectrolytes has promoted a ban on their use in treatment of drinking water in some Arab countries); and (3) a producer-mandated assistance program for proper detoxification or treatment of accidental releases of toxic chemicals in water courses from industrial, domestic, or agricultural sources.

Other enforcement measures include the withholding of various permits or licenses without which the polluter cannot lawfully operate. Using a court injunction to force a polluter to appear in court is a drastic measure that is rarely used.

Enforcement of the environmental laws (particularly the implementing decree 338/1995 of the environmental law 4/1994) is expected to face resistance from the polluting industries. Those who have been discharging wastes freely resent any curtailing of their "rights." Some industries alleged that they may be forced to close down if pollution-control regulations are enforced because they simply have no money to invest in pollution-abatement projects. If true, this would aggravate unemployment problems, and therefore would be politically unacceptable. EEAA may, therefore, find itself unable to force polluters into actions that may have socially unacceptable side effects.

I2. Subsidies

One method of encouraging polluters to comply with regulations is to provide money to help cover their costs. These subsidies may be in the form of direct payments or grants based on a percentage of the cost of pollution abatement or on a percentage reduction in effluent quantity or strength. They may also take the form of low-interest loans for the capital costs of improved treatment facilities such as EPAF. Alternatively, the government can reduce or defer taxes or relax other government requirements to encourage spending on pollution control.

The main advantage of subsidies is that they reduce the costs of pollution abatement to the polluter and limit the associated increase in production costs. Government grants can be used to cover capital costs, and tax incentives can be used to relieve operation and maintenance costs. Subsidies (the carrot) combined with regulations (the stick) can be used by government to reduce stress on the environment and at the same time encourage research and development by industry in pollution-abatement technology. The main disadvantage of polluter subsidies is that the government will have to increase taxes or direct money from other programs in order to pay the subsidies.

J. Capacity Building for Industrial Environmental Management

J1. Development of Human Resources for Industrial Environmental Management

For a few industrial managers, the environment is still conceived of as a convenient receptacle for waste and as a nuisance when its deterioration leads to imposing costly cleanup actions.

A fundamental change in this attitude is necessary to eliminate occupational risks to workers and to minimize the negative impacts on the surrounding environment. This can be achieved when those responsible for the day-to-day running of industrial facilities are convinced of the economic and environmental benefits of waste minimization and the opportunities for savings through material recovery and recycling of water and energy.

Because workers are more occupied with production problems rather than environmental concerns, their training should follow unconventional routes. Obviously, rigorous instructions in the classical training format is doomed to fail in this particular situation. An alternate is to expose the prospective trainees to real case studies and demonstrations in the industrial locations themselves.

In-situ training is recommended in this case. This may cover various aspects such as identification of pollution sources, process changes to reduce discharge, methods of material recovery, precautions for handling toxic chemicals, spill containment, in-house storage of hazardous residues, and simple on-site pretreatment of wastewater.

In addition to in-situ training of workers, the managers should learn of options for clean technology employed in similar installations throughout the country. This "show-how" approach is extremely useful, particularly when such technologies can be adopted at a reasonable cost.

Informal meetings and group discussions organized by an environmental trainer on site also enable workers to keep abreast of practical ideas and successful methods to control pollution. Sharing knowledge and experience in this manner should be advocated as a preliminary stage to bring environmental issues to workers attention, through exposure to disciplines and opinions of others.

While the development of in-house manpower is essential for the success of industrial environmental management, equally important is the development of expertise for planning, monitoring, and enforcement within the administrative mechanism of the local environmental authorities. Special attention should be given to training of personnel to become aware of the environmental impact of manufacturing operations, and to use the knowledge and experience gained to curb industrial pollution through the institution of appropriate regulations and administrative instructions .

J2. Information Exchange on Industrial Environmental Management

Manufacturers usually encounter difficulties when seeking solutions to their technical and environmental problems; access to pertinent information is either limited or unavailable. For example, international institutions or government agencies may have special technical arrangements to help entrepreneurs to solve their unique pollution problems; commercial banks may have low-term loans available for pollution control projects (i.e., Egyptian Pollution

Abatement Project of the World Bank); others may be in need of by-products or even the process wastes from a particular industry. These few examples illustrate the considerable scope and importance of providing information services to inform the concerned industries of these viable opportunities.

In view of the above, establishing a national information center is necessary to collect and disseminate information of interest to entrepreneurs. The type of information must include, among other things, environmental regulations concerning manufacturing; alternative technologies for pollution control; sources of financial aid; environmental training for small-scale industries; and opportunities for material exchange. The information may be disseminated through newsletters, computer networks, the Internet, or extension officers in the field.

In addition, the continuous tightening of pollution-control regulations (the grace period of law 4/1994 will expire in February 1997) and the rising prices of raw materials in Egypt may prove attractive to the profit-oriented entrepreneurs looking for markets for the valuable components of their wastes. Waste generators and potential users may be linked through an information clearing-house which receives offers of, and requests for, waste materials. These are published and circulated among member industries and their trade associations. The information system may include standardized formats for waste characterization and suggestions on reuse of various wastes.

K. Industrial Environmental Impact Assessment (IEIA)

It is important to recognize the impacts that industrialization has on the environment. The environmental impact matrix provides a convenient inventory and display of these impacts. The matrices for the impacts of industrialization are illustrated in Table 2. The horizontal axis lists various aspects of industrialization, while the vertical axis contains the components of the environment—the atmosphere, hydrosphere, lithosphere, and human impacts.

The impacts identified can then be classified as severe, moderate, slight, and unknown, or a numerical scheme may be used. The classification is ultimately subjective and should preferably be done by several individuals, each influencing the opinion of others, which may lead to an informed and impartial consensus on the issues to be addressed in the IEIA. Particular emphasis should be placed on environmental changes due to new industrial development projects that may cause severe or irreversible damage to natural resources, such as significant terrain disturbances, extinction of rare or endangered species, or widespread contamination.

New projects of an environmental impact statement (EIS) typically embrace the following (19):

- Description of a proposed action, as well as alternatives (including that of no action);
- Estimation of the nature and magnitude of the likely environmental effects of all alternatives;
- Identification of the relevant human concerns;
- Definition of the criteria to be used in measuring the significance of environmental changes, including the relative weights to be assigned in comparing different kinds of changes;

TABLE (2): ENVIRONMENTAL IMPACTS OF SELECTED GROUPS OF INDUSTRIES

Environmental consequences	Industrial component					
	Petrochemical	Metals	Food/beverage	Mining	Agriculture	Pulp and paper
ATMOSPHERE	Emissions to atmosphere from refining, processing plants (noxious, toxic)	Particulate, gas emissions during forging, working fabrication	Noxious fumes from food processing	Particulate matter from surface mining, transportation Noxious, toxic fumes from smelting	Drift of agricultural sprays Dust, pollen escape due to field operations	Release of noxious fume during processing
HYDROSPHERE	Plant emissions to receiving water bodies	Discharge of mill pickling liquors Other waste disposal to water bodies heavy metal releases (intentional, unintentional)	Wastes often have high organic content	Runoff from mine tailings Processing wastes disposed of directly into water bodies	Runoff to surface and percolation to subsurface waters of pesticides, fertilizers Silting of water bodies due to poor farming practices	Contaminated factory wastes (mercury, organic Silt from deforested slop Loss of wildlife habitat
LITHOSPHERE	Disposal of waste solids, sludges to landfill Accidental spills during transport, storage	Disposal of slag, waste products from processing		Dumping of mine tailings, processing wastes Disruption of agriculture, forestry, recreation by open-pit mines	Erosion of land surface Depletion of organic material, necessary soil microorganisms, etc.	Breakdown of ecosystem clear-cut areas Erosion of unprotected land
HUMAN IMPACTS	Some products, wastes toxic to many life forms Disruption of life style	health effects of released toxics in air, water		Health hazard to miners (mercury, asbestos, coal mining)	Health effects of biocides, polluted water, etc.	

- Estimation of the significance of the predicted environmental changes (i.e., estimate the impacts of the proposed action);

- Recommendations for either acceptance of the project, remedial action, acceptance of one or more alternatives, or rejection of the project; and

- Recommendations for monitoring procedures to be followed during and after implementation of the action. In some jurisdictions, the IEIA process stops short of making recommendations.

Often a baseline report must be prepared for submission in advance of or at the same time as the EIS. The baseline report contains an environmental inventory, i.e., a factual account of environmental condition in the region at the time of the report, together with trends that may have recently occurred. Where data are deficient, the assessor may be required to undertake a field program.

The description of the proposed action (new or expansion) should include a description of the construction phase of the project, the operating phase, and in some cases the shutdown phase as well. An important consideration is the selection of alternatives to the proposed project. The alternatives should include different ways of building and operating the project. The EIS may describe the project at only specific site. However, it is easier to compare impacts at a variety of sites than it is to determine the absolute value of any impact at one site. Without a consideration of alternative sites, there is a real difficulty in accepting a new industrial project which may cause negative environmental impacts. The nature and magnitude of the environmental changes that are likely to occur and that must be estimated and included in the EIS fall into three main classes:

- Physical, e.g., earthquake probabilities; water quality in groundwater, rivers, and lakes; and soil and air quality;

- Biological, e.g., vegetation, wildlife, sport and commercial fish species, and endangered species; and

- Socioeconomic, e.g., demographic, economic, and social values and attitudes.

Relying on scientific experience, predictions of physical impacts are relatively easy to make. Predications of biological and ecological impacts are much more uncertain. This is because living organisms and communities of organisms are subject to natural stresses from droughts, floods, overgrazing, as well as to stresses created by society. In addition, living organisms are adaptive and contain great genetic variability, so that their reactions to multiple environmental stresses are not always predictable. Early EISs included censuses of flora and fauna in the affected area, particularly with respect to endangered species. However, there is now a shift toward studies of life cycles, habitats, and food chains of representative species.

Predictions of socioeconomic impacts are extremely uncertain even in a qualitative sense. Nevertheless, these impacts are of fundamental importance to the persons affected and may cause biological and/or ecological changes over and above those caused by the project itself. Furthermore, the socioeconomic impacts may vary across a community: some people may support a new industry, because it will increase employment opportunities; others will be opposed, because of noise, air pollution, or the loss of a scenic view.

Finally, cumulative impacts may be important in some cases, with many small impacts leading to a major crisis many years later.

L. Environmental Management in Small-scale Industry

Environmental problems of small-scale industry have proved to be more problematic than those of large-scale facilities. This is due to spreading of pollution in residential areas and the difficulty of monitoring and enforcing environmental regulations on these widely scattered small enterprises. Agglomerations of small-scale specialized enterprises typically exist in cities and towns due to abundance of employment pool, availability of support services, access to utilities and transport networks, and closeness to principal markets.

The employment pattern in the small enterprises indicates reliance on labor-intensive operations that require less-skilled laborers. The dominant industries include service and maintenance workshops, chemical formulations, food processing and distribution, construction materials, and handicraft enterprises; they rely, by and large, on outdated technologies and obsolete equipment to produce low-cost goods.

Most small-scale industries generate appreciable pollution. Although their environmental impacts may be diffused in relatively clean environments, the generation of pollutants represents an additional pollution burden in major urban centers in Egypt, where intensive manufacturing activities exist. Tightening of monitoring and enforcement of environmental regulations on small enterprises is recommended to encourage the entrepreneurs to switch to clean technology despite the incurred capital outlay. This may lead to a temporary stagnation effect on employment. However, productivity and environmental conditions should improve due to upgrading manufacturing practices and reducing the pollution contributed by these diverse and widespread industrial establishments.

Most small-scale private industries consist of plants for conversion of primary materials into secondary products. Liquid wastes are discharged without pretreatment in most instances, either to the municipal sewerage system or to the drainage canals.

In large industrial areas, a thorough review of environmental impacts of industrial pollution is a complex and cumulative process. The impact of large pollution sources on the environment should be assessed with discharges from small- and medium-scale facilities in the same location while considering the prevailing climate, wind velocity, and the capacity of the receiving environment to absorb or assimilate the pollutants.

The audit should go beyond assessing direct effects of the industrial emissions on the environment to include other nuisances, such as excessive noise, progressive absorption of free space, and chaotic traffic. In addition to these nuisances, the unfavorable conditions of human settlements in the Egyptian cities expose the community to additional environmental dangers. These include vulnerability of groundwater resources to contamination, the greater complexity and potential hazards of working in small workshops, and poor occupational health conditions, particularly for children and elderly workers, and the prevailing malnutrition.

M. Development of an Industrial Environmental Management Scheme

The complexity and importance of environmental management requires formulation and execution of a reactive strategy that may entail the establishment of an Environmental Management Unit (EMU) within the administrative system of the regional branches of EEAA (The World Bank has recently supported establishing EMU's at the governorate level). The unit's mandate would be to monitor and control environmental quality according to the objectives and criteria set by national laws.

The scope of activities and performance level of EMU will obviously depend on available resources and may involve expanding the existing capabilities (i.e., public health monitoring laboratories, and water and sanitation authorities) and hiring a specialized cadre to carry out the assignments of the proposed EMU.

It is noteworthy to emphasize that EMU should not intend to replace or assume functions assigned to other institutions, but should work closely with them to fill existing gaps. The unit may undertake tasks of environmental management currently overlooked by other agencies, and to provide backup for their effective implementation.

The unit should be charged with managing pollution problems within major industrial complexes in the country and coordinating environmental protection activities with other concerned government institutions. The unit must use all practicable means consistent with the national environmental polices to strengthen pollution-control programs and optimize the manufacturing industry's use of resources. The proposed duties of the EMU's embrace inter alia:

- Review and appraisal of the various programs and activities of industrial plants and enterprises for the purpose of determining the extent to which such programs and activities are contributing to the achievement of the goals of environmental protection, making necessary recommendations to the concerned industries;

- Coordination with EEAA of the development and implementation of a collective program for off-site treatment of hazardous wastes, and supervision of operation of the centralized wastewater treatment plants, with emphasis on enforcing measures to reflect costs associated with pollutants' discharge so that they will be taken into account in the waste disposal decisions of the polluters;

- Implementation programs for manpower development and on-the-job training for pollution control and waste minimization;

- Enforcement of regulations for control of industrial emissions;

- Act as a pollution prevention center, supplying technical information, sponsoring workshops, and providing on-site assistance for Egyptian industries; and

- Development and implementation of a comprehensive pollution monitoring program (PMP).

The PMP may involve the tasks presented below.

M1. Discharge of Industrial Wastewater

The proposed scheme for issuing permits comprises three essential steps. Namely, preliminary review, issuance of clearance certificate, and issuance of discharge permit:

(1) **Preliminary review:** Prior to construction of new facilities or expansion of existing ones, industries will be required to submit a detailed report which would include the following information: description of the process; raw materials and auxiliaries used, especially hazardous and priority pollutants; water balance with schematic for points of use; recycle and discharge; characteristics and loads of pollutants generated in the raw effluents; descriptions of wastewater treatment facilities and the anticipated loads of pollutants discharge with the treated waste; layout of the plant and the waste treatment facility; and the anticipated date of operation. The report should be submitted to EMU four months prior to starting construction.

(2) **Clearance certificate:** Upon review of the report, EMU will advise the applicant of one of the following decisions: (a) clearance for starting construction; (b) provisional acceptability pending meeting additional requirements; or (c) refusal to grant clearance based on the submitted information. The receipt of the clearance certificate does not absolve the industry of its responsibility to complete procedures required by other government agencies. Steps (1) and (2) are presently imposed with some variations as prerequisites for approval of new projects. EEAA's No Objection Certificate is also requested before issuing the final project approval.

(3) **Discharge permit:** The discharge permit will include a description of effluent sources approved for discharge, pollutant parameters and their analysis frequency, applicable discharge standards, method of reporting spills, periodic reporting requirements, and the expiration date of the discharge permit.

(4) **Monitoring violations:** If priority parameters exceed those specified by 10 to 30 percent, this should be regarded as a "temporary event." This may be caused by industrial leaks, spills, or short-term non-point discharge. Identifying causes of temporary violations is difficult due to the transient nature of the source. Temporary violations should not be used as a regulatory tool as they provide only circumstantial evidence of pollution; yet they are valuable for assessing chronic problems of a transitory nature such as deliberate dumping of prohibited wastes and as a cross-check on incidents of major industrial leaks. A chronic violation, however, is defined as a case of more than 30 percent in excess of the limits of the regulated pollutants for three or more consecutive checks. This can be traced through periodic and annual reports to determine if a violation in certain plant is temporary or chronic.

M2. Monitoring Air Emissions

Activities of air monitoring may include:

(1) Monitoring ambient air quality through data collected from the fixed stations network to establish air pollution index (API), to predict long-term trends, and to correlate ambient concentrations with local meteorological data.

(2) Mobile monitoring, needed for hot spots (high-impact areas) identified through complaints and not covered by the stationary network, to measure the impact of specific industrial plants.

(3) Existing polluting industries are required to submit an overall assessment of their gaseous pollutants, and their proposed plan for abating air emissions. Actual or estimated API values above set criteria by EEAA will provide guidance for acceptance of proposed additional activities.

(4) New industries should submit prior to construction a review report covering the following: identification of emission sources (raw materials, fuel, products); characteristics and loads of fugitive emissions; location of stacks associated with point sources, type of control equipment and efficiency at full and normal loads; in-house monitoring program; and expected dates of completing construction and reaching normal operation.

M3. Solid and Hazardous Waste Monitoring

The plan involves monitoring compliance with guidelines for collection, transport, reuse or disposal of refuse and industrial residues. Implementation of the plan consists of the following:

(1) Implementing regulations for management of solid wastes and codes of practices for collection and transportation activities undertaken by the private contractors and the documentation data of the sanitation authorities (collection schedule, vehicles for pickups, vehicle maintenance, amount of trucked refuse, etc.).

(2) New and existing industrial facilities should submit a statement to EMU concerning the generated residues that are temporarily contained or disposed of with domestic refuse, and estimates of construction and demolition debris and their disposal method.

(3) Monitoring of hazardous residues generated from industries will be undertaken by EMU in coordination with EEAA. Generators shall submit information concerning: chemical composition and characteristics of the residues (ignitability, corrosivity, toxicity, radioactivity, mutagenicity, or infectiousness): quantities generated; storage location (climatic data, topographic and soil characteristics, hydrological data including anticipated impacts on water resources); and storage procedure (dikes, transfer areas, surface impoundments and tanks). Industrial operations must formulate and implement contingency plans for emergencies and major spills which specify a course of action in the event of accidental release of hazardous materials, equipment and material used to combat release, staff training, and notification procedures.

(4) As most of the hazardous wastes generated by the manufacturing industries are disposed of off-site, and since EEAA has been entrusted by law 4/1994 to develop a scheme for management of hazardous waste, it should institute a manifest system to track handling, transporting, and disposing of hazardous waste. The manifest should accompany a bulk shipment or individual batches and record the following information: the generators' name and address, description of waste, handling precautions and hazardous properties, quantity of transferred material, and designated disposal facility. Following the signing of the manifest by the operator of the disposal facility, it should be returned to EMU. Implementation of the new regulations in coordination with EEAA will eliminate most of the short comings of the present system of haphazard disposal of hazardous wastes.

M4. Monitoring Noise and Occupational Exposure

The occupational health departments of the major industrial facilities provide medical services for workers in case of injuries but do not provide regular services for monitoring working conditions or hazards which affect occupational health.

It is therefore suggested to integrate the functions of monitoring the work environment in the EMU activities; this task should be undertaken with full participation of the existing medical services.

The monitoring plan should set forth the procedures for acquisitions, reporting, and interpretation of noise and occupational exposure data.

(1) Noise monitoring at emission sources (locations of industrial, and construction activities) and receptor areas. Noise should be monitored at appropriate times such as periods of relaxation versus times of high-noise levels during rush-hours.

(2) Occupational exposures include a host of sources: physical (noise, vibration, excessive temperatures, ionizing radiation); biological (insects, molds, fungi, bacteria); biochemical (monitoring, repetitive motion, fatigue); and chemical inhalation or skin absorption (mists, vapors, gases, dusts, fumes). The monitoring plan may encompass: evaluation of sources of hazards and measurement of exposure level; and setting controls to reduces exposure.

N. Environment and Sustainable Industrial Development: an Agenda for Future Actions

While recognizing that industrialization is vital for sustainable development in Egypt, more emphasis should be placed on ensuring environmental-soundness of the manufacturing facilities. This can be achieved by employing cleaner technology, conservation of resources, and abatement of pollution at source. The following issues should be addressed within the framework of a national strategy on industrial environmental management:

- While incentives are offered to encourage private investment, such incentives have yet to incorporate protection measures to control industrial emissions within the context of the Egyptian Environmental Action Plan (EEAP). Creation of an environmental management unit within the institutional framework of the regional EAAs will provide a mechanism for addressing pollution problems and environmental concerns at the local level.

- There is a need to influence the options for new industrial activities and to make use of proper experience and judgment for identifying likely problems and proper mitigation measures for pollution control, particularly in hazard-generating industries. The environmental impact assessment (EIA) may produce such a prospect for proper environmental planning during the extension of existing industries and the development of new ones.

- Wastes are produced by almost all industrial production facilities, but some are most likely to produce hazardous constituents requiring special treatment. Particular attention should be given to proper containment of hazardous wastes from tanning, metal plating and finishing, printing, chemical formulations, textile finishing, pulp and paper manufacturing, and metallurgical industries. A cradle-to-grave policy should be adopted for proper management of hazardous wastes.

- An inadequate network of facilities and supporting infrastructure for hazardous waste disposal exists in major industrial sites. Alternatives for waste disposal include incineration, detoxication, and landfill containment. Incineration is not recommended, particularly in the congested urban centers, to avoid air pollution problems. Detoxication is practiced on a limited scale in some industrial establishments; however, the process generates large quantities of hazardous sludges, which complicates transfer and disposal problems. Landfilling appears indispensable for an integrated hazardous waste management scheme, but disposal sites have to be properly designed, operated, and monitored.

- A review of the existing economic incentives to investors is needed, to ensure their compatibility with the goals of conservation of resources and prevention of pollution; incentives that conflict with these goals should be removed. A priority action is to adopt and implement the polluter pays principal, which reflects the price of environmental damage arising from pollution in the production costs. Proper guidelines for an environmental audit of the existing industrial facilities should be developed and implemented by EEAA to ensure the sustainability of industrial development.

- A system for information services may act as a delivery mechanism for information concerning legislation, emission standards, cleaner technology, waste minimization, and other relevant issues influencing decisions regarding industrial environmental management. A national waste exchange system should be established based on a uniform classification of wastes. The system could operate through a clearing house to link potentially interested users with generators of wastes. The information might include characterization, amounts, and suggested reuses of wastes.

- The level of training on pollution prevention among industry personnel has to be strengthened. Development of human resources for effective pollution control should receive priority. On-the-job workshops for the workers and group seminars for industrial managers are bound to strengthen environmental skills, and hence enhance responsiveness to pollution-control initiatives and create a specialized cadre for management of the environment in the manufacturing facilities.

- Public awareness can be enhanced through increased flow of information from industry and government to the public, and vice versa. Better understanding of basic environmental concepts and rational utilization of resources can be achieved when the

public is given the opportunity to participate in policy decisions and in expressing their views concerning means of improving delivery of services.

- Facts about environmental quality and its links to sustainable development should be disseminated in a proper and simple manner through mass media. Developing close relations with NGOs, local officials, and industrialists in the country can help in identifying environmental problems, setting action priorities, and building political support for environment protection. The leaders in local governments and industry should be the prime targets for industrial environmental awareness programs.

- The private sector represents a main instrument that affects environmental development in Egypt, both positively and negatively. Private investments should be encouraged to play a major role in the transfer and application of new industrial environmental activities, particularly in the fields of pollution abatement, hazardous waste management, and recycling of materials.

- Pollution-control legislation should consider cost of pollution prevention technology, and the relation between emission loads and the assimilative capacity of the environment. Legislation should be drawn up and enforced in such a way that if violations occur, effective sanctions can be imposed.

- There is a need to link enforcement with evolving environmental jurisdiction through implementing an integrated monitoring scheme that involves liquid and gaseous emissions, solids and hazardous wastes, noise, and the work environment. The institution of an effective monitoring program in support of environmental enforcement will reflect the interest in maintaining a clean environment for the benefit of workers and the surrounding communities.

- Despite the increased interest in cleaner technology, its wide-scale application has yet to benefit from the new and proven technologies introduced in the industrialized countries. This is attributed to an inadequacy of information on new waste minimization technologies, management resistance to employ what they view as cumbersome changes, and a lack of policy measures conducive to investment in such technologies.

- Employing cleaner technologies and utilization of low-waste production systems should be regarded as an essential prerequisite to approving new industries (industrial permitting system). Such technology standards can be easily imposed during installation of new factories or when a plant is retooling and replacing worn out equipment. Retrofitting existing plants may be expensive, but inevitable if these plants are to be brought in compliance with the limitations on industrial pollution.

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SECTION II
INDUSTRIAL WASTE MANAGEMENT: SUBPROJECT SUMMARIES

A. Subproject No. 10: Locally Made Substitutes for Imported Asbestos and PVC/PVAC Copolymers in Vinyl Tiles Formulation

Awardee:	National Research Center	
End-User:	Canaltex Flooring Company	
Principal Investigator:	Professor Dr. Wafaa Abdel Fattah	
Period:	02/09/1990 - 02/01/1993	
Budget Breakdown:		**LE**
USAID/STC	$ 109,900 and LE 54,000	**427,660**
In Cash	GOE None End-user None	**None** **None**
In Kind	GOE 115,902 End-user 99,000	**214,902**
Total		**642,562**

A1. Subproject Description

This project (C/A 10) was granted by the Science and Technology Cooperation Project (STC) to researchers from the National Research Center for the period September 2, 1990 to February 1, 1993. The grant provides for research, production, and assessment of the technical and economic viability of the replacement of asbestos with less harmful, locally available materials in tile production.

Canaltex Company is a public sector company that produces tiles, tile covering, and insulation products for office and home use in Egypt. Before this subproject, the company used asbestos as its main raw material for the production of durable tile covering. The project researched various options for replacement of asbestos by indigenous materials such as talc and kaolin or phosphogypsum (a by-product of Abu Zaabal Fertilizer and Chemicals Company, a major public sector industries producing phosphate fertilizers). Three technical options for tile production were evaluated, ranging from partial to complete replacement of asbestos and dolomite by talc, kaolin, and phosphogypsum.

The experiments and research provided evidence on both the technical and economic viability of total replacement of asbestos and partial replacement of paste and dolomite by talc and kaolin. Selected tile formulae were produced several times for assurance testing on production. Tiles produced from the above ingredients were tested for water uptake, dimension stability, volatiles percentage, impact resistance, and indentation in accordance with specifications. As a result of the reformation, an added benefit in tile production stages (especially the oven stage) proved to be a reduction in energy consumption of approximately LE 30,000 per year.

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A2. Financial Analysis

Asbestos may be replaced by both talc and Kaolin or phosphogypsum, the latter of which is a by-product of Abu-Zaabal Fertilizer & Chemical Company. According to the mode and type of replacement, the following three cases are expected to be economically feasible:

Case 1: Partial replacement of asbestos and dolomite.

Case 2: Total replacement of asbestos and partial replacement of paste and dolomite by talc and kaolin.

Case 3: Total replacement of asbestos and dolomite by talc, kaolin, and phosphogypsum.

The mixture that was regularly used prior to this project can thus be considered as the base case. Four cost factors have been taken into consideration. They are:

- Cost of raw materials
- Cost of steam consumed in processing
- Reduction in custom duties for imported ingredients
- Cost of replacement

All calculations have been based on data obtained from the Techno-economic Assessment of the Canaltex report. Two sets of analysis were conducted for each case, the first comparing the annual financial returns of each case with the capital expenditure of the project, and the second comparing the costs of each case with the base one.

In the first financial analysis, the STC grant and the end-user and the GOE contributions were considered to be the project's capital expenditures. The capital expenditures were tested against the quantified annual cost savings over the lifetime of the project to arrive at the net present value for each case. This value then served as an indication of the feasibility of the project.

In the comparative cost analysis, the capital expenditures were excluded, because they are the same whatever mixture is used. Using a different mixture will only affect annual operating expenses, which are included in the annual cost savings achieved by using each type.

The results of the analysis were recorded as follows:

In million LE

Description	NPV from the financial analysis	PV of cost savings from comparative cost analysis
Case 1	1.892	2.532
Case 2	6.274	6.919
Case 3	3.563	4.206

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The calculations and assumptions related to the above analysis can be found in the appendix to this document.

In comparing the cost savings and their present value over 10 years for each proposed mixture, it was found that:

Case 1.	Partial replacement of asbestos and dolomite	
	Cost saving in first year	LE 0.373 million
	Present value of the annual savings	LE 2.532 million
Case 2.	Total replacement of asbestos and partial replacement of paste and dolomite by talc and kaolin.	
	Cost saving in first year	LE 1.018 million
	Present value of the annual savings	LE 6.919 million
Case 3.	Total replacement of asbestos and dolomite by talc and kaolin and phosphogypsum.	
	Cost saving in first year	LE 0.619 million
	Present value of the annual savings	LE 4.206 million

The annual net savings calculated above clearly demonstrate the superiority of case 2 (total replacement of asbestos and partial replacement of paste and dolomite by talc and kaolin), because it secures the maximum saving possible of LE 1.108 million per annum. It thus preserves a substantial amount of hard currency for the company.

In this project it is clear that the substitution of any of the proposed mixtures in tiles manufacturing will be economically beneficial, with annual savings ranging from LE 0.37 to LE 1.0 million. This is because of the reduction in costs of raw materials, steam, and custom duties that would otherwise have been incurred with the use of the imported materials.

A3. Subproject Achievements

A3a. Economic Benefits

The annual net savings calculated above clearly demonstrate the superiority of using the case 2 (total replacement of asbestos and partial replacement of paste and dolomite by talc and kaolin), because it achieves maximum savings, amounting to LE 1.1085 million per annum.

Reduced costs of importing. For asbestos, the reduction in import duties range between LE 31,400-57,000 depending on whether the replacement is partial or complete. For substitution of polymer option the reduction would be LE 69,400. This will in turn reduce the demand for hard currency.

Local market stimulation. Reliance on indigenous material activates local markets and improves socioeconomic conditions by introducing a multiplier effect. In other words, local suppliers supply the substitute raw materials, thereby contributing to the GDP and creating employment opportunities in feeding industries.

Economic industrial production. The economic benefits realized by implementing the proposed project will contribute to local market stability and will encourage other industries to adopt cleaner economic technology procedures.

Keeping the factory in operation. International restrictions on the trade in asbestos are increasing. Soon, Egypt will be unable to import asbestos from its main supplier (Canada), thereby affecting all industries that still use asbestos. By eliminating asbestos, this project will allow the factory to continue operations.

A3b. Environmental Impact

The project has two major environmental impacts. First, replacing asbestos as a raw material in the production of tiles at the company reduces the emissions within the working area, improving the working environment and surroundings. The second impact is the reduction of asbestos waste. Asbestos waste is hazardous and requires special attention and precautions for final disposal. Proper asbestos disposal procedures are not available in Egypt. Because of the practice of co-disposal of all types of solid wastes, the generated wastes inflict health hazards on the population.

A3c. Public Health Evaluation

Cleaner production and reduced environmental pollution. This project offers a demonstration of cleaner production alternatives that could serve as replicable examples for other industries. Indeed, the replacement of asbestos by talc and kaolin or phosphogypsum will reduce environmental pollution and occupational health impacts caused by the former, and will provide an economic use as raw material for the latter, which would have otherwise been treated as waste material.

A3d. Occupational Health

Handling asbestos creates significant health hazards among the 405 workers in this plant. These range from simple chest infections from short-term exposure to respiratory failure and malignancies as result of long-term exposure. Although no hard data exists, it is only logical to assume that the elimination of asbestos will lead to the elimination of asbestos exposure among the factory workers.

Potential hazards likely to occur when handling talc ¾, which is the proposed substitute material, include allergic reactions and respiratory difficulty such as asthma attacks that may be complicated by respiratory failure. The frequency of occurrence of these attacks may ultimately affect the productivity of workers and increase the rate of absenteeism. These effects can be mitigated through proper ventilation, dumping of dust, wearing of masks, administering medical screening of workers, and enforcing occupational health regulations. There is no evidence to suggest that these likely hazards have been taken into consideration.

A3e. Regulatory Compliance

Regulations for air emissions within and outside an industrial facility is stipulated by Law 137/1981 (enforced by the Ministry of Manpower and Labor) and Ministerial Decree 470/1972 concerning ambient air emissions (enforced by the Ministry of Health). Standards set within these laws allow for ambient (8-24 hours) conditions measurement with no specific chemical exposure

limits being defined. The subproject will contribute to the amelioration of the working and surrounding environment of this industrial facility thus avoiding asbestos exposure and related violations. Law 4/1994 sets standards for worker exposure to various air pollutants. This subproject could also lead to the reduction of pollution potential and enhanced compliance with this law.

The municipality is responsible for the collection and handling of solid waste generated in residential, commercial, and industrial areas (Law 38/1978). However, there are no standards set for the hazardous and non-hazardous components of the wastes to be collected, nor is there a requirement for waste segregation. Decreasing the amount of asbestos refuse generated within the activities in the country further reduces the hazardous components associated within the ordinary municipal waste and limits the adverse effects of the co-disposal practices in Egypt.

Science and Technology Cooperation Project

Subproject No. 010 - Locally Made Substitutes for Imported Asbestos and PVC/PVAC Copolymers in Vinyl Tiles Formulations

Comparison Between the Proposed Recipe and the Base Case.

Method 1 : Partial Replacement of Asbestos and Dolomite

(LE 000' s)

Description	Pre-commissioning	Projected 1	2	3	4	5	6	7	8	9	10	11
O&M EXPENSES METHOD 1												
Raw material		4,820	5,061	5,314	5,580	5,859	6,152	6,459	6,782	7,121	7,477	7,851
Cost of steam used in production		25	26	27	28	30	31	33	34	36	38	40
Custom duties of imported ingredients												
1. Asbestos		57010	59,861	62,854	65,997	69,296	72,761	76,399	80,219	84,230	88,442	92,864
2. Polymer		481,628	505,709	530,995	557,545	585,422	614,693	645,428	677,699	711,584	747,163	784,521
Total expenses		543,483	570,657	599,190	629,149	660,607	693,637	728,319	764,735	802,972	843,120	885,276
O&M EXPENSES BASE CASE												
Raw material		5,160	5,418	5,689	5,973	6,272	6,586	6,916	7,261	7,624	8,005	8,405
Cost of steam used in production		27	28	29	31	32	34	36	37	39	41	43
Custom duties of imported ingredients												
1. Asbestos		57041	59,893	62,888	66,033	69,334	72,801	76,441	80,263	84,276	88,490	92,914
2. Polymer		481,628	505,709	530,995	557,545	585,422	614,693	645,428	677,699	711,584	747,163	784,521
Total expenses		543,856	571,049	599,601	629,581	661,060	694,113	728,819	765,260	803,523	843,699	885,884
COST SAVINGS												
Savings in raw material		340	357	375	394	413	434	456	478	502	527	554
Savings in cost of steam		2	2	2	2	2	2	2	2	2	2	2
Savings in custom duties		31	33	34	36	38	40	42	44	46	48	50
		373	392	411	432	453	476	499	524	550	578	606
ANNUAL SAVINGS		373	392	411	432	453	476	499	524	550	578	606
PV (Discount rate 12%)	2,532											

Assumptions :

This analysis tests the feasibility of introducing new recipes of raw material in manufacturing tiles.

The capital expenditures and sales revenues have been excluded from the calculations since they are the same in all cases

This analysis compares cost savings resulting from using the proposed recipe as opposed to the annual costs incurred by using the current recipe.

Life time of the project is 10 years

Annual cost increase of 5%

Cost of Capital is 12%

Revenues = cost savings generated by using each recipe

All figures are based on data obtained from the techno-economic assessment of the sub-project..

CANAL1-2.XLS

Projected Cash Flow and Financial Returns (in LE 000's) (LE 000' s)

Method 1 : Partial Replacement of Asbestos and Dolomite

Description	Pre-commissioning	Projected 1	2	3	4	5	6	7	8	9	10
CAPITAL EXPENDITURES											
USAID/ STC grant in LE	54										
USAID/ STC grant in $	374										
End-User contribution	99										
GOE contribution	116										
Total Cap. Exp.	643										
COST SAVINGS											
Savings in raw material		340	357	375	394	413	434	456	478	502	527
Savings in cost of steam		2	2	2	2	3	3	3	3	3	3
Savings in custom duties		31	33	34	36	38	40	42	44	46	48
Total savings		373	392	411	432	454	476	500	525	551	579
ANNUAL CASH FLOW	-643	373	392	411	432	454	476	500	525	551	579
NPV (Discount rate 12%)	1,892										

Assumptions :

The capital expenditures are represented by the actual project expenditures as funded by either the STC or directly incurred in cash or in kind by the end user and GOE .

Life time of the project is 10 years

Operating expenses are excluded since they are implicitly calculated in the cost savings

Annual cost savings are inflated by 5% annually

Cost of Capital is 12%

Cost saving includes all the savings resulting from using the above recipe instead of the traditionally used recipe.

All figures are based on data obtained from the techno-economic assessment of the project.

CANAL1-2.XLS

Science and Technology Cooperation Project
Subproject No. 010 - Locally Made Substitutes for Imported Asbestos and PVC/PVAC Copolymers in Vinyl Tiles Formulations

Projected Cash Flow and Financial Returns (in LE 000's)

(LE 000' s)

Method 2 : Total Replacement of Asbestos and Partial Replacement of Paste and Dolomite by Talc and Kaolin

Description	Pre-commissioning	Projected 1	2	3	4	5	6	7	8	9	10
CAPITAL EXPENDITURES											
USAID/ STC grant in LE	54										
USAID/ STC grant in $	374										
End-User contribution	99										
GOE contribution	116										
Total Cap. Exp.	643										
COST SAVINGS											
Savings in raw material		890	935	981	1,030	1,082	1,136	1,193	1,252	1,315	1,381
Savings in cost of steam		2	2	2	2	3	3	3	3	3	3
Savings in custom duties		126	132	139	146	153	161	169	177	186	195
Total savings		1,018	1,069	1,122	1,179	1,238	1,299	1,364	1,433	1,504	1,579
ANNUAL SAVINGS	-643	1,018	1,069	1,122	1,179	1,238	1,299	1,364	1,433	1,504	1,579
NPV (Discount rate 12%)	6,274										

Assumptions :

The capital expenditures are represented by the actual project expenditures as funded by either the STC or directly incurred in cash or in kind by the end user and GOE .

Life time of the project is 10 years

Operating expenses are excluded since they are implicitly calculated in the cost savings

Annual cost savings are inflated by 5% annually

Cost of Capital is12%

Cost saving includes all the savings resulting from using the above recipe instead of the conventionally used recipe.

All figures are based on data obtained from the techno-economic assessment of the project.

Comparison Between the Proposed Recipe and the Base Case.
Method 2 : Total Replacement of Asbestos and Partial Replacement of Paste and Dolomite by Talc and Kaolin

Description	Pre-commissioning	Projected 1	2	3	4	5	6	7	8	9	10
O&M EXPENSES METHOD 2											
Raw material		4,270	4,484	4,708	4,943	5,190	5,450	5,722	6,008	6,309	6,624
Cost of steam used in production		25	26	27	28	30	31	33	34	36	38
Custom duties of imported ingredients											
1. Asbestos		56984	59,834	62,825	65,967	69,265	72,728	76,365	80,183	84,192	88,402
2. Polymer		481,559	505,637	530,919	557,465	585,338	614,605	645,335	677,602	711,482	747,056
Total expenses		542,838	569,980	598,479	628,403	659,823	692,814	727,455	763,827	802,019	842,120
O&M EXPENSES BASE CASE											
Raw material		5,160	5,418	5,689	5,973	6,272	6,586	6,915	7,261	7,624	8,005
Cost of steam used in production		27	28	29	31	32	34	36	37	39	41
Custom duties of imported ingredients											
1. Asbestos		57041	59,893	62,888	66,033	69,334	72,801	76,441	80,263	84,276	88,490
2. Polymer		481,628	505,709	530,995	557,545	585,422	614,693	645,428	677,699	711,584	747,163
Total expenses		543,856	571,049	599,601	629,581	661,060	694,113	728,819	765,260	803,523	843,699
COST SAVINGS											
Savings in raw material		890	935	981	1,030	1,082	1,136	1,193	1,252	1,315	1,381
Savings in cost of steam		2	2	3	3	3	3	4	4	5	5
Savings in custom duties		126	132	139	146	153	161	169	177	186	195
		1,018	1,069	1,123	1,179	1,238	1,300	1,365	1,434	1,506	1,581
ANNUAL SAVINGS		1,018	1,069	1,123	1,179	1,238	1,300	1,365	1,434	1,506	1,581
PV (Discount rate 12%)	6,919										

Assumptions :
This analysis tests the feasibility of introducing new recipes of raw material in manufacturing tiles.
The capital expenditures and sales revenues have been excluded from the calculations since they are the same in all cases
This analysis compares cost savings resuling from using the proposed recipe as opposed to the annual costs incurred by using the current recipe.
Life time of the project is 10 years
Annual cost increase of 5%
Cost of Capital is 12%
Revenues = cost savings generated by using each recipe
All figures are based on data obtained from the techno-economic assessment of the sub-project.

Science and Technology Cooperation Project

Subproject No. 010 - Locally Made Substitutes for Imported Asbestos and PVC/PVAC Copolymers in Vinyl Tiles Formulations

Projected Cash Flow and Financial Returns (in LE 000's)

(LE 000' s)

Method 3 : Total Replacement of Asbestos and Dolomite by Talc, Kaolin and Phosphogypsum

Description	Pre-commissioning	Projected 1	2	3	4	5	6	7	8	9	10
CAPITAL EXPENDITURES											
USAID/ STC grant in LE	54										
USAID/ STC grant in $	374										
End-User contribution	99										
GOE contribution	116										
Total Cap. Exp.	643										
COST SAVINGS											
Savings in raw material		560	588	617	648	681	715	750	788	827	869
Savings in cost of steam		2	2	2	2	3	3	3	3	3	3
Savings in custom duties		57	60	63	66	69	73	76	80	84	88
Total savings		619	650	683	717	753	790	830	871	915	960
ANNUAL SAVINGS	-643	619	650	683	717	753	790	830	871	915	960
NPV (Discount rate 12%)	3,563										

Assumptions :

The capital expenditures are represented by the actual project expenditures as funded by either the STC or directly incurred in cash or in kind by the end user and GOE.

Life time of the project is 10 years

Operating expenses are excluded since they are implicitly calculated in the cost savings

Annual cost savings are inflated by 5% annually

Cost of Capital is 12%

Cost saving includes all the savings resulting from using the above recipe instead of the conventionally used recipe.

All figures are based on data obtained from the techno-economic assessment of the project.

CANAL3-2.XLS

Subproject No. 010 - Locally Made Substitutes for Imported Asbestos and PVC/PVAC Copolymers in Vinyl Tiles Formulations

Comparison Between the Proposed Recipe and the Base Case.
Method 3 : Total Replacement of Asbestos and Dolomite by Talc, Kaolin and Phosphogypsum

Description	Pre-commissioning	Projected 1	2	3	4	5	6	7	8	9	10
O&M EXPENSES METHOD 3											
Raw material		4,600	4,830	5,072	5,325	5,591	5,871	6,164	6,473	6,796	7,136
Cost of steam used in production		25	26	27	28	30	31	33	34	36	38
Custom duties of imported ingredients											
1. Asbestos		56984	59,834	62,825	65,967	69,265	72,728	76,365	80,183	84,192	88,402
2. Polymer		481,628	505,709	530,995	557,545	585,422	614,693	645,428	677,699	711,584	747,163
Total expenses		543,237	570,399	598,919	628,865	660,308	693,323	727,989	764,389	802,608	842,739
O&M EXPENSES BASE CASE											
Raw material		5,160	5,418	5,689	5,973	6,272	6,586	6,915	7,261	7,624	8,005
Cost of steam used in production		27	28	29	31	32	34	36	37	39	41
Custom duties of imported ingredients											
1. Asbestos		57041	59,893	62,888	66,033	69,334	72,801	76,441	80,263	84,276	88,490
2. Polymer		481,628	505,709	530,995	557,545	585,422	614,693	645,428	677,699	711,584	747,163
Total expenses		543,856	571,049	599,601	629,581	661,060	694,113	728,819	765,260	803,523	843,699
COST SAVINGS											
Savings in raw material		560	588	617	648	681	715	750	788	827	869
Savings in cost of steam		2	2	2	2	3	3	3	3	3	3
Savings in custom duties		57	60	63	66	69	73	76	80	84	88
		619	650	683	717	753	790	830	871	915	960
ANNUAL SAVINGS		619	650	683	717	753	790	830	871	915	960
PV (Discount rate 12%)	4,206										

Assumptions :
This analysis tests the feasibility of introducing new recipes of raw material in manufacturing tiles.
Therefore, the capital expenditures and sales revenues have been excluded from the calculations since they are the same in all cases
This analysis compares cost savings resulting from using the proposed recipe as opposed to the annual costs incurred by using the current recipe.
Life time of the project is 10 years
Annual cost increase of 5%
Cost of Capital is 12%
Revenues = cost savings generated by using each recipe
All figures are based on data obtained from the techno-economic assessment of the sub-project.

B. Subproject No. 14: Production of Aluminum Fluoride from Fluosilicic Waste of Phosphate Fertilizer Industry

Awardee:	Central Metallurgical Research and Development Institute (CMRDI)	
End-User:	Center for Metallurgical Research and Development Abu Zaabal Fertilizer and Chemical Company (AZFC)	
Principal Investigator:	Professor Dr. Ibrahim Fathy Howeidy (CMRDI) Engineer Gamal Attia (AZFC)	
Period:	02/01/1991 - 02/12/1993	
Budget Breakdown:		**LE**
USAID/STC	$ 123,000 and LE 149,800	**568,000**
In Cash	GOE None End-user None Aluminum Company of Egypt	**None** **None**
In Kind	GOE 97,000 End-user 35,000	**132,000**
Total		**700,100**

B1. Subproject Description

This subproject aims to develop alternative process designs for the manufacture of aluminum fluoride using flousilicic acid wastes and assessing its efficacy on a pilot scale.

Pollution problems arising as a result of the discharge of waste from the phosphoric acid and superphosphates industrial sector have been difficult to address because of the high cost of alternate solutions and their technical implications.

Another problem is that the local aluminum industry relies heavily on the import of aluminum fluoride for its processes, which is considered a burden on the national economy and a potential constraint to industrial development within that particular sector .

Mainly comprised of flousilicic acid, wastes from the phosphoric acid and superphosphates industry could be used as raw material for the local production of aluminum fluoride.

In order to realize their above-mentioned objective, the subproject team initially undertook an extensive literature survey to investigate relevant national and international experience in this regard.

In sequence, the subproject team conducted a series of bench-scale experiments to define optimum conditions—temperature and reaction time—of processes employed for the production of aluminum fluoride. The aluminum fluoride produced was analyzed chemically to determine its quality. Three processes were tested and comparatively assessed. These are:

66

B1a. Aluminum Hydroxide Process

The process involves the reaction between aluminum hydroxide and flousilicic acid. The optimum temperature of the reaction as determined by the results of testing is 70°C and the optimum reaction time is 30 minutes. Under these conditions, a 98 percent conversion rate of aluminum hydroxide to aluminum fluoride and an 83 percent recovery rate for aluminum fluoride would be achieved.

B1b. Ammonia Process

The process is based on the reaction between hydroflousilicic acid and ammonia effluents arising from scrubbing systems at the Abu Zaabal Fertilizer and Chemical Company (AZFC). The process yields silica precipitates that are filtered off, washed, and could be reused in the manufacture of paper. Aluminum sulphate solution is then added to form ammonium cryolite which is then precipitated, filtered, and then thermally decomposed to form anhydrous aluminum fluoride. For each step in the process, the optimum temperature and reaction time were determined.

Four different models of the ammonia process were tested by the subproject team and assessed based on their efficacy.

B1c. Alumino-Ferrous Process (Clay Process)

Using this process, clay and hydroflousilicic acid most effectively react at an optimum temperature of 80°C and within an optimum time frame of 40 minutes. For the purpose of this subproject, clay was provided by the Sinai Manganese Company.

For each of the three main processes an extensive techno-economic evaluation was performed. The subproject team determined equipment needs for these processes to be implemented on a pilot scale and set their required technical specifications. In addition, the direct cost per tonnage of aluminum fluoride was estimated.

In terms of equipment costs, there was no significant variations between the three processes. The direct operating costs were reported to be lower for the clay process as opposed to the other two. Yet the clay process had a drawback related to the high content of phosphorus pentaoxide at greater than 0.2 percent in the produced aluminum fluoride.

In parallel, the subproject team assessed the status of scrubber systems at AZFC. A number of modifications were proposed that would produce flousilicic acid with a low phosphorus pentaoxide content that is less than 0.2 percent, as indicated in the literature.

Having addressed its main drawback, the subproject team designed and implemented the clay process on a pilot scale. The experience proved to be potentially replicable on a larger scale and an economic assessment supplemented by a financial scenario for securing initial and operating costs was prepared for a larger-scale plant with an annual production capacity of 5,000 tons.

The subproject team prepared an overview of the types of solid, liquid, and gaseous wastes (potential pollutants) that would arise from their selected process and a summary of their

health impacts. The characteristics of these wastes have been defined in the subproject's technical reports in addition to means of their control and disposal.

B2. Financial Analysis

The financial analysis of this project was based on data obtained from the final report. The analysis involved two steps: first, the selection of an optimum production method for aluminum fluoride using a comparative cost analysis, and, second, the selection of an economically feasible financial structure to finance the project.

From the above-mentioned data a comparative cost analysis was conducted. It was observed that direct operating costs for the clay process are markedly low compared with the other two processes, although the equipment cost is nearly the same. Therefore, the most attractive process from the technical and economic points of view is the clay process.

The second step of the financial analysis was concerned with identifying the most feasible financial structure for the implementation of a plant producing 5,000 tons AlF3 annually from clay. Two financial scenarios were tested. The first option assumes full coverage of the investment cost by loans, whereas the second assumes coverage of the project construction expenditures of the first year (about 53 percent of investment cost) by share capital.

The projected cash flow statements for the two options over the 15-year life time of the project were used to test annual financial returns against the capital expenditure of the plant and its annual operating expenses. The net present value for the first option (investment cost covered totally by loans) was negative (LE 8.248 million), whereas the value for the second (share capital 53 percent of the investment cost) was positive (2.613).

The calculations and assumptions related to the above analysis can be found in the appendix to this document.

B3. Subproject Achievements

B3a. Economic Benefits

There are two main economic benefits arising from this project. First, this project revealed the most efficient process for the preparation of aluminum fluoride from the technical and economical perspectives. Thus extra costs that would otherwise have been incurred if another process had been adopted were saved.

Second, the latter stage of the analysis calculated the net present value for the two proposed scenarios of the financial structure of the plant. It shows that the second option (of 53 percent share capital) is economically feasible because a positive NPV means that annual financial returns exceed the initial capital investment costs and the annual operating expenses of the project. The proposed plant would generate LE 7.5 million annually, enough to cover annual operating expenses and lead to an average net cash surplus of LE 3.0 million annually.

B3b. Employment Generation Benefits

In addition, the new plant would require a staff of 120 persons. This would generate new job opportunities for labor of different skill levels and accordingly help in decreasing the unemployment problem in the economy.

B3c. Demonstration of Waste Exchange among Industrial Sectors

The likely reduction in pollution problems and the subsequent reduction in environmental costs, in addition to the savings that will be made in costs for purchase of raw material, are the positive implications of the waste-exchange process that has been successfully initiated on a pilot scale in this subproject.

B3d. Reduced Import and Subsequent Foreign Currency Expenditure

Promotion of the local aluminum industry by the utilization of flousilicic acid for the manufacture of aluminum fluoride is likely to reduce the reliance on imported aluminum fluoride that currently amounts to 6,000 tons/year.

Subproject No. 014

Production of Aluminium Fluoride from Fluosilicic Acid Waste of Phosphate Fertilizers Industry

Projected Cash Flow and Financial Returns (in LE 000's;
Option 1 : All investment costs are to be supplied by loans,

(LE 000's)

Description	pre-commissioning	-2	-1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
				Projected														
CAPITAL EXPENDITURES																		
Land	1000	1000	0															
Building and civil	2283	1142	1142															
Steel structure	1523	1066	457															
Machinery and equipment	8374	5024	3350															
Anti-acid paints and insulation	980	0	980															
Tractors and cars	750	0	750															
Studies, designs, engineering, etc.	1500	1500	0															
Contingencies	820	410	410															
Interest during construction	4686	1127	3560															
working capital	476		476															
Total Cap. Exp.	22392	11269	11125															
O&M EXPENSES																		
Raw materials																		
Fluosilicic acid				571.00	643	714	714	714	714	714	714	714	714	714	714	714	714	714
Clay				722.00	812	902	902	902	902	902	902	902	902	902	902	902	902	902
Utilities				506.00	568	631	631	631	631	631	631	631	631	631	631	631	631	631
Spare parts				447.00	447	447	447	447	447	447	447	447	447	447	447	447	447	447
Salaries				959.00	959	959	959	959	959	959	959	959	959	959	959	959	959	959
Total O & M Expenses				3,204	3,429	3,653	3,653	3,653	3,653	3,653	3,653	3,653	3,653	3,653	3,653	3,653	3,653	3,653
LOAN REPAYMENTS				0	1,127	2,240	2,240	2,240	2,240	2,240	2,240	2,240	2,240	2,240	1,113	0	0	0
Total Annual Expenses				3,204	4,556	5,893	5,893	5,893	5,893	5,893	5,893	5,893	5,893	5,893	4,766	3,653	3,653	3,653
ANNUAL GAINS																		
Revenues				6000	6,750	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500
Loans		11,269	11,124	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Equity		0	0															
Total Annual Gains		11,269	11,124	6,000	6,750	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500
Annual Surplus (Deficit)	-22,392	0	-1	2,796	2,194	1,607	1,607	1,607	1,607	1,607	1,607	1,607	1,607	1,607	2,734	3,847	3,847	3,847
NPV (Discount rate 12%) (for 15 years)		-8,247																

Assumptions :

Capital expenditures are the estimated project investment cost based on the assumed financial structure (all investment cost supplied by loans) .

Life time of the project is 15 years

All annual expenses and gains are constant after operating at full capacity

Cost of Capital =12%

All figures are based on data obtained from the final report of the project .

The research team is led by Principal Investigator Prof. Dr. Ibraheim Fathy Hewedy

Projected Cash Flow and Financial Returns (in LE 000's)

Option 2 : Investment costs in the first construction year are to be covered by share capital whereas that in the second year are to be furnished by loans

LE 000' s

Description	pre-commissioning	-2	-1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CAPITAL EXPENDIT.																		
Land	1000	1000	0															
Building and civil	2284	1142	1142															
Steel structure	1523	1066	457															
Machinery and equipment	8374	5024	3350															
Anti-acid paints and insulation	980	0	980															
Tractors and cars	750	0	750															
Studies, designs, engineering, etc.	1500	1500	0															
Contingencies	820	410	410															
Interest during construction	829	0	829															
working capital	366		366															
Total Cap. Exp.	18426	10142	8284															
O&M EXPENSES																		
Raw materials																		
Fluosilicic acid				571.00	643	714	714	714	714	714	714	714	714	714	714	714	714	714
Clay				722.00	812	902	902	902	902	902	902	902	902	902	902	902	902	902
Utilities				505.00	568	631	631	631	631	631	631	631	631	631	631	631	631	631
Spare parts				447.00	447	447	447	447	447	447	447	447	447	447	447	447	447	447
Salaries				959.00	959	959	959	959	959	959	959	959	959	959	959	959	959	959
Total O & M Expenses				3,204	3,429	3,653	3,653	3,653	3,653	3,653	3,653	3,653	3,653	3,653	3,653	3,653	3,653	3,653
LOAN REPAYMENTS				0	0	828	828	828	828	828	828	828	828	828	828		0	0
Total Annual Expenses				3,204	3,429	4,481	4,481	4,481	4,481	4,481	4,481	4,481	4,481	4,481	4,481	3,653	3,653	3,653
ANNUAL GAINS																		
Revenues				6000	6,750	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500
Loans		0	8,283	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Equity		10,142	0															
Total Annual Gains		10,142	8,283	6,000	6,750	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500
Annual Surpluses (Deficits)	-18,426	0	-1	2,796	3,321	3,019	3,019	3,019	3,019	3,019	3,019	3,019	3,019	3,019	3,019	3,847	3,847	3,847
NPV (Discount rate 12%) (for 15 years)		2,688																

Assumptions :

Capital expenditures are the estimated project investment cost based on the assumed financial structure

(53% of investment cost supplied by share capital)

Life time of the project is 15 years

All annual expenses and gains are constant after operating at full capacity

Cost of Capital is 12%

All figures are based on data obtained from the final report of the project .

The research team is led by Principal Investigator Prof. Dr. Ibrahim Fathy Hewedy

Science and Technology Cooperation Project
Subproject No. 014 -
Production of Aluminium Fluoride from Fluosilicic Waste of Phosphate Fertilizer Industry

Comparative Cost Analysis for Major Techniques for Preparation of Aluminium Floruide in a plant of 5000 ton/year capacity

Description	Aluminium Hydroxide Method	Clay Method	Ammonia Method			
			Method I	II	III	IV
Aluminium Fluoride Specifications						
AlF3	95.60%	96.40%	95.10%	97.40%	95.90%	94.30%
SIO2	0.17%	0.28%	0.10%	0.15%	0.17%	0.20%
P2 O5 text says 0.2% max	0.25%	0.20%	0.01%	0.02%	0.07%	0.15%
Fe2 O3			0.01%	0.01%	0.01%	0.01%
Recovery						
Al recovery	64.0%	65.0%	97.0%	95.0%	96.5%	97.0%
F recovery	64.0%	65.0%	95.6%	37.7%	71.0%	95.6%
Heat Required (Kcal) for prod. of one ton AlF3	5,862,759.0	5,983,260.0	2,915,857.0	3,625,107.0	2,052,719.0	2,915,857.0
Estimated Equipment Cost (LE '000)	7,190.00	7,283.00	8,302.00			
Estimated Direct Operating Cost						
Raw materials and utilities	11,164.60	3,376.00	11,544.70	17,953.59	12,901.90	11,544.70
Direct labor and supervision	2,232.90	675.20	2,308.90	3,590.70	2,580.40	2,308.90
Plant maintenance	1,326.90	552.40	1,889.10	2,937.90	2,111.20	1,889.10
Operating supplies	1,014.90	306.90	1,049.50	1,632.10	1,172.90	1,049.50
Total Direct Costs	15,739.30	4,910.50	16,792.20	26,114.29	18,766.40	16,792.20
Direct Cost/ton AlF3 in LE '000	3.15	0.98	3.36	5.22	3.75	3.36

FLUORID2.XLS

C. Subproject No. 21: Pollution Control of Industrial Effluents in Rosetta Branch Water Course

Awardee:	National Research Center	
End-User:	Egyptian Salt and Soda Company, Kafr El Zayat Egyptian Financial and Industrial Company, Kafr El Zayat	
Principal Investigator:	Prof. Dr. Sohair Abo-Elela, Water Pollution Control Department, National Research Center	
Period:	17/02/1991 - 17/12/1995	
Budget Breakdown:		**LE**
USAID/STC	$ 331,200 and LE 448,385	**1,574,463**
In Cash	GOE None End-user 1,000,000	**1,000,000**
In Kind	GOE LE 49,200 End-user LE 25,000	**74,200**
Total		**1,649,663**

C1. Subproject Description

This subproject aims to identify alternatives for the treatment of the effluents discharged from the industrial city of Kafr El Zayat prior to their discharge into the Rosetta Branch of the River Nile.

The city of Kafr El Zayat is considered one of the major industrial areas in the Delta region. Located along the Rosetta Branch of the Nile, the city accommodates a wide range of industries, some of which date back to the late 1800s. Among the first established were large-scale industries such as the oil and soap factories, which further encouraged the establishment of other industries in the area. At present there are five large-scale publicly owned industries that constitute the core activities within the area. They are as follows:

- Oil and soap plants of the Salt and Soda Company
- Alexandria Oil and Soap Company
- El Maliya Fertilizers and Chemicals plant
- Kafr El Zayat (KZ) Pesticides plant
- Vetra Paper Mill

In general, industrial pollution from Kafr El Zayat, particularly effluent discharges, have serious negative effects on the quality of the Nile water, particularly at the point of their discharge and downstream of it. The continuous introduction of high concentrations of organic and inorganic wastes into the river significantly impacts its ecosystem.

To reduce the pollution load into the River Nile from the city of Kafr El Zayat, the Government of Egypt has planned the construction of a primary and secondary wastewater treatment facility for the city and a number of communities within its vicinity. This new facility is expected to start operation in the late 1990s. The treatment capacity of the facility will be

120,000 m3/day of industrial and domestic discharges. The final effluents from the treatment process will be discharged into the Ganag drain, which is one of the major agricultural drains in the region.

To this end, the local administration of Kafr El Zayat has initiated the establishment of a sewage collection system and the necessary infrastructure to effectively direct the city's effluents to the treatment facility. Accordingly, all industrial facilities will require a license for the discharge of their effluents into the sewer, as stated by Law 93/1962 which sets the standards for industrial wastewater discharges into municipal sewers. This precondition necessarily requires that all industrial effluents will be pretreated on-site prior to their final discharge.

Initially, the subproject team investigated the origin and flow of the various wastewater streams discharging into the Rosetta Branch. Three agricultural drains were identified along the route to the district of Kafr El Zayat. The three drains discharge a combination of untreated and/or primary treated domestic and agricultural wastewater. At the City of Kafr El Zayat, an additional mix of agricultural and domestic discharges is introduced into the river. Direct discharges from industrial sources along the course of the river in that region average 50, 000 m3/day.

A detailed investigation and analysis of the latter stream of discharges undertaken by the subproject team indicated that two of the five industrial facilities located in the city of Kafr El Zayat account for 80 percent (40,000 m3/day) of the discharges.

Results of the investigation also revealed that the Alexandria Oil and Soap Company and the Verta Paper Mill discharge their effluents directly to the Ganag drain and a main canal, respectively. KZ Pesticides formerly discharged its wastewater directly to the Nile, but recently had to redirect its wastewater discharges to an old municipal wastewater treatment plant as per the Local Administration's directions. The remaining two facilities: oil and soap plants of the Salt and Soda Company and El Maliya Fertilizers still discharge their wastewater effluents directly into the Nile. The subproject team hence selected these two plants as the prime area for further analysis and investigation. The objective of this phase was to characterize effluent discharges of these plants and to evaluate the operational conditions and processes taking place.

The oil and soap plants extend over an area of 55 feddans and comprise a number of units for the production of edible oil, toilet and laundry soap, pharmaceutical and industrial grade glycerin, silicates and fodder. The plants have a single network that receives all effluents arising from their industrial processes and cooling units. Effluents are then transferred to a pit that is located beside the facility. Pumps are fitted onto this pit to allow for the direct discharge of effluents into the Nile.

A detailed monitoring program was prepared and implemented by the subproject team to determine the quantity and the quality of the effluents arising from the various units and to characterize wastestreams up to the final discharge point. Monitoring results identified the following units as the major contributors to the pollution load arising from the oil and soap plants:

- The saponification unit
- The oil refinery and fats distillation unit
- Fuel tank units
- Glycerin production unit

High levels of organic and inorganic pollutants were detected in the analyzed discharge samples. Alternatives for reducing this pollutant load were identified by the subproject team. These include conventional end of pipe treatment and the application of in-house control measures for waste minimization.

The oil and soap plants generate 29, 000 m3/day of untreated wastewater. The main waste constituents identified during analysis are emulsified and floating oil, fatty acid, triglycerides, unsaponified matter from glycerol processing, and some inorganic salts. After examining the plants, the subproject team concluded that it was difficult to separate process from cooling water.

Taking this into consideration, the subproject team proposed and tested a scheme for end-of-pipe wastewater treatment. The proposed scheme involves the application of dissolved air-floatation procedures that would be complemented by a chemical coagulation sedimentation process. This would reduce the pollutants to the permissible levels for discharge into municipal sewers. In the case of effluents to be discharged into surface waters, the subproject team recommends biological treatment to achieve compliance with national standards in this regard.

In order to promote pollution prevention at the oil and soap plants, the subproject team, based on their findings, identified a number of measures that need to be applied to the manufacturing processes. These include:

- Soap recovery from the hot spent lye in saponification units to avoid excessive foaming.
- Proper recovery of residual soap resulting from steam blowing during shut down periods in processing units using a jacketed storage tank.

Further, the subproject team conducted an economic assessment of their proposed control measures, the results of which indicate total annual savings of LE 237,600 and an 86 percent return on investment.

El Maliya Fertilizer and Chemicals Company, a facility identified by the subproject team as a major source of pollution in the City of Kafr El Zayat, was also subjected to a detailed investigation and analysis within this subproject. The company's main products are sulphuric acid and single superphosphate. By-products of the manufacturing processes within the company include sodium flousilicate and ferrous sulphate. The quantity of wastewater discharges from El Maliya Company is 20, 000 m3/day of which about 7,000 a day are process waters. Analysis of the final effluents indicated a high content of inorganic pollutants, namely silicate, phosphate, and fluoride salts. Detailed analysis was further undertaken following characterization of the final effluent discharges in order to identify alternatives for the reduction of these pollutant loads.

The subproject team proposed a number of control measures based on the introduction of some modifications to the manufacturing process of sodium fluosilicate. One is the use of a closed circuit recycling continuous production technique. Another is the segregation and treatment of wastewater generated from the scrubbing towers using lime in a coagulation/sedimentation process in order to avoid any shock loads in future treatment processes and to prevent pipe corrosion. With respect to pollution control in the ferrous sulphate unit, certain modifications were proposed to increase the efficiency of the process and to effectively utilize the wasted mother liquor. The subproject team also proposed the mixing of end of pipe effluents to be

discharged into surface waters with cooling waters from other departments as a means of dilution, in order to comply with the national standards. These control measures were successfully implemented in cooperation with the company's management.

C2. Financial Analysis

Two separate sets of analyses were carried out, one for each company. All calculations were based on the data obtained from the techno-economic study of the project's report.

C2a. Treatment of Wastewater in Salt and Soda Company

Three alternative methods are possible for the final disposal of the wastewater of treated effluent:

1. End pipe effluent discharged into surface water (agriculture drain).

2. End pipe effluent discharged into the public sewerage system.

3. Separation of cooling water for reuse through cooling towers. The process water will be treated separately for final discharge into surface water or the public sewerage system.

Because annual financial returns are not quantifiable in the data available, the selection of an appropriate alternative depends mainly on the capital investment cost of each method. To this end, a comparative cost analysis was conducted to identify the least-cost method. The availability of the alternative is also an essential factor in determining the recommended method.

Alternative 1 requires a high degree of purification and the treatment system consists of dissolved air flotation followed by biological treatment using an activated sludge process. The estimated cost of this system is LE 5.070 million.

Alternative 2 (wastewater disposal into public sewerage system) can be approached in two ways:

- Dissolved air flotation aided with chemicals. The estimated cost of this system is LE 0.492 million.

- Chemical coagulation followed by sedimentation. In this case, the system's cost is estimated at LE 0.516 million.

Alternative 3 (reuse of cooling water through cooling towers) shows that cooling water represents about 93 percent of the total wastewater effluent from the company. This water is relatively clean and can be either separated for reuse through cooling towers or disposed of directly to surface water. Accordingly, the process water can be treated separately for final disposal into surface water or to the public sewerage system. The total capital investment for cooling towers is LE 5.822 million. It should be noted that this result was attained by theoretical analysis.

The least costly method for wastewater final disposal from Salt and Soda company is therefore alternative 2 (disposal of wastewater into the public sewerage system). The two

approaches used in this method (air flotation and sedimentation) have almost the same construction cost. However, air flotation combined with alum is recommended because of its flexibility in meeting required standards.

C2b. Treatment of Wastewater in El Maliya Company

An effective way of eliminating the chemical pollutants in the wastewater in El Maliya Company is the chemical treatment of washing water from the scrubbing towers using lime, for pH adjustment and as a coagulant. The main problem associated with this method is the large amount of lime required. In order to reduce the amount of lime, two alternatives were examined:

1. Treating the final pipe effluent from the department

2. Recycling part of the chemically treated wastes from the scrubbing towers to be mixed with the same raw wastes in the treatment unit.

The efficiency of each method was found to be almost the same when compared to the original method of treatment. Accordingly, an appropriate method was selected by conducting a cost analysis, including the cost of construction and chemicals required for operation during a period of 20 years. The treatment plant required in each case was designed based on criteria obtained from the laboratory experiments.

From the financial and economical points of view, the chemical treatment of washing water from scrubbing towers including recycling a percentage of treated effluent waste (1:2) is recommended (alternative 2) since its capital investment and operation costs are less than those of other alternatives. The total cost of the recommended system amounts to LE 0.846 million.

The calculations and assumptions related to the above analysis can be found in the appendix to this document.

C3. Subproject Achievements

C3a. Reduced Pollution Load on the Rosetta Branch of the Nile River

The control measures proposed and implemented at two major industrial facilities directly discharging their polluted effluents into the Nile will contribute significantly to the quality improvement of this surface water resource. The potential for replicability of the experience among similar industries employing the same practice for disposal of their wastewater is significant because of the practicality of the design and its economic effectiveness.

C3b. Resource Conservation and Waste Minimization

This subproject has introduced a number of opportunities for resource conservation that ultimately result in the reduction of waste quantities. One of the these is the recovery of fluoride, calcium, phosphate, and silicate from the treatment sludge and its supplementation to raw material required for process operations. Another is the proposed recovery of soap using a jacketed storage tank.

C3c. Effective Monitoring of Pollution Loads

The monitoring program prepared and implemented in the initial phases of this subproject will be the basis for establishing a sound monitoring system within the companies that would enable them to detect changes in their pollutant levels, identify their sources, and plan accordingly for their management.

C3d. Economically Viable Pollution Reduction Measures

Implementing some of the proposed measures within this subproject can be anticipated to yield an 86 percent return on investment and annual savings amounting to LE 237, 600 at the Soap and Oil Company.

C3e. Economic Benefits

In discussing the achievements of this project, each company will be dealt with separately.

Treatment of Wastewater in Salt and Soda Company

In the case of the Salt and Soda Company where three alternative methods were considered, selection of an appropriate method was governed by capital investment cost. Based on the calculated costs of the three methods, the dissolved air flotation aided with chemicals as a primary treatment prior to discharge to the public sewerage network is recommended. This recommendation is also based on the fact that in Kafr El Zayat there is a public sewerage system under construction. The capacity of the system is sufficient to accommodate the quantity of waste generated by the company.

Treatment of Wastewater in El Maliya Company

The selection of alternative 2 (recycling part of the chemically treated wastes from scrubbing towers) has proved to be economically beneficial for the following reasons:

1. The cost of construction and operation is less than the cost of other alternatives.[1]

2. The amount of chemicals is less, therefore reducing the problem of handling and transportation of chemicals.

3. The sludge produced is much less; thus problems arising from its drying and handling are reduced.

[1] The construction and operation costs of other alternatives were not available in the report.

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Estimated Cost of Wastewater Treatment in El Maliya Company LE ' 000	
Description	Segregation and treatment of wastewater from scrubbing towers
Equipment required for lime addition	80
- Lime emulsion tanks	
- Lime feeding pumps	
- Mixing tanks	
Clariflocculator	100
Treated wastewater recycling pump station	150
Raw wastewater pump station	
Inter-connecting pipes, valves, etc.	50
Sludge drying beds	300
Unseen works	166
Total cost	846

Science and Technology Cooperation Project

Subproject No. 021 -

Pollution Control of Industrial Effluents in Rosetta Branch Water Course

Comparative Cost Analysis for Wastewater final Disposal of Salt & Soda Company

Description	Alternative One: ~~Disposal of The End Pipe~~ Effluent Discharge into Surface Water	Alternative Two: ~~Disposal of The End Pipe~~ Effluent Into Public Sewerage System — Option A: Air Flotation Tanks	Alternative Two: ~~Disposal of The End Pipe~~ Effluent Into Public Sewerage System — Option B: Sedimentation Tanks
A. Primary Treatment			
Equipment required for lime addition	40	40	40
Air flotation tanks, compressors and compressors buildings	220	220	0
Sedimentation tanks equiped with skimmers	0	0	240
	260	260	260
B. Secondry Treatment			
Equipment required for addition of nutrients	20	0	0
Aeration tanks	0	0	0
Final sedimentation tanks	2,800	0	0
Sludge pump station	1,100	0	0
	3,920	0	0
C. Sludge Drying and Treated Waste Disposal			
Sludge drying beds	70	30	30
Effluent pump station	120	120	120
	190	150	150
D. Unseen Works (20%)	700	82	86
Contigency	700	82	86
Total	5,070	492	516

Description	Alternative Three: Separation of Cooling Water for Reuse Through Cooling Towers — L.E.'000 in 1979 *	L.E.'000 in 1993 **	LE '000 in 1993
Purchase Cost for Cooling Towers			
Purchase Cost of tower A	70.0	114.8	390.3
Purchase cost for motor with 30 hp	1.5	2.5	8.4
Purchase cost of fan	0.9	1.5	5.0
Purchase cost of 3 pumps	66.0	108.2	368.0
Purchase cost of cooling tower B	75.0	123.0	418.1
Purchase cost for motor with 35 hp	1.7	2.8	9.5
Purchase cost of fan	1.0	1.6	5.6
Purchase cost of 3 pumps	75.0	123.0	418.1
Purchase cost of cooling tower C	80.0	131.2	446.0
Purchase cost for motor with 40 hp	2.0	3.3	11.2
Purchase cost of fan	1.2	2.0	6.7
Purchase cost of 3 pumps	90.0	147.6	501.8
Total	464.3	761.3	2588.5
Other Investment Costs			
Cost of piping	324.8	532.6	1810.8
Cost of erection	185.6	304.3	1034.7
Cost of foundation	23.2	38.0	129.3
Instrumentation	46.4	76.1	258.7
Total	580.0	951.0	3233.5
Total Capital Investment	1,044.3	1712.4	5822.0

* All costs were calculated on cost index at 1979

** Cost at 1993 = Cost at 1979 x (cost index at 1993/cost index at 1979)

D. Subproject No. 30: Production of Magnesium Oxide from the Bittern Solution of Al Max Saline

Awardee:	Chemical Engineering and Pilot Plant National Research Center	
End-User:	El Nasr Saline Company	
Principal Investigator:	Professor Dr. Hammam El Abd	
Period:	15/10/1991 - 14/4/1994	
Budget Breakdown:		**LE**
USAID/STC	$ 110,000 and LE 561,950	**935,950**
In Cash	GOE None End-user None	**None**
In Kind	GOE 50,000 End-user 145,000	**195,000**
Total		**1,130,950**

D1. Subproject Description

This subproject aims to develop an economically viable technology alternative that is capable of producing magnesium oxide from saline water at El Max salt beds in Alexandria using natural power sources.

Sea water bittern is presently considered a major resource for the recovery of magnesium and its compounds. The subproject identified a number of alternative process technologies that could be used for the recovery of magnesium oxide percales from the bittern of Max salines, i.e., from sea water bittern.

In their comparative assessment of these alternative technologies, the team determined the potential uses and marketability of the by-products of each that in turn influence the final choice of the process to be employed.

Process technologies employed for this purpose—as indicated in the subproject's technical reports—strongly influence the properties of the magnesium oxide produced and the overall efficiency of the recovery process.

In this regard, three alternative processes were identified and are presented below.

D1a. Thermal Composition Process

In this process, magnesium oxide is produced by the thermal decomposition of magnesium chloride, sulphate, magnesium and the basic carbonate at a temperature range of 1,300-1,700°C. Periclase is produced with simultaneous recovery of the acid components.

There are 20 commercial plants that exist worldwide that employ the thermal decomposition process to produce periclase. This process yields high quality periclase that is 99.55 percent magnesium oxide.

To ensure maximum thermal decomposition, the subproject team recommend that water evaporation from the process should be kept at a minimum and the magnesium content should not be less than 26 percent weight of magnesium chloride. In addition to the main product periclase, the by-products of the thermal decomposition process are: calcium chloride, gypsum, hydrochloric acid, sodium chloride, and potassium sulphate.

In assessing this technology, the subproject team recommend the undertaking of an extensive market survey to determine the demand for calcium chloride. The annual production of hydrochloric acid using this process is 200,000 tons/year. Its conversion to chlorine by electrolysis could be feasible based on the results of the market study. Otherwise its disposal could lead to adverse environmental effects with serious economic implications.

D1b. Chemical Precipitation Process

This has been the conventional process utilized for the commercial production of magnesium oxide from sea water bittern since 1869. Regardless of the source, the solution and/or the concentration of magnesium chloride, the basic process remains the same. It is based on the conversion of soluble magnesium salts and insoluble caustic magnesium by using caustic lime. Caustic lime may come from oyster shells, lime stone, or dolomite. The process can be successfully applied to sea water, brine, and bittern solutions as long as they are treated to remove their sulphate, carbonate and bicarbonate content. This is to avoid the precipitation of insoluble calcium compounds with caustic magnesia. By-products as a result of this process are boric acid, calcium chloride, bromine and gypsum.

D1c. Combined Process

This process simulates the thermal decomposition process in a number of its steps. The by-products of this process are: periclase, potassium sulphate, gypsum, calcium chloride, boric acid and vacuum salt.

The subproject team conducted a series of bench-scale experiments using chemical, thermal and x-ray analysis to effectively pretreat bittern for the production of magnesium oxide, to characterize the properties of the produced magnesium oxide, and finally to determine the factors influencing the process of its separation. In addition, a number of preliminary studies to test the marketability of the by-products of the various processes were conducted. The combined process was selected as the most feasible alternative based on environmental and economic considerations.

The subproject team successfully prepared magnesium oxide on a pilot scale and has identified optimum operating conditions for each step in the process. The temperature used for the whole process is room temperature except for drying which takes place at 1,050C and calcination at 1,050oC. A full characterization of the magnesium oxide output produced and the process efficiency was done.

D2. Financial Analysis

During the course of solar production, brine is concentrated in the crystallizers by solar evaporation. NaCl crystallizes leaving magnesium, potassium, sulphate, and other ions of minor concentration in the residual effluent (bittern). Presently, the bittern is pumped back to the concentration ponds without any use, although it could be stored in holding ponds as a raw material suitable for further processing. One possible use for the bittern is the production of high-grade magnesium oxide (MgO) by thermal decomposition of MgO(OH)2 precipitated from the bittern using a cheap alkali precipitant such as slaked lime Ca(OH)2.

This section tests the feasibility of the recovery of 75,000 ton/year magnesia, dead burnt grade or what is known as synthetic periclase from El-Max saline bittern.

According to the data obtained, the capital investment costs have been estimated based on the following assumptions:

1. Prices for process equipment are based on quotes by TECHMASHIMPORT dated 1993 for a plant with a capacity of 75,000 ton/year.

2. Custom duties were calculated at 10 percent.

3. Interest rates are 14 percent for local loans and 4.5 percent for foreign loans.

4. The selling price is estimated at the lowest price as a factor of safety.

The total capital expenditures amount to LE 236.492 million. Annual operating expenses consist of running expenses such as raw material, utilities, labor, and so forth. Total operating expenses reach LE 67.055 million per year.

Annual financial revenues (sales revenues), however, may reach LE 163.875 million annually full capacity. The projected annual operating costs and financial returns have been assumed constant over the lifetime of the project and exclude all variable factors.

The results of the above calculations yielded a positive net present value of LE 80.564 million when using loans as a source of finance. It. however. reached LE 121.643 million after eliminating the burden of loan financing. In both cases the positive NPV indicates that annual financial gains cover and exceed both capital expenditures and annual operating expenses over the lifetime of the project.

The calculations and assumptions related to the above analysis can be found in the appendix to this document.

D3. Subproject Achievements

D3a. Economic Benefits

The economic benefits stem mainly from the financial profitability of the proposed project. It generates average annual financial returns of about LE 60.00 million.

In addition, the data gathered during the course of the project revealed that the estimated demand of synthetic magnesia exceeds the local production. Thus the local production of this product is of prime importance, because it would save the economy large amounts of hard currency spent on importing refractory grade magnesia.

It is also anticipated that there exists a great possibility of exporting locally produced magnesia to the Arab countries in the near future. These countries have an increasing demand for basic refractories to cope with the expanding developments in their metallurgical, cement, and other industries.

D3b. Development of an Efficient Process

The process, as developed by the subproject team, has an efficiency of 70.8 percent. The specifications of the produced magnesium oxide are in accordance with the imported brand presently being used. Furthermore, its properties have been tested and found appropriate for its use as a conditioner for fertilizers.

D3c. Identifying Local Substitutes for Imported Material

The team's preliminary investigations on the market potential of the combined process by-products indicate that there is a high demand for boric acid and bromine that are currently imported. The former is considered a valuable material that is used in the pesticide industry and the latter is widely used in the glass industry.

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Science and Technology Cooperation Project

Subproject No. 030 -

Production of Magnesium Oxide from the Bittern Solution of Al Max Salines

Projected Cash Flow and Financial Returns (in LE 000's)

LE 000's

Description	Pre-marketing	Projected -3	-2	-1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CAPITAL EXPENDITURES																			
Purchased equipment	95,685.0																		
Installation	20,196.5																		
Instrumentation and control	7,094.8																		
Piping	18,554.5																		
Electrical	10,169.2																		
Building	30,271.1																		
Site preparation	2,128.4																		
Service facilities	6,671.8																		
Land	2,364.9																		
Engineering and supervision	14,189.6																		
Construction expense	14,189.6																		
Contractors fees	2,364.9																		
Contingencies	14,709.9																		
Total Cap. Exp.	236,640	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ANNUAL EXPENSES																			
Total costs		80,492.00	106,092	11,000	16,825	4,228	2,044	0	0	0	0	0	0	0	0	0	0	0	0
Operating costs		0.00	0	0	48,845	61,170	67,065	67,065	67,065	67,065	67,065	67,065	67,065	67,065	67,065	67,065	67,065	67,065	67,065
Cost of finance		3288.34	10,567	15,062.40	15,547	15,264	14,232	13,100	11,856	10,488	8,882	7,323	5,494	3,868	2,042	0	0	0	0
Repayment		0.00	0	0	6,919	13,340	14,372	15,504	16,748	18,110	19,622	21,281	13,567	15,196	17,019	0	0	0	0
Corporate taxes		0.00	0	0	0	0	20,061	20,413	20,811	23,915	24,397	24,928	25,513	26,034	26,618	27,271	27,271	27,271	27,619
Dividends		0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total cash out flow		93,780	116,659	26,062	88,137	94,003	117,753	116,072	116,470	119,574	120,058	120,587	111,629	112,150	112,734	94,336	94,336	94,336	94,574
ANNUAL GAINS																			
Financial resources		93781	116659.5	26062.00	3907.9	1008.3	484.2	0	0	0	0	0	0	0	0	0	0	0	0
Sales Revenue		0	0	0	98,325	147,487	163,875	163,875	163,875	163,875	163,875	163,875	163,875	163,875	163,875	163,875	163,875	163,875	163,875
Total cash inflow	0	93,781	116,660	26,062	102,232	148,496	164,359	163,875	163,875	163,875	163,875	163,875	163,875	163,875	163,875	163,875	163,875	163,875	163,875
Annual Surplus (Deficit)	-236,640	0	0	-0	14,095	54,493	46,606	47,803	47,404	44,300	43,818	43,288	52,246	51,724	51,141	69,539	69,539	69,539	69,301
NPV (Discount rate 12%) (for 15 years)	90,564																		
Annual Surplus (Deficit) without loan financing	-236,640	3,288	10,567	15,062	36,582	85,087	78,210	76,407	76,009	72,906	72,422	71,883	71,304	70,785	70,201	69,539	69,539	69,539	69,301
NPV (Discount rate 12%) (for 15 years)	121,843																		

Assumptions :

Capital expenditures are the estimated capital investment cost based on an offer from TEKHMASHPRI, Moscow; Federal Republic of Russia to NSCO in 1993.

Life time of the project is 15 years

Production costs and sales revenue are constant

Cost of Capital is 12%

All figures are based on data obtained from the report of the sub project . The research team led by Principal Investigator Prof. Hassan I. Darrah

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E. Subproject No. 38: Process Development for Recovery and Use of Cellulosic Fibers from White Liquor and Water Reuse in RAKTA Company

Awardee:	Faculty of Engineering, Alexandria University	
End-User:	General Company for Paper Industry (RAKTA)	
Principal Investigator:	Professor Dr. Mohamed Sadek Al Adawi	
Period:	20/04/1993 -20/01/1995	
Budget Breakdown:		**LE**
USAID/STC	$70,357 and LE 427,532	**666,746**
In Cash	GOE None End-user None Rakta Co.	**None**
In Kind	GOE 156,850 End-user 2,000	**158,850**
Total		**825,596**

E1. Subproject Description

The project (C/A 038) was granted by STC to researchers from the Chemical and Sanitary Engineering Department, Faculty of Engineering, Alexandria University to conduct research at the end-user facility, the General Company for Paper Industry (RAKTA), Abu Qir, Alexandria, during the period from April 20, 1993 to October 19, 1994. The grant provides for research, design, and assessment of the technical and economic viability of the proposed system for wastewater treatment and treated water re-use options.

RAKTA was established in 1960 in Abu Qir Bay in Alexandria and is probably the world's largest rice straw pulp mill with an annual production of up to 45,000 tons of bleached rice straw pulp. Abu Qir Bay, originally hosting small communities of fishermen and their families, is a shallow 16 m-deep inland rock-based bay. The bay also represents the geographic collection discharge point of a number of agricultural drains in the area and at its easternmost end, the Rasheed Nile Branch.

The yearly consumption of paper in Egypt in 1991 was reported to be 654,000 tons of which 64 percent was imported amounting to 419,000 tons/year. Only 34 percent of this amount (254,000 tons/year) of the paper and board is manufactured locally.

Pulp and paper mills in Egypt belong to the Chemical Industries Holding Company. RAKTA, the end-user of this subproject, ranks first among the major public sector pulp and paper mills with respect to its production capacity. The factory is located around the inland bay of Abu Qir, east of the Alexandria Metropolitan Area.

The pulping operation employed by RAKTA for fiber rendering consumes a considerable amount of water, estimated to be about 5 million m3/year. More than 4 million m3/year of wastewater is discharged at a rate of 20,000 m3/day to Abu Qir Bay through Amia drain. This

industrial wastewater of RAKTA (known as white liquor) contains a high content of suspended solids comprised mainly of cellulosic fibers and fiber debris that escape from the paper machines.

The subproject researched three technical applicable methods (sedimentation, flotation, and filtration) for suspended matter removal from the wastewater. Technical results indicated the effectiveness of all three methods with respect to quantity of recovered fibers and quality of clarified waters. Economic assessment favored the sedimentation process as offering more economic benefits with respect to capital investment and its lower operation costs.

The amount of fibers recovered by this method averaged 22.9 tons/day that were of suitable quality for low-grade paper production, as in cardboard fillings. The economic return on this type of recovered fiber was estimated to be 200 LE/ton. Options investigated for clarified water re-use revealed its adequacy for recycling as cooling water in the paper mill as well as dilution water in the cardboard-making process. The amount of clarified wastewater recovered for reuse by these resource savings at this stage of the project was estimated to be 18,470 m3/day.

E2. Financial Analysis

This section analyzes the project profitability from the owners point of view, in this case RAKTA. In order to evaluate the commercial profitability of the project, its capital expenditures and annual operating expenses were tested against the expected annual revenues over the project's lifetime—10 years—to determine the net present value of the project.

The subproject puts forward three alternative methods for fiber recovery and water reuse (sedimentation, flotation, and poly disk filter). The net present value for each method has been calculated separately.

The capital expenditures in the analysis consist of the actual investment costs of the project: building, machines, equipment, engineering, and erection costs. Annual operating expenses include all the elements required for running the project's fixed capital. These elements include: raw materials, direct and indirect labor, energy, maintenance, and the like. Operating expenses are increased by 5 percent annually to account for inflation.

The annual revenues (financial returns), however, of this project have been estimated as follows:

1. Quantity of recovered valuable fibers in tons times the average price per ton.

2. Amount of recoverable clarified water in cubic meters times the average price per cubic meter of water after treatment.

The projected financial returns were increased annually by 10 percent in the case of water and 5 percent in the case of fibers because of inflation and privatization programs.

The following table summarizes the net present value attained by each method at different discount rates (DR):

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Description	NPV at 12% Discount Rate	NPV at 20.6% Discount Rate[2]
Method 1: Sedimentation Method 2: Flotation	10.9 million LE	6.9 million LE
Method 3: Poly Disk Filter	8.0 million LE	4.5 million LE

The calculations and assumptions related to the above analysis can be found in the appendix to this document.

E3. Subproject Achievements

E3a. Economic Benefits

The two most important project benefits are the positive net social benefits represented in environmental improvements and described elsewhere in this document, and the economic profitability realized by implementing the project.

Different criteria were used to test the profitability of the three methods and gave positive results in each case indicating that all methods are profitable, although they differ in the degree of profitability. The sedimentation method can be considered the most successful one from the profit-making point of view.

All three methods gave a positive NPV, their internal rate of return is higher than the nominal discount rate, their benefit cost ratio is greater than 1, and their maximum payback period is two years. As a result, the above-mentioned benefits clearly demonstrate the advantages gained from this project in terms of generating annual cash flows which circulate in the market and create local employment.

E3b. Environmental Impact

A direct environmental impact of this project is the reduction of pollutant content and quantity of untreated industrial effluent currently being discharged to Abu Qir Bay from this major pulp and paper producing facility. This was achieved by the implementation of physical pretreatment intended for both fibers recovery and wastewater clarification within the factory premises.

The noted decrease of suspended solids content effectively decreases sediment formation at the bay bed as well as within the drain leading to it. Sediment formation is likely to cause disturbance in the receiving water because of its chemical content thus promoting algae and weed growth and adversely affecting biodiversity. Implementing recovery procedures and water re-use in the area will improve the prevailing receiving water flora and fauna conditions in the bay as well as protect this area of the Mediterranean coast.

[2] Although a 12 percent discount rate is normally assumed in calculations for NPV, the economic assessment part of the current subproject report suggests a much higher discount rate (20.6 percent). Therefore, the analysis was based on both discount rates to prove subproject profitability in either case.

Another benefit of this technology is in greatly increased water efficiency. The project conserves about 4 million m3/year of clarified water for use in industrial pulping processes at RAKTA.

Improved quality of wastewater discharges. The white water discharged from the manufacturing process contains a high percentage of calcium carbonate with resultant hardening of water. It also has a high content lime (caustic soda) which impairs the quality of marine water and adversely affects the marine life in Abu Qir Bay.

Measures for cleaner production such as the recycling of white water and fiber recovery have significantly contributed to the reduction of pollution in Abu Qir Bay and fresh water utilization by the factory (5 million m3 of clarified water).

It is worth noting that repeated and extensive water reuse may result in increased temperature and build up of suspended solids that can lead to a number of operational problems. The dissolved solids accumulate odors, colors, slime, and foam and lead to corrosion and scaling of the process equipment. It is not clear from the documentation provided whether or not these points have been taken into consideration in the design of the project.

E3c. Public Health Impact

There are reduced negative health impacts (mainly silicosis) among workers and inhabitants of surrounding communities. Silica dust inhalation by workers and inhabitants of surrounding areas leads to a variety of respiratory infections and diseases. The incidence and magnitude of these diseases is further aggravated by the climatic conditions (relatively high humidity levels) prevailing in the area, and the poor socioeconomic conditions of area dwellers that affect their resistance to disease. The limited capacity of health care facilities in the area, in terms of staffing and diagnostic and medical services, renders the community highly vulnerable to prolonged suffering from these pollution impacts. These negative health impacts will be reduced to a large extent following the implementation of the proposed interventions.

E3d. Occupational Health Impact

There is no evidence that occupational health hazards and safety measures have been accounted for in the subproject. Likely occupational risks in a pulp and paper manufacturing plant include:

- Contact with chemicals: skin inflammations and infections.
- Prolonged exposure to chemicals: impairment of liver and kidney functions.
- Exposure to dust: respiratory diseases.
- Odors: irritation, suffocation.
- Defective storage: fire hazards, rodents breeding.
- Noise: impairment of hearing.
- Other physical injuries related to defective design of the working place and excess load handling.

All these potential hazards can be effectively mitigated by ensuring proper ventilation of the working place, gloves when handling chemicals, periodic health surveillance for workers, and safe design of the working place.

E3e. Regulatory Compliance

Law 48/1982 is set to protect the Nile and its waterways and to provide regulatory guidelines for municipal wastewater and industrial effluents discharged into inland lakes and bays. The Water Surface Police implements this aspect of the law in cooperation with the Ministry of Public Works and Water Resources. Through the implementation of this project a noticeable reduction of both pollutant and wastewater discharge to the canals and sea waters will be achieved.

Science and Technology Cooperation Project

Subproject No. 038 -

Process Development for Recovery Use of Cellulosic Fibers from White Liquor Water reuse in Rakta Co.

Projected Cash Flow and Financial Returns (in LE 000's)

Method 1 : Sedimentation

(LE 000' s)

Description	Pre-commissioning	Projected 1	2	3	4	5	6	7	8	9	10	11
CAPITAL EXPENDITURES												
1) Reinforced concrete tanks	1,042											
2) Pumps, Fittings (installed)	340											
3) Control Instrument	36											
4) Engineering & Supervision (4% of (1))	40											
5) Erection consultation (4% of 1)	40											
6) Contingency	30											
Other Cap. Exp. (Rehabilit.)							246					396
Total Cap. Exp.	1,528	0	0	0	0	0	246	0	0	0	0	396
O&M EXPENSES												
Labor		29	30	32	34	35	37	39	41	43	45	47
Supervision		29	30	32	34	35	37	39	41	43	45	47
Maintenance		28	29	31	32	34	36	38	39	41	43	46
Electrical Power		59	62	65	68	72	75	79	83	87	92	96
Chemicals		72	76	79	83	88	92	96	101	106	112	117
Filter fabric cost		0	0	0	0	0	0	0	0	0	0	0
Fresh water (washing)		0	0	0	0	0	0	0	0	0	0	0
Rent of land		17	18	19	20	21	22	23	24	25	26	28
Total expenses		234	246	258	271	284	299	314	329	346	363	381
EXPECTED REVENUES												
Recovered fibers		1,374	1,443	1,515	1,591	1,670	1,754	1,841	1,933	2,030	2,132	2,238
Recovered clarified water		488	536	590	649	714	785	864	950	1,045	1,150	1,265
Total Revenues		1,862	1,979	2,105	2,240	2,384	2,539	2,705	2,884	3,075	3,281	3,503
ANNUAL CASH FLOW	-1,528	1,628	1,733	1,847	1,969	2,100	1,994	2,392	2,554	2,730	2,918	2,725
NPV (Discount rate 12%)	10,895											
NPV (Discount rate 20.06%)	6,985											

Assumptions :

The capital expenditures are represented by the actual investment cost of the method used for fiber recovery and water reuse

Life time of the project is 10 years

Annual cost increase of 5%

Cost of Capital is 12%

Rehabilitation valued at 10% of initial investment cost every five years inflated by 10% /year (compounded)

Revenues = Expected price x Quantity of recovered fiber or clarified water

All figures are based on data obtained from the economic feasibility study in "The Fiber Recovery and Water Re-use in RAKTA" report.

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Projected Cash Flow and Financial Returns (Ir. LE 000's)

Method 2 : Flotation

(LE 000' s)

Description	Pre-constructing	Projected 1	2	3	4	5	6	7	8	9	10	11
CAPITAL EXPENDITURES												
1) Flotation cell	2,100											
2) Freight	25											
3) Custom clearance (20%)	420											
4) Equalization tank	60											
5) Pumps, Fittings (installed)	380											
6) Installation of flotation cell	40											
7) Instruments of control	60											
8) Electrical (installed)	50											
9) Basic engineering	60											
10) Construction and consultation	60											
11) Contingency	86											
Other Cap. Exp. (Rehabilit.)							538					867
Total Cap. Exp.	3,341	0	0	0	0	0	538	0	0	0	0	867
O&M EXPENSES												
Labor		29	30	32	34	35	37	39	41	43	45	47
Supervision		29	30	32	34	35	37	39	41	43	45	47
Maintenance		60	63	66	69	73	77	80	84	89	93	98
Electrical Power		55	58	61	64	67	70	74	77	81	85	90
Chemicals		108	113	119	125	131	138	145	152	160	168	176
Filter fabric cost		0	0	0	0	0	0	0	0	0	0	0
Fresh water (washing)		0	0	0	0	0	0	0	0	0	0	0
Rent of land		17	18	19	20	21	22	23	24	25	26	28
Total expenses		298	313	329	345	362	380	399	419	440	462	485
EXPECTED REVENUES												
Recovered fibers		1,374	1,443	1,515	1,591	1,670	1,754	1,841	1,933	2,030	2,132	2,238
Recovered clarified water		488	536	590	649	714	785	864	950	1,045	1,150	1.265
Total Revenues		1,862	1,979	2,105	2,240	2,384	2,539	2,706	2,884	3,075	3,281	3,503
ANNUAL CASH FLOW	-3,341	1,564	1,666	1,776	1,895	2,022	1,621	2,308	2,464	2,635	2,819	2,151
NPV (Discount rate 12%)	8,334											
NPV (Discount rate 20.08%)	4,696											

Assumptions :

The capital expenditures are represented by the actual investment cost of the method used for fiber recovery and water reuse

Life time of the project is 10 years

Annual cost increase of 5%

Cost of Capital is 12%

Rehabilitation valued at 10% of initial investment cost every five years inflated by 10% /year (compounded)

Revenues = Expected price · Quantity of recovered fiber or clarified water

All figures are based on data obtained from the economic feasibility study in "The Fiber Recovery and Water Re-use in RAKTA" report.

Projected Cash Flow and Financial Returns (in LE 000's)
Method 3 : Poly Disk Filter (PDF)

(LE 000' s)

Description	Pre-commissioning	Projected 1	2	3	4	5	6	7	8	9	10	11
CAPITAL EXPENDITURES												
1) Cost of purchased filter	2,040											
2) Freight	25											
3) Custom clearance (20%)	408											
4) Filter installation cost	40											
5) Pumps, Fittings (installed)	280											
6) Control installation cost	40											
7) Electrical (Installed)	125											
8) Basic engineering	15											
9) Erection, Construction	200											
10) Contingency	240											
Other Cap. Exp. (Rehabilit.)							550					885
Total Cap. Exp.	3,413	0	0	0	0	0	550	0	0	0	0	885
O&M EXPENSES												
Labor		29	30	32	34	35	37	39	41	43	45	47
Supervision		29	30	32	34	35	37	39	41	43	45	47
Maintenance		68	71	75	79	83	87	91	96	100	105	111
Electrical Power		79	83	87	91	96	101	106	111	117	123	129
Chemicals		0	0	0	0	0	0	0	0	0	0	0
Filter fabric cost		45	47	50	52	55	57	60	63	66	70	73
Fresh water (washing)		61	64	67	71	74	78	82	86	90	95	99
Rent of land		17	18	19	20	21	22	23	24	25	26	28
Total Expenses		328	344	362	380	399	419	440	462	485	509	534
EXPECTED REVENUES												
Recovered fibers		1,374	1,443	1,515	1,591	1,670	1,754	1,841	1,933	2,030	2,132	2,238
Recovered clarified water		478	536	590	649	714	785	864	950	1,045	1,150	1,265
Total Revenues		1,852	1,979	2,105	2,240	2,384	2,539	2,705	2,884	3,075	3,281	3,503
ANNUAL CASH FLOW	-3,413	1,524	1,635	1,743	1,860	1,985	1,571	2,265	2,422	2,591	2,772	2,083
NPV (Discount rate 12%)	8,033											
NPV (Discount rate 20.06%)	4,468											

Assumptions :
The capital expenditures are represented by the actual investment cost of the method used for fiber recovery and water reuse
Life time of the project is 10 years
Annual cost increase of 5%
Cost of Capital is 12%
Rehabilitation valued at 10% of initial investment cost every five years inflated by 10% /year (compounded)
Revenues = Expected price x Quantity of recovered fiber or clarified water
All figures are based on data obtained from the economic feasibility study in "The Fiber Recovery and Water Re-use in RAKTA" report.

F. Subproject No. 39: Chromium Recovery from Industrial Wastewater of El Nasr Leather Tanning Company for Reuse in the Industry

Awardee:	Alexandria University	
End-User:	El Nasr Tanning Company	
Principal Investigator:	Prof. Dr. Mohamed Safwat El Mahdy Abdo	
Period:	20/04/1993 - 20/04/1995	
Budget Breakdown:		**LE**
USAID/STC	$144,500 and LE 335,635	**826,935**
In Cash	GOE None End-user None	**None** **None**
In Kind	GOE 140,000 End-user 62,800	**202,800**
Total		**1,029,735**

F1. Subproject Description

This project (C/A 39) was granted by STC to a research group from the Chemical Engineering Department, Faculty of Engineering, Alexandria University for the period from April 20, 1993 to April 19, 1995. The grant provides for research, design, construction, and start-up as well as a technical and economic assessment of methods for chromium recovery from the wastewater of the El Nasr Leather Tanning Company (NTC) at El Maxx, Alexandria Metropolitan Area.

Leather tanning is considered to be one of the activities of the chemical industry sector in Egypt. Leather tanning has two centers: El Basateen Area (Old Cairo) and Al Maxx Area (Alexandria). El Nasr Leather Tanning Company is the second largest public sector tannery. This industrial complex has a production capacity of about 6 million square feet of leather per year.

The annual water consumption of NTC averages about 150,000 m^3/year discharging approximately 1,000-1,200 m^3/day. The company employs two methods for tanning hides, namely: chromium tanning for lighter leather and vegetable-based compounds tanning for heavier leather. During the process of chromium tanning, 30-40 percent of the chromium salt used is estimated to be discharged with the resulting effluent. Calculating this into tonnage, it is equivalent to a loss of over 16 tons per year, a loss to the company of LE 44,800 (1 ton chromium salt costs LE 2,800). Chromium is a heavy metal, with stringent limitations by law 48/1982 for discharge into water bodies and limitations by law 93/1962 for discharge into the sewer system.

The project investigated several methods for industrial effluent treatment aiming at both the recovery of wasted salt and evaluating options for reuse of the recovered material and the clarified waters. Optimal results were obtained from the following method: The chromium liquor is concentrated or thickened prior to a chemical precipitation stage. The slurry produced is conveyed to a rotary drum vacuum filter for drying and then storing. The recovered clarified

waters have a low chromium concentration and are amenable either to direct discharge or as make-up water in the tanning processes. Technical evaluation of the mixing of the recovered salt cake with the freshly prepared chromium salt solution indicated an enhancement of the salt absorption property of the tanned hides. The technology reduces the size and cost of the industrial wastewater pretreatment facilities required.

F2. Financial Analysis

An analysis of the projected financial returns on the Recovery of Chromium sub-project was performed, basing the project revenue calculations on data obtained from the project's technical reports.

Capital expenditures were calculated based on the actual investment cost of the project, although its annual operating expenses were calculated as 10 percent of total investment cost of the project inflated by 10 percent annually.

The financial revenues from this project were computed by multiplying the quantity of chromium recovered by the price of chromium salt, which was then increased by 10 percent annually to account for inflation and other market factors.

The results of the analysis yielded a negative net present value of approximately LE 0.536 million over the 15-year projected cash flow. This is because of the annual operational and maintenance costs exceeding annual financial returns.

The calculations and assumptions related to the above analysis can be found in the appendix to this document.

F3. Subproject Achievements

F3a. Economic and Environmental Benefits

There are several ways to estimate the economic benefits that could be generated by the project. The process for chromium recovery (the precipitation technique followed by thickening of the sludge) has proved to be successful and economically efficient compared with other techniques. Although this process resulted in a negative net present value (discounted annual cash flows are less than initial capital costs), the real benefit of this project is in minimizing the pollution impact of chromium in wastewater.

F3b. Environmental Impact

This subproject achieved a 90 percent reduction in the chromium content of the tannery's wastewater and reduced the total chromium loading into the sea by 15 tons per year. Apart from the obvious positive natural resource conservation implications, this will also improve the quality of bathing waters in the Mediterranean and lessen potential for contamination of marine wildlife.

F3c. Public Health Impact

Possible reduction of negative health impact. Chromium is a controversial chemical because of the potential toxicity of some of its chemical forms. Depending on its chemical state it has various levels of impact on humans, aquatic life, and terrestrial plants with some ability to

move between media. However it is difficult to determine the precise reduction in negative health impact, if any, in absence of health-monitoring data concerning the population groups residing in the vicinity of the factory or using water where the effluents have been discharged. Moreover, there were no data on exposure levels or the duration of exposure in the project reports.

Improved quality of effluent discharge. Very high pollution loads of chromium referred to in non-precise quantitative terms in the available documentation, receive no treatment. These pollutants damage the ecology of the receiving waters near the sewer outfall. The clarified water after implementing the new technology contains negligible amounts of chromium salts (3ppm) which is below the permissible limits.

Waste minimization and resource recovery. The available documentation indicates the possible recovery of 15 tons of chromium salts annually using the described technology. This is a positive attribute if viewed from a natural resource conservation viewpoint. In financial terms, this would account for LE 42,000 of savings. This is in addition to savings in wastewater pretreatment costs as a result of improved quality of effluent.

F3d. Occupational Health

The pilot plant as described is a closed operation that would present no hazards to workers. However, because of the dangerous properties of some of the substances used in the recovery process (e.g., sulphuric acid), strict occupational safety and hygiene procedures should be followed in order to ensure the safety of workers against exposure caused by leakages, spills, or any error within the system.

F3e. Regulatory Compliance

Reduction in chromium discharges moves the company closer to compliance with law 4/1994, which regulates discharges to coastal water and achieves compliance with law 93/1962 (assuming the water will eventually be conveyed to a treatment plant).

Science and Technology Cooperation Project

Subproject No. 039 - Chromium Recovery From the Industrial Waste-Water of El Nasr Leather Tanning Company for Reuse ~~in the industry~~.

Projected Cash Flow and Financial Returns (in LE 000's)

(LE 000' s)

Description	Pre-[illegible]	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
CAPITAL EXPENDITURES																	
Civil work	125																
Machinery & Equipments	658																
Tools	25																
Company's contribution	71																
University's contribution	18																
Accrued expenses	42																
Total Cap. Exp.	937	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O&M EXPENSES																	
Labor & other expenses		10	11	12	13	15	16	18	19	21	24	26	29	31	35	38	42
Total Expenses		10	11	12	13	15	16	18	19	21	24	26	29	31	35	38	42
EXPECTED REVENUES																	
Recovered Chromium		42	46	51	56	61	68	74	82	90	99	109	120	132	145	159	175
Total Revenues	0	42	46	51	56	61	68	74	82	90	99	109	120	132	145	159	175
ANNUAL CASH FLOW	-937	32	35	39	43	47	52	57	62	69	75	83	91	100	110	122	134
NPV	-536																

Assumptions :

Fifteen years of operations

Annual cost & revenue increase of 10%

Cost of Capital 12%

Revenues = quantity of chromium recovered x price of chromium salt /ton

All figures are based on data obtained from the Technical reports NO. 1,2,3 of "Chromium Recovery from Industrial Waste Water of El Nasr Leather Tanning Company for Reuse in the Industry".

Principal Investigator Prof. Dr. Mohamed Safwat El Mahdy Abdo

G. Subproject No. 40: Establishment of an Innovative Technology for the Utilization of Wooden Wastes at the Nile Match Company in Production

Awardee:	Faculty of Engineering, Alexandria University	
End-User:	Nile Match Company	
Principal Investigator:	Prof. Dr. Mohamed Ahmed El Tarabolsi Faculty of Engineering, Alexandria University	
Period:	20/04/1993 - 20/06/1995	
Budget Breakdown:		**LE**
USAID/STC	$121,612 and LE 188,662	**602,163**
In Cash	GOE None End-user None	**None** **None**
In Kind	GOE 338,800 End-user 39,400	**378,200**
Total		**980,363**

G1. Subproject Description

This project (C/A 40) was granted by STC to the Faculty of Engineering, Alexandria University for the period April 4, 1993 to October 19, 1994. The grant provides for the research and development, design, implementation, and assessment of technology to utilize wooden wastes resulting from the Nile Match Company to produce economical products at the National Pulp and Paper Company, both companies being located in the Alexandria Governorate.

The Nile Match Company imports wooden blocks that are processed to produce match sticks. This activity produces veneer wastes and sawdust by-products (approximately 1,500 t/y), which represent a costly disposal problem for the company. The project aims to develop and assess applied technologies to utilize these wastes in the manufacture of chemical pulp in the neighboring National Pulp and Paper Company (NAPA).

The project provided the engineering design to upgrade the pulping section at NAPA to produce high quality unbleached and bleached pulp from wooden wastes. Equipment was added and the existing industrial unit was retrofitted to size wooden waste and screen sawdust fines prior to the infeed to the production operation. The upgraded facility has an improved production capacity of 9,000 tons/year.

Enhanced production of the facility utilizes 6,200 tons of veneer wastes to produce 3,000 ton/year of either unbleached or bleached veneer pulps. The wood pulp produced from local wooden wastes replaces the equivalent amount of imported hard wood chemical pulp. Production potential of the facility is further enhanced for the utilization of 8,000 tons of other wastes for production of extra 3,000 tons of pulp and/or the utilization of other cellulosic materials for the production of 6,000 tons/year of bleached pulps. The produced paper has the strength and brightness of the normal product, plus superior surface smoothness and formation.

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The cost of the bleached pulp produced by NAPA is 1,369 LE/ton. The produced pulp is actually short fiber wood pulp of similar quality to imported short fiber wood pulp (2,700 LE/ton) which is mixed with bagasse to provide the desired paper fiber quality. The importance of bleached veneer pulp as an economic source of pulp will be fully realized only when Edfu Sugar Pulp Mill stops delivering bagasse pulp to other public sector pulp and paper mills as it commences its own production line of bagasse pulp based paper.

G2. Financial Analysis

Based on the data obtained from the project report by Prof. Dr. Mohamed El Tarabolsi, it was observed that the proposed bleached Kraft pulp has a cheaper market substitute produced by Edfu mills. Therefore, two sets of analysis were performed of the projected financial returns by utilization of wooden wastes by The Nile Match Co. Under the first scenario, the manufacturing of unbleached pulps only was assumed. The result of this analysis yielded a positive net present value of approximately LE 62.4 million over the 15-year projected cash flow.

The second scenario assumes the manufacturing of bleached pulps which are going to be sold at the same price of similar quality imported short fiber wood pulps. This scenario is based on of the following assumptions:

1. Edfu Mill will stop delivering bagasse pulp upon commissioning its contracted writing and printing P.M.

2. There will be an increase in the price of bagasse.

3. The produced paper, including the proposed bleached pulps, is superior with respect to surface smoothness and formation, thus, giving the proposed bleached pulp a competitive edge over its substitute. As a result, this scenario a shows a positive net present value of LE 0.172 million.

The calculations and assumptions related to the above analysis can be found in the appendix to this document.

G3. Subproject Achievements

G3a. Economic Benefits

In this subproject the most important economic benefit is the savings associated with the domestic manufacturing of bleached and unbleached pulps as opposed to the cost of importing an equivalent amount of hardwood chemical pulps.

Comparing the costs of the locally produced pulps with the imported ones:

1. The cost/ton of unbleached pulp:

Produced locally	906	LE/ton
Imported	2,700	LE/ton

2. The cost/ton of bleached pulp:

Produced locally	1,369	LE/ton
Imported	2,700	LE/ton

3. The total capital investment of proposed equipment is 4.3 million LE, and the expected annual profit exceeds 5 million LE.

Cost savings are estimated as follows:

Savings from producing unbleached pulps	=	5.38 million LE/year
Savings from producing bleached pulps	=	3.99 million LE/year[3]

The annual net savings calculated above clearly demonstrate the advantages of producing the pulps in terms of creating local employment and preserving hard currency.

G3b. Environmental Impact

The significant environmental impact of this project would result from the effective reuse of wooden solid waste, generated at the Nile Match Company, as a viable resource in the paper and pulp production processes. Wastes emanating from the match production are liable to be highly contaminated with chemicals and might not be safe for co-disposal with other solid wastes. Such an effective reutilization decreases some hazards associated with the waste, and provides economical resources for paper production from local sources, instead of using a raw material currently being imported.

G3c. Public Health

Waste minimization. The technology presented allows for the production of 3,000 tons per year of either unbleached or bleached veneer pulps from 6,200 tons of veneer wastes, i.e., the waste generated is minimized by 50 percent. This offers the dual advantage of reducing costs of waste management (collection, transportation, and disposal) and reducing the public health impacts resulting from the open dumping of such wastes. It also decreases the potential to spread fires and chest diseases.

Reduced health impacts of wooden wastes and veneer dust. Wooden wastes pose serious environmental and public health threats because of their potential to initiate and spread fire. They also host rodents which are reservoirs of several diseases.

[3] Assuming all production of bleached pulps will be sold at the price of similar imported short fiber wood pulp and no cheaper market substitute exists.

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Veneer wastes and sawdust byproducts resulting from the match manufacturing process at the Nile Match Co. can also result in various forms of respiratory diseases (pneumoconiosis) among residents of the vicinity of the Nile Match Co. and can also contribute significantly to the deterioration of air quality.

G3d. Occupational Health

Workers involved in the manufacture process of writing and printing paper and kraft liner may be exposed to the following potential hazards:

- Contact with chemicals
- Accidents caused by spillage of chemicals
- Air emissions inside the working environment
- Noise from vibrators
- Physical injuries from grinders or knives

There is no particular reference within the STC report to attention given to occupational safety measures and procedures or to anticipated occupational risks. However, the protection of workers from these hazards is feasible through the use of appropriate safety measures and risk education of workers.

G3e. Regulatory Compliance

Law 38/1969 regulates the co-disposal of industrial solid waste with the municipal wastes. There is no identification of legal standards for permissible pollutant levels and concentrations within this law and no disposal options are set. However, generally speaking, potential violations are minimized by minimizing waste.

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Science and Technology Cooperation Project

Subproject No. 040-

Establishment of an Innovative Technology for the Utilization of Wooden Wastes of the Nile Match Co. in Production of Economical Products.

Projected Cash Flow and Financial Returns (in LE 000's)

Scenario 1 : Manufacturing Unbleached Pulps Only. *

(LE 000' s)

Description	Pre-construction	Projected 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
CAPITAL EXPENDITURES *																	
Equipment cost	3,155																
Shipping, sales taxes, spares	757																
Piping and fitting	366																
Installation equipment	22																
Other Cap. Exp. (Rehab.%)							693					1,115					
Total Cap. Exp.	4,300	0	0	0	0	0	693	0	0	0	0	1,115	0	0	0	0	0
O&M EXPENSES																	
1- Unbleached Pulp		2,718	2,990	3,289	3,618	3,979	4,377	4,815	5,297	5,826	6,409	7,050	7,755	8,530	9,383	10,322	11,354
2- Bleached Pulp			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Expenses		2,718	2,990	3,289	3,618	3,979	4,377	4,815	5,297	5,826	6,409	7,050	7,755	8,530	9,383	10,322	11,354
EXPECTED REVENUES																	
Unbleached Pulps		7,290	8,019	8,821	9,703	10,673	11,741	12,915	14,206	15,627	17,189	18,908	20,799	22,879	25,167	27,684	30,452
Bleached Pulps			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Revenues		7,290	8,019	8,821	9,703	10,673	11,741	12,915	14,206	15,627	17,189	18,908	20,799	22,879	25,167	27,684	30,452
ANNUAL CASH FLOW	-4,300	4,572	5,029	5,532	6,085	6,694	6,671	8,100	8,910	9,800	10,781	10,743	13,044	14,349	15,784	17,362	19,098
NPV	52,284																

* There is a market substitute for the Bleached pulps with lower cost so production will be limited to unbleached pulps only

(Bagasse costs LE 1000 as opposed to the proposed bleached pulp which costs LE 1369)

Assumptions :

The capital expenditures are presented by the actual investment cost required for the utilization of wooden wastes

Fifteen years of operations

Annual cost increase of 10%

Cost of Capital is 12%

Rehabilitation valued at 10% of initial investment cost every five years inflated by 10% /year (compounded)

Revenues = production x selling price (cost of similar imported product less -10%)

All figures are based on data obtained from The Utilization of Wooden Wastes of The Nile Match Co. report by Prof. Dr. Mohamed Ahmed El Taraboulsi .

Projected Cash Flow and Financial Returns (in LE 000's)
Scenario 2 : Manufacturing of Bleached Pulps only *

(LE 000' s)

Description	Pre-operation	Projected 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
CAPITAL EXPENDITURES																	
Equipment cost	3,155																
Shipping, sales taxes, spares	757																
Piping and fitting	366																
Installation equipment	22																
Other Cap. Exp. (Rehabilit.)							693					1,115					
Total Cap. Exp.	4,300	0	0	0	0	0	693	0	0	0	0	1,115	0	0	0	0	0
O&M EXPENSES																	
1- Unbleached Pulp			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2- Bleached Pulp		4,107	4,518	4,969	5,466	6,013	6,614	7,276	8,003	8,804	9,684	10,653	11,718	12,890	14,178	15,596	17,156
Total Expenses		4,107	4,518	4,969	5,466	6,013	6,614	7,276	8,003	8,804	9,684	10,653	11,718	12,890	14,178	15,596	17,156
EXPECTED REVENUES																	
Unbleached Pulps			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bleached Pulps		7,290	8,019	8,821	9,703	10,673	11,741	12,915	14,206	15,627	17,189	18,908	20,799	22,879	25,167	27,684	30,452
Total Revenues		7,290	8,019	8,821	9,703	10,673	11,741	12,915	14,206	15,627	17,189	18,908	20,799	22,879	25,167	27,684	30,452
ANNUAL CASH FLOW	-4,300	3,183	3,501	3,851	4,237	4,660	4,434	5,638	6,203	6,823	7,505	7,141	8,081	8,889	10,988	12,087	13,296
NPV	34,869																

* This scenario is valid only if :
1- Edfu mill will stop delivering bagasse pulp
2- Bagasse pulp price will increase
3- Proposed bleached pulp will result in better quality writing paper

Assumptions :
The capital expenditures are presented by the actual investment cost required for the utilization of wooden wastes
Fifteen years of operations
Annual cost increase of 10%
Cost of Capital is 12%
Rehabilitation valued at 10% of initial investment cost every five years inflated by 10% /year (compounded)
Revenues - production x selling price (cost of similar imported product less -10%)
All figures are based on data obtained from The Utilization of Wooden Wastes of The Nile Match Co. report by Prof. Dr. Mohamed Ahmed El Taraboulsi.

H. Subproject No. 52: Development of Innovative Technology for the Utilization of Tire Wastes of the Transportation and Engineering Company (TRENCO)

Awardee:	National Research Center - Department of Polymers and Pigments	
End-User:	Transportation and Engineering Company (TRENCO)	
Principal Investigator:	Prof. Dr. Abbas A. Yehia	
Period:	02/05/1993 - 01/05/1995	
Budget Breakdown:		**LE**
USAID/STC	$ 176,400 and LE 190,813	**618,773**
In Cash	GOE None End-user None	**None**
In Kind	GOE 211,600 End-user 169,200	**380,800**
Total		**999,573**

H1. Subproject Description

This subproject aims to reutilize the tire wastes generated at the Transportation and Engineering Company (TRENCO) by means of an innovative and economic technological procedure.

Rubber wastes arising from tire manufacturing or its scrap presents serious problems in its management in terms of its storage and disposal. Whole tires are difficult to landfill because they tend to float on the surface. Stockpiles of scrap tires, however, pose a serious fire threat because of their flammable potential.

TRENCO is the main producer of rubber tires in Egypt. TRENCO's wastes are comprised of coated, unvulcanized rubber fabric scraps resulting from trimming of tire carcass, rejected vulcanized inner tubes, and used bladders in addition to scorched rubber mixes of different formulations. TRENCO's rubber wastes are currently stockpiled on the company's premises with a minor portion sold to scrap dealers.

Initially the subproject team undertook an extensive literature survey with the objective of identifying alternative technologies for the reutilization of tire wastes used worldwide and collecting information on relevant research. Following an on-site waste survey was conducted at TRENCO to determine the quantity and to analyze the composition of the waste generated. The results of the survey indicated that 400 tons of rejected tires are generated annually comprising 1 percent of the total production capacity of the company. These include inner tubes, bladder, and flap. In addition, 500 tons of uncurled rubber waste are generated annually comprised of unbeaded green tires, carcass trimmings, and scorched mixtures.

The information gathered by the subproject team and the comparative analysis undertaken of chemical, mechanical, and mechanochemical procedures employed for the reutilization of rubber wastes strongly suggested that rubber grinding is a precondition for the reutilization of

rubber. In comparison with grinding at normal temperature, grinding at low temperature (freezing conditions) has the following advantages:

- The danger of additional heat generation during the process is avoided.
- Energy consumption is reduced.
- Components such as fabric and metal cord are readily separated.

To this end, the subproject team designed a prototype for a cryogenic grinding machine. Operating under deep freezing conditions, the machine can be cooled by liquid air or nitrogen. With the glass transition temperature of rubber which is reported to be within the value range of -68 degrees C to -73 degrees C, liquid nitrogen sufficiently provides cooling of wastes up to -80 degrees C. Using this procedure, cured wastes can be ground cryogenically into fine rubber powder that could be reutilized. Uncurled wastes can also be treated to produce cement, adhesives and finally coarse rubber powder can be treated by a reclamation process.

A number of ideas for the reutilization of rubber wastes and its conversion into profitable products have been tentatively explored by the subproject team. The results of these preliminary investigations have indicated that rubber wastes—mixed with concrete—could be used in asphalt, road paving and surfacing, and roofings. It could also be integrated in building material, rubber composites, coatings, and laminations.

H2. Financial Analysis

This section tests the feasibility of the project using the Net Present Value method. In order to evaluate the commercial profitability of the project, its capital expenditures and annual operating expenses were tested against the expected annual revenues over the project's lifetime—10 years—to determine the net present value of the project.

This project suggests the utilization of tire wastes, which amount to 1,000 tons per year, classified as follows:

In this section the feasibility of two main production lines is tested. These two lines include the production of cements and adhesives and the production of rubber molded articles. They utilize the refused rubber compounds and the carcass trimmings only (180 and 300 tons, respectively).

According to information obtained from a meeting with Prof. Dr. Abbas Yehia (the principal investigator), the technology suggested for using tire wastes has no capital investment cost. This is because equipment used in the process is fully depreciated and barrels used for collecting the wastes are already used in the factory. However the project budget as funded by either the STC or directly incurred by the end user or GOE has been used as the project's capital expenditures.

All operating expenses for the two production lines are given in the techno-economic study of the project. As mentioned before, this section deals with two production lines only (cement and adhesives, and molded articles). It is assumed that the carcass trimming (the common raw material in the both production lines) is divided equally between the two kinds of products. Cement and adhesives production would consume 150 tons of carcass trimming and

molded articles production would consume the rest of the quantity (150 tons) as well as refused rubber compound according to the production formula:

1 kg molded articles needs: 750 g carcass trimming and 250 g scorched rubber mixes.

As a result, using 150 tons carcass trimming would only require the use of 50-ton rubber compounds.

The annual revenues (financial returns) of this project, however, are estimated by adding 30 percent profit on the annual operating cost of each product.

The projected annual operating costs and financial returns are increased by 5 percent annually to account for the inflation in raw material, energy, salaries, and packaging.

Although the assumed sale price, including the 30 percent profit margin which is far below the market price for these products, results obtained from the calculations gave us a positive net present value of LE 2.249 million. This means that annual financial returns cover and exceed both capital expenditures and annual operating expenses over the lifetime of the project.

The calculations and assumptions related to the above analysis can be found in the appendix to this document.

H3. Subproject Achievements

H3a. Economic Benefits

The economic benefits of this project are divided into two categories: 1) the utilization of tire wastes proved to generate financial returns and be economically profitable, and 2) using these wastes instead of trying to dispose of them saves costs that would otherwise have been incurred (cost of storage, shredding, or protection from fires).

Financial profits are generated by using carcass trimmings and rubber compounds in the production of cements and adhesives and molded articles. The cements can be used during the production of tires and if they are very diluted they can be used as a finishing agent for the produced tires by spraying. The cements of dry content can be converted to excellent adhesives for repairing punched inner tubes.

The scorched rubber compound can be used for the production of flap or when added to the refined carcass can produce more soft rubber articles such as tiles for car flooring, advertising articles, rubber tiles, and so forth.

The sale price of one kg of adhesives according to our calculations = LE 3.575, whereas the lowest market price for the same kg is LE 10, making an added profit of approximately LE 6.4 per kilogram. This would result in an added profit of LE 3.5 million annually by using 150 tons of carcass trimming.

The sale price for a molded article (model tire), however, according to TRENCO, is LE 0.85, whereas the market price is LE 2.5. TRENCO produces 20,000 pieces annually. This means there is an added profit of LE 0.033 million.

In addition, rubber powder can be modified chemically and can be incorporated in rubber mixes to improve their physical and chemical properties. Also, rubber powder can be reclaimed by using the mechano-chemical method. The obtained reclaimed rubber has good theological properties and can replace 10 percent of virgin rubber without sacrificing its physical and mechanical properties.

The chemical modification of rubber powder by sulphonation and chloronation opens a new area for the use of rubber powder. It has proved to be a good ion exchanger and can be used for wastewater purification from heavy metals such as copper.

H3b. Potential for Effective Reutilization of Rubber Waste

Rubber wastes in Egypt constitute a major environmental problem with respect to its collection, storage, and disposal. This subproject has identified a number of economic alternatives for the reutilization of rubber wastes. These alternatives could be further developed into business opportunities whereby profit would be maximized and danger to the environment minimized.

H3c. A Prototype for a Rubber Grinding Machine

The subproject's design for a prototype grinding machine is a major achievement of this subproject. The design is based on worldwide experience and yet tailored to suit the physical characteristics and economic and technical resources of a major Egyptian firm, rendering it appropriate for wider-scale applicability.

H3d. Reduced Potential Fire Hazard at the Transportation and Engineering Company (TRENCO)

The current practice employed at TRENCO for the disposal of its rubber wastes (stockpiling) constitute a serious potential for fires. The potential is further exacerbated by the absence of effective fire-fighting measures. The identification of an alternative disposal outlet will undoubtedly reduce the likelihood of such fires and the associated economic losses and health safety implications.

Science and Technology Cooperation Project

Subproject No. 052 -

Development of Innovative Technology for Utilization of Tire Wastes of TRENCO

Projected Cash Flow and Financial Returns (in LE 000's)

(LE 000' s)

Description	Pre Commissioning	Projected 1	2	3	4	5	6	7	8	9	10
CAPITAL EXPENDITURES											
USAID/ STC grant in LE	191										
USAID/ STC grant in $	600										
End-User contribution	212										
GOE contribution	169										
Total Cap. Exp.	1171										
O&M EXPENSES											
Production of Adhesives			0	0	0	0	0	0	0	0	0
Material		358.3	376.3	395.1	414.8	435.6	457.3	480.2	504.2	529.4	555.9
Salaries		277.8	291.7	306.2	321.6	337.6	354.5	372.2	390.9	410.4	430.9
Energy , water etc.		201.7	211.7	222.3	233.5	245.1	257.4	270.3	283.8	298.0	312.9
Overhead		203.9	214.1	224.8	236.0	247.8	260.2	273.2	286.9	301.2	316.3
Package &sticker		277.8	291.7	306.2	321.6	337.6	354.5	372.2	390.9	410.4	430.9
Total cost for utilizing 150 ton carcass		1,319.4	1,385.4	1,454.7	1,527.4	1,603.8	1,684.0	1,768.2	1,856.6	1,949.4	2,046.9
Production of Rubber Molded Articles			0	0	0	0	0	0	0	0	0
Material		30.5	32.0	33.6	35.3	37.1	38.9	40.9	42.9	45.1	47.3
Salaries		150.0	157.5	165.4	173.6	182.3	191.4	201.0	211.1	221.6	232.7
Energy , water etc.		72.6	76.2	80.0	84.0	88.2	92.7	97.3	102.2	107.3	112.6
Overhead		65.8	69.1	72.5	76.2	80.0	84.0	88.2	92.6	97.2	102.1
Other expenses		40.0	42.0	44.1	46.3	48.6	51.1	53.6	56.3	59.1	62.1
Total cost for utilizing 150 ton carcass		358.9	376.8	395.7	415.5	436.2	458.1	481.0	505.0	530.3	556.8
Total O & M Expenses		1,678.3	1,762.3	1,850.4	1,942.9	2,040.0	2,142.0	2,249.1	2,361.6	2,479.7	2,603.7
ANNUAL GAINS											
Selling price of adhesives		1,715.3	1,801.0	1,891.1	1,985.7	2,084.9	2,189.2	2,298.6	2,413.6	2,534.3	2,661.0
Selling price of rubber molded articles		466.6	489.9	514.4	540.1	567.1	595.5	625.2	656.5	689.3	723.8
		2,181.9	2,290.9	2,405.5	2,525.8	2,652.1	2,784.7	2,923.9	3,070.1	3,223.6	3,384.8
NCF in case of adhesives prod.	-1,171	503.5	528.7	555.1	582.9	612.0	642.6	674.7	708.5	743.9	781.1
NPV (Discount rate 12%)	2,249.1										

Assumptions :

- All wastes are utilized again and sold (300 ton of carcass trimming and 50 ton only rubber mix)
- Half of the carcass trimming is used in cement and adhesives production and the other half in the rubber molded articles production

The capital expenditures arepresented by the actual project expenditures as funded by either the STC or directly incurred by the end user or GOE.

Life time of the project is 10 years

Operating expenses and annual gains are inflated by 5 % annually.

Cost of Capital is 12%

All figures arebased on data obtained from the technoeconomic study of the project in the 5th technical report

The research team is led byPrincipal Investigator Prof. Dr. Abbas A. Yehia

I. Subproject No. 53: Recovery of Residual Oil Entrained in the Spent Clay and Regeneration of Clay for Ruse of the Alexandria

Awardee:	National Research Center	
End-User:	Alexandria Oil & Soap Company	
Principal Investigator:	Prof. Dr. Hala Ahmed Talaat National Research Center	
Period:	05/02/1993 - 15/06/1995	
Budget Breakdown:		LE
USAID/STC	$119,150 and LE 443,908	**849,018**
In Cash	GOE None End-user None	**None**
In Kind	GOE 250,000 End-user 250,000	**500,000**
Total		**134901**

I1. Subproject Description

This project (C/A 53) was granted by STC to a group of researchers from the Pilot Project and Chemical Engineering Division at the National Research Center (NRC), Cairo, for the period May 1993 to August 1994. The grant, providing an estimated budget of 1.25 million LE, provided for the research, design and construction, start-up, and assessment of running and maintenance costs for a wastewater treatment system that would recover over 95 percent of the oil content in wastewater. The second component of the grant provided for the research leading to the recovery of residual oil from spent clay used in the bleaching process, as well as re-activation of this waste and the evaluation of feasible options for its re-use.

The end-user, the Extracted Oil and Derivatives Company, located in Moharam Bey, Alexandria, is a major public sector enterprise that produces and refines both imported and locally produced edible oil in Egypt. Thus the company's activity is considered an asset to the Food Industries Holding Company.

Edible oil is a high priority consumer commodity produced, subsidized, and distribution-regulated in quotas by the government to satisfy the needs of a growing population. The national annual consumption of edible oil is 800,000 tons, with government expenditure of LE 1.2 billion per year. About 85 percent of the consumed amount is imported and refined locally. The overall public sector oil and soap companies' production capacity of edible oil in Egypt covers on average 10-15 percent of the required market demand.

Oil refining from both imported and local sources is the major activity performed at this industrial facility in Alexandria. This operation further reduces the final product loss by 2-7 percent, all of which is discharged liberally to the sewer system in Alexandria. This is equivalent to a loss of 450,000 tons per year and a resource equivalent of LE 67 million per annum.

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The subproject demonstrates waste and residual oil recovery and assesses its cost-effectiveness. The subproject achieved the gradual recovery of 97 percent of the oil through the application of a gravity separation process (waste oil recovery) followed by air flotation and membrane separation (micro-filtration) processes to further enhance the residual oil recovery from industrial wastewater.

The second part of the subproject focused on the application of effective methods for residual oil recovery from spent clay. With the recovery of the oil content (approximately 30 percent of solid waste weight), chemical reactivation of the spent clay was achieved accordingly. The procedure decreases the amount of solid waste generated from the above process while residual oil recovery decreases final product loss in this operation. Furthermore, the process reduces both the value and oil content of the final wastes, which are co-disposed with other conventional wastes in the area of Alexandria.

I2. Financial Analysis

An analysis of the projected financial returns on the Recovery of Residual Oil subproject was performed. This project suggests two ways for oil recovery:

1. Residual oil recovery from industrial wastewater

2. Residual oil recovery from spent clay

Therefore two sets of analyses have been performed to test each approach separately.

The financial returns for each approach have been tested against its investment and annual operating costs to reach the relevant net present value for each method used for oil recovery. Results revealed the following:

Method	Net Present Value in Million LE
1. Oil recovery from industrial wastewater	
A. Gravity separation	35.798
B. Dissolved air flotation	37.236
C. Microfiltration	35.514
2. Oil recovery from spent clay	0.765

The above results showed that both methods of recovering oil suggested by this project gave positive net present values. This means that annual financial returns cover both capital expenditures and annual operational and maintenance costs over the lifetime of the project. However, in the case of recovering oil from industrial wastewater, it is recommended to use the dissolved air flotation method from the economic point of view. This is because although its capital expenditures are high, this method recovers more oil leading to higher financial returns and a greater NPV.

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I3. Subproject Achievements

I3a. Economic Benefits

There are several ways to estimate the economic benefits that are generated by the proposed project. From the project team's perspective, there are three important economic benefits obtained from this project:

1. The project realizes annual returns and cash surpluses from the annual operations resulting in a positive net present value.

2. The project recovers wasted raw materials (oil) on the industrial level with 90-99 percent from the liquid wastes and bleaching dust with different oil recovering methods. Thus, oil may be supplied to the soap manufacturing industry, another benefit being the use of recovered bleaching dust as a secondary product in the bleaching process.

3. As any industrial project, it generates extra job opportunities in the market and accordingly helps in decreasing the severity of the unemployment problem in the Egyptian economy.

I3b. Potential for Wider Application in the Vegetable Oil Refining Sector

The benefits of this project can be summarized in its potential for replicability among the expanding oil refining industry in Egypt. Because Egypt has several oil refining plants using basically the same technology, replication potential exists.

I3c. Environmental Impact

The project aims to decrease the oil content in wastewater and spent clay, both of which are being discharged liberally into the Alexandria sewer system. Because the majority of the industries in Alexandria are served by this sewer system, the oil and clay loadings only further reduce the effectiveness and efficiency of wastewater treatment and pollutes the receiving waters, agricultural drains, or the Mediterranean Sea.

I3d. Public Health Impacts

Waste minimization/resource recovery. Waste oil from the oil refining industry is a serious environmental problem in Egypt because of the limited capacity for liquid waste treatment at industrial facilities. Waste oil is discharged into waterways and sewerage systems causing serious degradation in water quality and sewerage systems.

This project offers an economic alternative for the recovery of waste oil resulting from the refining process and improves environmental quality with a subsequent positive impact on the state of public health.

Reducing negative health impacts resulting from waste dust. Within the present technology, oil will also be recovered from bleaching dust. This will to a large extent reduce the negative environmental and health impacts occurring as a result of harboring of bacteria and

viruses onto dust particles, and affecting a large sector of the population with acute and chronic respiratory diseases.

I3e. Occupational Health

Workers working within the oil recovery facilities would be potentially exposed to the following:

- Contact with chemicals
- Exposure to high temperatures

Exposure to these potential hazards can be easily avoided by means of protective measures such as special garments, proper ventilation, protective clothing, and general compliance with occupational safety regulations concerning standards for the working environment and for maintaining workers' health.

I3f. Regulatory Compliance

The discharge of industrial effluent to the sewer system in Egypt is governed by Law 93/1962. The law effectively requires pretreatment of industrial wastewater to be discharged into public sewers, in order to prevent corrosion or explosion within the sewers and to render conventional municipal wastewater treatment adequate. Construction of large projects of municipal wastewater treatment plants integrate these standards as design criteria. Excessive oil content reduction is therefore required for the efficient operation of the biological treatment procedures.

Law 38/1969, in general, regulates the co-disposal of industrial solid waste with the municipal wastes. It does not set standards for permissible pollutant levels and concentrations, or provide disposal options. Recovering residual oil within the spent clay and the chemical reactivating of clay reduces industrial wastes and ensures the compatibility of this type of waste with those from other sources.

Projected Cash Flow and Financial Returns (in LE 000's)
Method 1 : Residual Oil Recovery from Industrial Wastewater

(LE 000' s)

Description	Pre-construction	Projected 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
CAPITAL EXPENDITURES																	
I- Liquid waste																	
a. Gravity separation	30																
Rehabilitation							5					9					13
b. Dissolved air flotation	238																
Rehabilitation							38					61					99
c. Microfiltration	1,100																
Rehabilitation							177					285					459
O&M EXPENSES																	
I- Liquid waste																	
a. Gravity separation		19	20	22	25	27	30	33	36	40	44	48	53	58	64	70	77
b. Dissolved air flotation		64	70	77	85	93	102	112	124	136	150	165	181	199	219	241	265
c. Microfiltration		207	227	250	275	302	333	366	403	443	487	536	589	648	713	785	863
EXPECTED REVENUES																	
I- Liquid wastes																	
a. Gravity separation		2,880	3,168	3,485	3,833	4,217	4,638	5,102	5,612	6,174	6,791	7,470	8,217	9,039	9,943	10,937	12,030
b. Dissolved air flotation		3,060	3,366	3,703	4,073	4,480	4,928	5,421	5,963	6,559	7,215	7,937	8,731	9,604	10,564	11,620	12,782
c. Microfiltration		3,150	3,465	3,812	4,193	4,612	5,073	5,580	6,138	6,752	7,428	8,170	8,987	9,886	10,875	11,962	13,158
ANNUAL CASH FLOW																	
a. Gravity separation	-30	2,862	3,148	3,462	3,809	4,190	4,604	5,069	5,576	6,134	6,747	7,416	8,164	8,981	9,879	10,867	11,941
b. Dissolved air flotation	-238	2,997	3,296	3,626	3,988	4,387	4,788	5,308	5,839	6,423	7,066	7,711	8,549	9,404	10,345	11,379	12,419
c. Microfiltration	-1,100	2,943	3,238	3,562	3,918	4,309	4,683	5,214	5,738	6,309	6,940	7,349	8,398	8,238	10,181	11,178	11,836
NPV																	
a. Gravity separation	35,798																
b. Dissolved air flotation	37,238																
c. Microfiltration	35,514																

Assumptions :
Fifteen years of operations
Annual cost increase of 10%
Cost of Capital is 12%
Rehabilitation valued at 10% of capital expenditures every five years inflated by 10% /year (compounded)
Revenues = quantities of oil recovered x selling price per ton
All figures are based on data obtained from the oil recovery report by Prof. Dr. Hala Talaat & Dr. Yousef Howaila

Projected Cash Flow and Financial Returns (in LE 000's)
Method 2 : Residual oil recovery from spent clay

(LE 000' s)

Description	Pre-construction	Projected 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
CAPITAL EXPENDITURES																	
2- Painting dust	3,400																
Other Cap. Exp. (Rehabilit.)							548					882					
Total Cap. Exp.	3,400	0	0	0	0	0	548	0	0	0	0	882	0	0	0	0	0
O&M EXPENSES																	
2- Painting dust		1,100	1,210	1,331	1,464	1,611	1,772	1,949	2,144	2,358	2,594	2,853	3,138	3,452	3,797	4,177	4,595
Total Expenses		1,100	1,210	1,331	1,464	1,611	1,772	1,949	2,144	2,358	2,594	2,853	3,138	3,452	3,797	4,177	4,595
EXPECTED REVENUES																	
2- Painting dust		1,475	1,623	1,785	1,963	2,160	2,376	2,613	2,874	3,162	3,478	3,826	4,208	4,629	5,092	5,601	6,161
Total Revenues		1,475	1,623	1,785	1,963	2,160	2,376	2,613	2,874	3,162	3,478	3,826	4,208	4,629	5,092	5,601	6,161
ANNUAL CASH FLOW	-3,400	375	413	454	499	548	56	664	731	804	884	91	1,070	1,177	1,295	1,424	1,566
NPV	765																

Assumptions :
Fifteen years of operations
Annual cost increase of 10%
Cost of Capital is 12%
Rehabilitation valued at 10% every five years inflated by 10% /year (compounded)
Revenues = quantities of oil recovered x selling price per ton
All figures are based on data obtained from the oil recovery report by Prof. Hala Talaat & Dr. Yousef Howaila

J. Subproject No. 54: In-Plant Modification and Improvement of Handling Processing to Reduce Wastes at Al Ameria Petroleum Refinery

Awardee:	Environmental Studies Department, Institute of Graduate Studies and Research, Alexandria University	
End-User:	Al Ameria Petroleum Refinery	
Principal Investigator:	Professor Dr. Shacker Helmi El Sayed Helmi	
Period:	14/04/1994 - 13/01/1996	
Budget Breakdown:		**LE**
USAID/STC	$ 0 and LE 558,165	**558,165**
In Cash	GOE None End-user 49,170	**49,170**
In Kind	GOE LE 110,000 End-user LE 10,000	**120,000**
Total		**727,335**

J1. Subproject Description

This subproject aims to identify clean technology measures for the control of industrial pollution stemming from El Ameria Petroleum Refinery (EAPR). The underlying strategy of the subproject is to introduce a number of modifications to existing operational systems and to implement housekeeping measures that would reduce water consumption and minimize material losses.

EAPR is a major petrochemical industry located at the southwestern end of the Alexandria Metropolitan area. The industrial operations taking place at EAPR consist of the separation of crude oil into its molecular constituents, molecular cracking, molecular rebuilding, and solvent finishing.

In general, refinery operations require large amounts of water for cooling purposes. The total hourly water consumption at EAPR is 18,000m3, 83 percent of which is used for cooling operations. The resulting wastewater from all processes and the cooling cycle is pretreated to separate suspended matters, pheno,l and oil content according to the international standards of the American Petroleum Institute (API). In compliance with these standards, the EAPR employs a conventional API oil separator for the pretreatment of its effluents prior to their final discharge into Lake Mariout. Despite its effectiveness in the reduction of the oil and phenol content of the various wastewater streams to the permissible limits, this technique has failed to effectively separate suspended matter from these streams.

To this end, the company commissioned the installation of an additional dissolved air floatation (DAF) system in 1987. The main function of the system is to support the pretreatment process and to enhance the separation of the suspended matter content. Unfortunately, the DAF system also could not effectively separate the matter, a situation that has rendered the refinery incapable of complying with the national standards (Law 48/1982) set in this regard.

The initial stage of this subproject focused on determining the overall operational efficiency of the refinery's processes. This was based on data collected during a number of site visits conducted by the subproject team in collaboration with the refinery's technical team. The subproject team then identified the different water streams within the refinery, which is comprised of the following:

- Water inlet to the refinery
- The outlet of the desalter in the crude oil distillation unit
- The outlet of the phenol extraction unit
- The inflow and outflow from each unit in the pretreatment facilities (e.g., API and DAF)
- The common outflow from the refinery

A monitoring program was prepared in order to characterize the pollutant types in each of these streams. A detailed analysis of samples from each of these water streams was undertaken to determine their pollutant levels.

Results of analysis of the water inlet to the plant pointed out to a high BOD, COD, bacterial count, and salt content. The latter could lead to pipe corrosion upon its discharge. The analysis of the influent to the existing pretreatment system indicated that 1/3 of the oily wastewater bypasses pretreatment and proceeds directly to the final discharge point.

In their reports on these two streams, the subproject team recommend strict monitoring of the pretreatment process and the application of a biological treatment technique to improve the quality of the refinery's effluents.

Furthermore, the subproject team analyzed the effluents arising from the oil desalting and phenol-extraction processes. The oil-desalting process involves the washing of crude oil with hot water to dissolve the salt and reduce its suspended matter content. The effluent discharged from such an operation is characterized by a high oil content and a relatively lower salt content.

The phenol extraction process, however, is one that employs phenol as a solvent for the extraction of aromatics from lubricating oil feed stocks. By separating the aromatic portion of the feed stock, the sludge-forming tendency of lubricants is reduced.

In their overall analysis and evaluation of the situation at EAPR, the subproject team recommend two lines of actions, the underlying objective of which is to control the wastewater pollution arising from the refinery's activities. The first is to reduce the volume of final effluents from refinery operations by reusing wastewater from one process to another. The second is to recirculate used cooling water to be reused as process water or once again as cooling water. In addition, the subproject team proposed the introduction of some modifications that would limit the contamination of cooling water with oil. These include the replacement of barometric condensers with surface condensers.

The subproject team also developed a wastewater recycling scheme specifically for the desalter and the phenol-extraction units. The scheme is based on the introduction of process wastewater into holding tanks in order to increase the retention time of effluents prior to their discharge. The procedure promotes better separation of the oil and water mixture, and allows a larger portion of the water to be recycled.

J2. Subproject Achievements

J2a. Economic Benefits

It has traditionally been believed that the cost of removing industrial waste from the environment imposes an added financial burden on the industrial sector. This perception has, however, become less common as environmental awareness spreads all over the country.

Although the direct economic benefits of an environmental project cannot, in most cases, be easily spotted, their indirect effects can be felt, for instance, in improved health levels, which increase the productivity of labor, and consequently decrease production costs. Also, environmental goods, either in the form of conserving or improving environmental qualities, can serve as by-products of environmental projects. An example is the employment of more efficient technology by the refinery to reduce crude oil losses, and consequently production cost. This leads to a better environment in the form of less oily waste to dispose of. Similarly, adopting recycling systems would both save a natural resource and minimize effluent volume which contributes to pollution.

As a result the economic benefits of this project can be summarized qualitatively in the following points:

The Phenol Extraction Unit (recirculating phenolic water after removing oil)

- Saving in materials in terms of both the large quantities of water unit used only once, and, consequently, its treatment costs and the cost of wasted phenol.
- Reduction in the frequency of faults caused by oily water being discharged into the sewer system.

Desalter (reuse of saline water discharge from the desalter)

- Reduction in the load of wastewater dumped in the sewer.
- Savings in the total amount of water consumed by the company as well as the cost of treating this large amount of water.
- Reduction of the load on API units, improving their performance, and thus saving on the costs of treating discharged water.
- Slow down of the rate of corrosion in the sewer network and possible breakdown of the system.

Cooling Water (use of cooling water blown down as seal water on high temperature pumps)

- Reduce the amount of water consumed by the company.
- Reduce the load on the existing treatment plant (both from oil and sludge).
- Convert sludge wastes, after treatment, into a useful product.

J2b. Reduced Negative Environmental Impact on Lake Mariout

The discharge of large amounts of cooling water to Lake Mariout over the years has led to a serious state of thermal pollution in the lake. Negative impacts, such as decreased solubility of oxygen in the receiving water and the promotion of anaerobic biological activity, have adversely affected the aquatic life in the lake. The control of the pollutant load of wastewater effluents from the EAPR that are directly discharged into the lake are likely to contribute to improving its water quality.

J2c. Improved Pretreatment Efficiency

The techniques introduced within this subproject for better separation of oil and water mixtures will not only allow for recycling of water but will improve the quality of the wastewater effluents requiring pretreatment, thus improving efficiency of the systems. Furthermore, the subproject team has developed a monitoring program that could be used as a tool for early fault detection within the pretreatment process.

J2d. Reduced Pollutant Load Discharges into the Pipes System

The effective removal of the oil and phenol from the refineries effluents will reduce the recurrent formation of the highly corrosive hydrogen sulphide and other sulphur compounds and thus alleviate their destructive impact on pipelines.

J2e. Reduced Fire Hazard at EAPR

The reduction of the oil content in the effluents and its subsequent recovery will reduce the likelihood of fire that is posed by the accumulation of oil layers on the circulating waters within the refinery water system.

J2f. Water Conservation

The introduction of water recirculating systems is likely to reduce the overall water consumption by the refinery. In-house measures described and economically assessed by the subproject team for reuse of wastewater from one process to another will reduce the water consumption by the refinery and support the adoption of cleaner technology concepts.

K. Subproject No. 57: Process Development for the Utilization of Steel Slag at the Egyptian Copper Works (ECW) in the Construction Industry

Awardee:	Environmental Studies Department, Institute of Graduate Studies and Research, Alexandria University	
End-User:	Egyptian Copper Works (ECW)	
Principal Investigator:	Prof. Dr.Mohamed Esam El Rafey	
Period:	14/04/1994 - 14/10/1995	
Budget Breakdown:		**LE**
USAID/STC	$ 139,600 and LE 227,767	**702,407**
In Cash	GOE None End-user None	**None**
In Kind	GOE 50,000 End-user 50,000	**100,000**
Total		**802,407**

K1. Subproject Description

This subproject aims to determine the potential usefulness of steel slag within the construction industry at large and its application as a coarse aggregate to concrete composition in particular.

Slag is formed as a nonmetallic melt during the thermal reduction of metallic ores to the metallic state. The term slag also applies to molten materials produced during other processes such as coal combustion or phosphorus production. Slag has the important function of removing undesirable impurities from the metal, and is produced as a by-product in the conversion of pig iron and/or scrap steel. In terms of its composition, steel slag closely resembles Portland cement.

With the exception of the Helwan Iron and Steel Company that reuses its blast furnace slag and its Thomas Convertor slag in the manufacture of cement and fertilizers, respectively, Egyptian iron- and steel-making companies are experiencing difficulties in disposing of the large quantities of slag resulting from their industrial processes. Currently employed disposal practices of slag in Egypt result in significant environmental pollution impacts. The Egyptian Copper Works (ECW) Company in Alexandria is one of the few companies that have made large investments to
dispose of its slag.

The use of wastes as substitutes to naturally occurring substances in the construction industry is a trend that serves to reduce waste volumes, promotes natural material conservation, reduces diggings, and preserves land. Metallurgical slag arising as a by-product of metal refining processes has been widely used as building material. Copper slag is used in road markings, lead slag in landfilling, zinc slag as fine aggregate, nickel slag in brick making, and tin slag as road-making material.

A considerable amount of research has been conducted worldwide on the characterization and usefulness of steel slag as a primary raw material in the construction industry. To this end, the subproject team undertook an extensive literature survey aimed at investigating studied applications of steel slag for three main purposes:

- As an aggregate for road construction
- As an aggregate for concrete manufacture
- As an aggregate for concrete used for wave breakers

Blast furnace slag as a by-product of iron manufacture is an example of how this type of waste could be potentially useful within the construction industry. The results of the literature survey identified two major applications, the nature of which determines the way in which the slag should be processed. One alternative is to tap the slag and allow it to air cool until a dense material is formed that could then be used as aggregate. Another alternative is to granulate the slag by rapid quenching. The formed granules are dried and ground to a fine powder.

As indicated in the subproject's technical reports, ground granulated blast furnace slag has superior cementitious properties particularly when combined with Portland cement. Over the past two decades, it has repeatedly been used as an additive to the concrete mix.

The ECW produces steel using two types of furnaces, the open hearth and electric arc ones. Both furnaces are designed to operate using steel scrap and pig iron with a proportion of 2/3 and 1/3 of the charge, respectively. The efficiency of the furnaces influences the quality of steel produced and the quality of the slag formed.

The subproject team conducted a series of chemical analyses for samples of steel slag produced by the different furnaces at the ECW in order to examine their composition and determine alternatives for their further application. The results of the analysis indicated that the expansive nature of steel slag is a limitation to its usefulness despite its other desirable physical and chemical engineering properties. The subproject team thus concluded that controlling the expansion characteristics of slag is important to enhance its application.

Having identified its individual properties, the subproject team extended the scope of their analysis to include the identification of slag properties when combined with other materials such as asphalt and cement mixtures. Fresh and old samples of slag were also analyzed to determine the differences in quality with time.

Mineralogical analysis of slag samples was also conducted using optical microscopic and X-ray diffraction techniques. The mineralogical characterization of slag produced by both types of furnaces define its porosity, its performance in sulphate solution, its morphology, and its stability in the presence of cement, as reported by the subproject team. The results of the analysis showed no signs of a deleterious reactions between steel slag aggregate and the cement paste.

The standard limits of the Egyptian code for coarse aggregate were used to compare cement and asphalt concrete with the various properties of slag. Results were tested against those of lime stone concrete. The cement content, water cement ration, and aggregate cement ratio ranged from 350 to 550, 0.45 to 2.9, and 3.1 to 5.34 by weight, respectively, for lime stone concrete. The aggregate cement ratio for slag concrete ranged from 3.7 to 6.4 by weight. Cube compressive strength, splitting, and flexural strengths and modules of elasticity for both types of concrete were also tested. The additional statistical analysis conducted by the subproject team

concluded that properties of steel slag concrete and lime steel concrete are similar and that there are no significant differences between the two types.

The subproject team finally implemented a comparative study at ECW investigating the properties of slag concrete and gravel concrete. Their results indicated that properties of concrete were greatly improved when slag was used as a coarse aggregate. On the basis of their extensive analysis and investigation, the subproject team proposed the following as appropriate applications for slag produced by the ECW:

- Aggregate in road foundations and road surfaces
- Aggregate in concrete
- Additive to Portland cement or as a raw material for manufacturing of cement clinker

K2. Subproject Achievements

K2a. Economic Benefits

Steel slag produced at ECW is considered an industrial waste with no effective use. This project explores using this waste material as an alternative to naturally occurring aggregates in the construction industry. This would help reduce the accumulation of waste tips, which is a relatively minor role.

The major reason for encouraging the use of these waste materials is to conserve good quality aggregate materials that can be put to better use elsewhere, thus avoiding disturbance of the landscape caused by the digging of borrow pits to obtain construction materials. From this point of view, there are considerable economic benefits to be gained from the use of ECW waste material.

Technical studies proved that properties of steel slag concrete and lime stone concrete (used in concrete) were similar. No significant difference between them was found, and no sign of any deleterious reaction between steel slag aggregate and the cement paste was detected. Steel slag can thus be used successfully as an aggregate for normal and high strength concrete.

Asphalt concrete containing slag as coarse aggregate proved to sustain high stability. Heavier traffic loading, longer period of service, and lower road maintenance cost should be achieved.

K2b. Alternative for Resource Recovery and Reuse

This subproject offers three viable alternatives for the recovery and use of steel slag which is currently posing a disposal problem in Egypt. With the rapidly growing development sector in Egypt, there is significant potential for creating demand for this type of resource that would also reduce reliance on naturally occurring raw material used for the same purposes.

K2c. Potential for Large-Scale Applicability within Egypt

As stated in the subproject's technical reports, the majority of iron and steel companies are facing financial and logistical problems in order to dispose of their slag. The subproject results should be widely disseminated within this sector in order for the proposed applications for steel slag to be adopted.

K2d. Improved Concrete Quality

The results of the conducted testing and analysis show that the quality of concrete is greatly enhanced by adding steel slag.

K2e. Potential for Reducing Environmental Problems at Solid Waste Dumpsites

Steel slag currently disposed of at open dumpsites presents a number of environmental problems. In addition to unnecessary occupation of space, steel slag is a constraint to proper solid waste segregation.

L. Subproject No. 59: Recovery of Urea and Its Derivatives from Industrial Wastewater of Abu Qir Company for Fertilizers and Chemical Industries

Awardee:	National Research Center	
End-User:	Abu Qir Company for Fertilizers and Chemicals Industries	
Principal Investigator:	Prof. Dr. Abdel Ghani G. Abul Nour	
Period:	01/09/1993 - 01/11/1995	
Budget Breakdown:		**LE**
USAID/STC	$ 101,000 and LE 486,700	**830,100**
In Cash	GOE None End-user None	**None**
In Kind	GOE LE 250,000 End-user LE 250,000	**500,000**
Total		**1,330,100**

L1. Subproject Description

This subproject aims to identify alternative methods for the control of urea-containing industrial effluents emitted from the Abu Qir Company for Fertilizers and Chemical Industries and at investigating their possible recovery into the production process.

Abu Qir is a recently established company that produces nitrogen fertilizers. The industrial complex was constructed in the early 1980s and is located 20 kms east of the Alexandria metropolitan area overlooking the Abu Qir Bay. The overall annual production capacity of the company is 1,325 k tons of nitrate and urea, which account for a 60 percent share of the local market.

The Abu Qir industrial complex comprises two major production lines. The first produces urea and its derivatives, and the second, established more recently, produces ammonium nitrate pellets. In addition, the company has an ammonia production unit with a capacity of 1,000 tons/day. This unit is the first in the region to use low pressure gas as its source of gas supply.

The total wastewater discharges from the Abu Qir industrial complex average 20,000 m3/day, 70 percent of which arises from the cooling cycle. The remaining 30 percent is process water arising from its two main production lines. The nitrate and urea waste streams as well as that of the cooling cycle flow separately until they reach their final discharge point.

The rate of effluent discharges from the urea and the nitrate plants are 1,000 m3/hr and 300 m3/hr, respectively. The nitrogen content of these effluent discharges is constantly discharged into the closed Abu Qir Bay. Efforts to reduce the ammonia content of these effluents include steam stripping of the ammonia in process condenses. This procedure successfully reduces the original ammonia content of the water (600 ppm) by 25 percent. Although the recovered ammonia is recycled, the wastewater with residual ammonia concentration is discharged into vehicles for final disposal outside the plant premises. This creates significant

losses to the company because the final urea concentration in the disposed of wastewater reaches 1 percent/liter representing a loss of 10 tons of urea/hour.

Based on this information, the subproject team undertook two main activities. The first was to characterize the wastewater discharges arising from the various processes and the second was to conduct a technical and an economic assessment of operations taking place that would facilitate the subsequent identification of optimal means for the recovery of urea.

Following a period of investigation and analysis, the subproject team proposed two technological alternatives for effective urea recovery. The first involved the installation of a hydrolyzer for the removal of the urea contained in effluent discharges. The function of the hydrolyzer is to break down the urea into its main gaseous constituents: ammonia and carbon dioxide. Following their recovery, both gases and part of the process waters can be recycled within the process itself. This technological alternative is characterized by having a long payback period which was not favored by the company management at the time of its proposal.

The second alternative proposed by the subproject team is based on the application of the reverse osmosis technique for the recovery of urea and its derivatives from the wastewater stream. Using this technique, the effluent has to be subjected to thermal preconditioning in order to increase its urea concentration prior to its introduction into the membrane system. The effluent is then conveyed to a series of membranes for the removal of salt and inorganic matter. Resulting effluent discharges will be split into two streams: one with a higher concentration of urea (50-70 percent) and another of high quality water. The urea stream is thermally concentrated and finally introduced to the production lines. The high quality water stream, however, is directed to a complementary coagulation/sedimentation treatment process for the removal of residual solids prior to final disposal or reuse.

Both options satisfy the following selection criteria:

- The system should be capable of recovering urea (or derivatives) and water.
- The system should include operations and/or processes that have been proven to be commercially successful in similar applications.
- The system should be capable of tolerating any variations in feed rate and/or characteristics
- The system must satisfy the requirements for wastewater disposal to water bodies according to existing legislation.

Because thermal concentration systems consume much more energy than reverse osmosis systems, the latter system can be considered preferable from the technical and economical points of view.

L2. Financial Analysis

The financial evaluation of this project was based on data obtained from the first technical report of this project. The initial capital expenditures of this project were calculated by using the preliminary construction cost estimates of the proposed system (reverse osmosis) which amounts to LE 12.9 million. Annual operating expenses consist of maintenance, membrane replacement,

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utilities, labor, and so forth. Total operating expenses were calculated at LE 1.648 million annually.

Revenues consist of two main sources:

Recovered Urea:	LE	1,280,000
Treated water:	LE	300,000
Total Annual Gains:	LE	1,580,000

The results of the analysis yielded a negative net present value of approximately LE 13.362 million over the 15-year projected cash flow. This is because annual operating expenses are greater than annual gains leading to annual net deficits throughout the lifetime of the project. Therefore, neither the investment costs nor the annual operating costs can be covered by the total financial returns to this project.

The calculations and assumptions related to the above analysis can be found in the appendix to this document.

L3. Subproject Achievements

L3a. Reduced Pollution Discharges into The Abu Qir Bay

For years the closed bay of Abu Qir has been the final receiving point of highly polluted discharges from the fertilizers company and others located in the area. The implementation of the pollution control and wastewater treatment alternatives proposed within this subproject is likely to reduce the negative impacts of these highly polluted discharges on the quality of water in the bay and its ecosystem.

L3b. Training of Company Staff on the Application of Treatment Technologies

The subproject team provided training to the company's staff members on the implementation, operational monitoring, and maintenance of the treatment technologies. This training is perceived as complementary to the company's efforts to promote awareness on environmental pollution issues and trends for sound environmental management among both management and technical staff members.

L3c. Resource Recovery and Reuse

The application of the proposed technologies for the recovery of urea and its derivatives from wastewater discharges of the company is anticipated to improve the operational capacity of the urea plant by recovering an extra 10 tons/hour.

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L3d. Alternatives for Effective Wastewater Treatment and Pollution Control

The proposed treatment alternatives, particularly reverse osmosis, which was more favored by the company (as opposed to the use of the hydrolyzer), are easily operated and maintained. They are low cost alternatives that may currently be promoted as effective and economic procedures for the removal of inorganic waste loads and in certain instances the removal and concentration of some organic constituents.

Projected Cash Flow and Financial Returns (in LE 000's)
for the Reverse Osmosis System Proposed for Concentrating Urea Solution.

(LE 000' s)

Description	Pre-construction	Projected 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CAPITAL EXPENDITURES																
Installed equipment	8,570															
Electrical and control	860															
Civil and complementary works	860															
Contingencies and engineering	2,610															
Total Cap. Exp.	12,900															
O & M EXPENSES																
Maintenance		429	449	472	495	520	546	574	602	632	664	697	732	769	807	847
Membrane replacement		125	131	138	145	152	160	168	176	185	194	204	214	224	236	247
Utilities		846	888	933	979	1,028	1,080	1,134	1,190	1,250	1,312	1,378	1,447	1,519	1,595	1,675
Labour		84	88	93	97	102	107	113	118	124	130	137	144	151	158	166
Others		165	173	182	191	201	211	221	232	244	256	269	282	296	311	327
Total annual expenses		1,648	1,730	1,817	1,908	2,003	2,103	2,208	2,319	2,435	2,557	2,684	2,819	2,960	3,108	3,263
ANNUAL GAINS																
Savings in raw material		1,280	1,344	1,411	1,482	1,556	1,634	1,715	1,801	1,891	1,986	2,085	2,189	2,299	2,414	2,534
Savings in cost of steam		300	315	331	347	365	383	402	422	443	465	489	513	539	566	594
Total savings		1,580	1,659	1,742	1,829	1,920	2,017	2,117	2,223	2,334	2,451	2,574	2,702	2,837	2,979	3,128
ANNUAL SURPLUS (DEFICIT)	-12,900	-68	-71	-75	-79	-83	-87	-91	-96	-100	-106	-111	-116	-122	-129	-136
NPV (Discount rate 12%)	-13,362															

Assumptions :

The capital expenditures are represented by the actual costs of the proposed system (Reverse Osmosis System)

Lifetime of the project is 15 years

The basis for calculating operating expenses are as follows :

- Maintenance : 5% of installed equipment cost
- Membrane replacement : at LE 0.4/m3 as an average
- Electricity : 1.74 million Kwh/year at LE 0.23/Kwh
- Steam : 14850 ton/year at LE 30/ton
- Labour : 14 persons, average salary LE 7000/year

Operating expenses and annual gains are inflated by 5% annually

Cost of Capital 12%

Annual gains consist of the quantity of Urea and treated water recovered multiplied by the unit price

All figures are based on data obtained from the technical report No. 1 of the project

The research team is led by Principal Investigator Prof. Dr. Abdel Ghani M. G. Abulnour.

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M. Subproject No.68: Industrial Wastewater Treatment at 6th of October City

Awardee:	National Research Center	
End-User:	6th of October City and Two Selected Factories	
Principal Investigator:	Prof. Dr. Fatma El-Gohary, Water Pollution Control Division, NRC	
Period:	1/11/1994 - 01/07/1995	
Budget Breakdown:		**LE**
USAID/STC	$6,000 and LE 688,570	**70897**
In Cash	GOE None End-user None	**None**
In Kind	GOE None End-user None	**None**
Total		**70897**

M1. Subproject Description

This subproject aims to develop an industrial wastewater management program for the 6th of October City as part of an overall integrated wastewater management plan for the city. The use of an integrated approach serves to enhance the efficiency of the already existing municipal wastewater treatment network that also receives industrial discharges and provides opportunities for reuse of treated wastewater within the city.

The 6th of October City is one of the recently developed communities in Egypt. Established in 1979 and strategically located in Giza governorate 38 kms southwest of Cairo, the city was intended as a satellite development that would promote the mobilization of the population and industrial activities from congested cities such as Cairo and Giza to new human settlements. The city stretches over an area of 360 million sq m, which is equivalent to the size of the Alexandria metropolitan area. The city's eastern and southern borders overlook the Cairo-Alexandria and Cairo-El Fayoum roads, respectively, rendering it an easily accessible industrial center. Industrial, recreational, and residential areas within the city are categorically located based on a detailed physical plan.

The industrial zone of the 6th of October City is situated at its southwestern limits. It is comprised of four subzones that have been designed to accommodate 847 factories representing different industrial sectors. At the time of this subproject, 351 factories were in operation, 156 under construction, and the remaining 340 still being planned. Industrial facilities are grouped in designated areas based on their compatibility with one another.

One of the prominent infrastructure features of the city is that the main municipal wastewater system has been designed in such a way so as to receive mixed industrial and domestic effluents, given that they comply with the national standards for discharge in public sewers. The system employs a series of oxidation ponds for the biological treatment of these effluents. However, with the growing industrial development in the area and the subsequent increase in discharges of varying characteristics, serious problems have been encountered in

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relation to wastewater management that relies mainly on the application of the slow aerobic oxidation procedure.

As a step toward the enhancement of the existing biological treatment process, the city council constructed an activated sludge system. Furthermore, industrial facilities will have to acquire licenses to discharge into the central system in order to ensure the compliance of their effluents with the quality standards for discharges into sewers as set by Law 93/1962 and its Amendment No. 9/1989.

To this end, the subproject team initially undertook a detailed assessment of the city's industrial activities that comprised a zonal characterization and quantification of industrial wastewater streams. This was followed by an identification of the major polluting sources and the proposal of a number of feasible mitigation alternatives.

Data was collected from the General Organization for Industrialization (GOFI) and the city council on 25 major industrial groupings within the city. An assessment of the efficiency of the existing treatment system was also conducted analyzing samples taken from the final pumping station and the oxidation pond system. The information and data gathered was fed into an industrial pollution monitoring database that was set up by the subproject team.

Based on the data collected and the results of the analysis, a pilot monitoring program was designed and launched in a selected number of factories (119). As part of this preliminary industrial waste auditing, effluents from these factories were characterized to facilitate prioritization among factories based on the type of pollutants and the quantity of their daily discharges. Forty-five of the 119 factories initially audited were selected as being priority factories where more detailed audits would be conducted by the subproject team.

The results of the detailed audits indicated that 36 of the 45 factories discharged effluents that were not in compliance with the national standards. Accordingly, the subproject team proposed a number of in-house measures that would serve to pretreat these effluents prior to their discharge into public sewers. These measures were tested by the subproject team in some of these factories.

Finally, the subproject team prepared environmental and public health impact statements relating to the existing wastewater management practices based on the data and information that they gathered during the course of their work.

M2. Financial Analysis

A financial evaluation cannot be performed on this project because developing an industrial wastewater management program for 6th October City is an intangible activity that cannot be measured quantitatively. However, the success of this project can be measured by achieving its objectives in the long run.

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M3. Subproject Achievements

M3a. Economic Benefits

The economic benefits of this project can be qualitatively measured and appreciated examining the disadvantages that otherwise would result if the project's objectives were not implemented.

The analytical data for the 45 samples collected from the factories during the sampling program showed that only four of these samples complied in all respects with the requirements of law 93, whereas 35 failed to comply with BOD and/or COD standard only.

Discharging effluents that do not comply with the law standards, leads to many negative effects as follows:

1. Effects on the Existing Sewage Collection System

- High pH effluents result in the corrosion of concrete and metal fittings (e.g., Egyptian Clothing Co.).
- Cyanide or sulphide could be released inside the sewer.
- Alkaline effluents may dissolve oils and grease causing problems elsewhere and can release ammonia in its gaseous form, which could be a health hazard.
- Suspended matter present in excessive quantities may lead to blockage of pipes and consequently to flooding of the sewage system (e.g., food industries, paper, marble and granite, and soap factories).
- Heavy loads of oil and grease can also lead to blockage of pipes, particularly when they are of animal origin and occur in conjunction with suspended matter (e.g., Qangari Meat Processing Company, Modern Paint Company, and General Motors).

As a result of the above, the existing sewerage network is badly affected and maintenance costs are increased although the lifetime of the system is decreased.

2. Effects on the Biological Wastewater Treatment Facility (the biologically based treatment plant)

- Oil and grease coat structures and reduce transfer from air to sewage, thus accelerating the onset of anaerobic conditions. They may also kill micro-organisms active in biological processes.
- Heavy metals are toxic to bacteria and may thus affect biological treatment processes.
- Detergents are active surface compounds and therefore reduce oxygen transfer leading to inefficient treatment processes.

3. Effects of Contaminated Treated Industrial Effluents

From the above, it is clear that effluents contain components that affect the sewage treatment process. As a result, the final effluent from the Biological Wastewater Treatment Facility which is supposed to be used for irrigation purposes becomes contaminated. This has a number of economic implications:

- The contaminated irrigation water negatively affects agricultural crops leading to a smaller and weaker harvest.
- Soil continuously irrigated by such water becomes contaminated and no longer suitable for agricultural uses.
- Contaminated soils can leach chemicals leading to contamination of groundwater sources.

4. Effects on the Proposed (under construction) System (activated sludge wystem)

This system should produce sludge to be used as soil conditioner or fertilizer. Hence, if this sludge contains toxic substances it would be accumulated in the sludge, making sludge unusable.

As a result, the development of the industrial wastewater management system proposed by this project is essential for the sustainable development of the city. This management system proposes a pollution-prevention approach inside the factories and engineering solutions for end-of-pipe effluent whenever required.

The implementation of these recommendations would lessen or eliminate the existing problems of the industrial wastewater not complying with the standards and thus save costs incurred on maintenance. It would also save on the costs of constructing new systems as well as ensuring the growth of healthy crops and the maintenance of suitable soil and clean groundwater sources. In addition, the management system proposed can be used as a model for all new cities.

M3b. Setting a Framework for Efficient Wastewater Management in the 6th of October City

The various outputs of this subproject include the proposed in-house control measures for pretreatment of industrial effluents, the pollution monitoring program and the industrial pollution data base. They can be considered as a framework for further planning and monitoring within the wastewater management sector in the city.

M3c. Environmental and Public Health Statements for Wastewater Management Practices in the 6th of October City

The environmental and public health statements prepared by the subproject team will serve as a baseline for future monitoring activities and the data included could be used as indicators for evaluating progress.

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M3d. Demonstration of Sound Environmental Practices Relating to Industrial Pollution Control

This subproject has offered several opportunities to demonstrate a number of concepts relating to industrial pollution control. These include industrial auditing, pretreatment of highly polluted effluents, pollution monitoring and environmental and public health assessment.

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N. Subproject No.70: Treatment of Industrial Wastewater of Small Discharges for Greater Cairo

Awardee:	The Technical and Technological Consulting Studies and Research Fund (TTCSRS)	
End-User:	General Organization for Sanitary Drainage	
Principal Investigator:	Eng. Mohammed Dia El Din Tantawy	
Period:	01/10/1994 - 30/06/1995	
Budget Breakdown:		**LE**
USAID/STC	$5,000 and LE 905,150	**922,150**
In Cash	GOE None End-user None	**None**
In Kind	GOE LE 216,000 End-user LE 250,000	**466,000**
Total		**1,388,150**

N1. Subproject Description

This subproject aims to design and to develop the technical specifications for prototype wastewater treatment facilities. The treatment facilities are intended to cater for the needs of a selected group of chemical, engineering, and metallurgical industries with small wastewater discharges of less than 500 m3/day. The selected industries are located in the Greater Cairo region.

Within the greater Cairo region, the Helwan area was further selected as the focal location of this subproject. The selection was based on the long-standing industrialized profile of the area which is considered a national industrial base. This is partly because of its strategic location at the southern east border of the greater Cairo region and also because it accommodates the national iron and steel industry and some other large scale metallurgical industries.

The industrial facilities in the Helwan area are either publicly owned or military owned enterprises. Even though their number does not exceed 100 facilities, their large scale has had significant impacts on the progress of urbanization and environmental quality within the Helwan area.

Generally speaking, the efficiency of metal production operations is dependent on the use of large quantities of water. In some of these operations, such as metal rolling, galvanizing, and electroplating, lubricants and inorganic chemicals should be used. Accordingly, resulting wastewater effluents are characterized by their high pollutant content. Particular concerns usually arise in relation to pH levels, oil and grease content, and the levels of suspended matter, organic matter, and heavy metals in these discharges.

Over the past 40 years, most industrial facilities in Helwan liberally discharged their mixed untreated effluents directly into the Nile. The exception were a few facilities that had

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adopted some imported measures for effluent pretreatment. These included the installation of oil separators and the sedimentation of suspended matter. The operation and maintenance of these measures were rather problematic because of the high costs and unavailability of spare parts for the imported equipment in the local market and the deficiency of specialized technical skills.

With the recent construction of the new municipal wastewater treatment plant (MWWTP) in Helwan, factories were requested to direct their effluents for discharge into the municipal sewer for treatment at the new plant. The uncontrolled discharge of untreated mixed industrial wastewater along with the municipal wastewater stream initiated a number of operational problems at the new plant. These problems were because of the contamination of the municipal treatment system with the high pollutant load that incapacitated the operation of its biological processes. Results of sludge analysis point to high concentrations of heavy and toxic metals further confirming the inefficiency of the treatment process. These highly polluted industrial effluents passing through the municipal sewer system and pipes also had their adverse impacts on its structural maintenance and functional capacity.

To this end, the subproject team undertook a preliminary survey of industrial facilities in the Helwan area. The survey was conducted with the assistance of General Organization for Industrialization and the local authorities. Initially, 44 publicly and military-owned industrial facilities were screened, and, finally, 22 industries were selected as sites for more in-depth auditing of their processes.

The auditing program was jointly carried out with the Tebeen Institute for Metallurgical Studies. The objectives of the program were to characterize the final effluent stream from these industrial facilities and to determine the type and concentration of pollutant arising from its individual processes.

Results of the analytical procedures indicated that the majority of these facilities' discharges did not comply with the legal standards. Based on the audit results, the subproject team, using a database software, developed a matrix as a tool for action prioritization among these industrial facilities. Criteria for prioritization set by the subproject team included pollutant types and concentrations, discharge rates, and willingness and commitment of the management to participate in action implementation. Using the selection matrix, seven industrial facilities were considered priority areas requiring immediate action planning.

The subproject team investigated a number of wastewater treatment alternatives taking into account their technical feasibility, operational efficiency and economic viability. Successfully, the team designed and set the specifications for two prototype modular equipment packages. The first is designed for the treatment of cyanide wastestreams with a flow rate of 1 m3/hr. The second is for oil and grease removal from industrial wastewater at a flow rate of 5 m3/hr. The two packages are characterized by being small in size to facilitate their placement on the industries' premises. In addition, the operational design of the packages is flexible allowing for the combination of more than one modular equipment in the case of any changes that the industries may introduce to their processes.

N2. Subproject Achievements

N2a. Economic Benefits

This project is concerned with the design, implementation, and assessment of a prototype for industrial wastewater treatment for industries of small discharge (below 500 m3/day).

The analytical data for the 22 samples collected from the factories during the field survey showed that 40 percent of the collected samples violated limits for COD, and only 7 had higher BOD levels than permitted by law. In addition, oil and grease limits have been exceeded in many samples, and other major pollutants like cyanides and heavy metals have reached alarming levels in some samples.

Discharging effluents that do not comply with the law standards can cause severe deterioration of the sewer piping and fabrics. Also, the new MWWTP in the Helwan area is adversely affected by the contamination of undesirable pollutants. This obviously reduces the efficiency of the treatment plant and incapacitates the biological treatment technologies.

Adopting the pretreatment technology package proposed by this project, would, in the future, set the foundations for a completely new industry for locally manufactured equipment required for wastewater treatment at the factory level. Accordingly, a reduction in overall equipment cost will be achieved. In addition, new job opportunities would be created and hard currency saved.

N2b. Opportunities for Cleaner Technology in Major Industries in the Helwan Area

Characterization and separation of wastestreams at the factory presents opportunities for water conservation, in general, and recycling of cooling water, in particular. The results of the audits could also facilitate the identification of problem areas and solutions to address them, serve as a basis for future monitoring and targeted planning for industries in the Helwan Area

N2c. Reduced Pollutant Load Discharges into the Municipal Sewer System

The prototype modular equipment packages designed within this subproject are expected to reduce pollutant load discharges into the municipal sewer system

O. Subproject No. 71: Industrial Wastewater Treatment and Efficient Utilization of Water in the Industrial Process at Misr Beida Dyers Company

Awardee:	Chemical Engineering and Pilot Plant Department National Research Center	
End-User:	Professor Dr. Azza Ibrahim Hafez	
Principal Investigator:	Misr Beida Dyers Company	
Period:	01/10/1994-30/06/1995	
Budget Breakdown:		**LE**
USAID/STC	$ 6,000 and LE 614,004	**634,404**
In Cash	GOE None End-user None	**None**
In Kind	GOE LE 216,000 End-user LE 250,000	**725,800**
Total		**1,360,204**

O1. Subproject Description

This subproject aims to develop economical and environmentally sound processes by which hazardous wastes generated at Misr Beida Dyers Company can be managed.

Misr Beida Dyers Company is a large industrial enterprise made up of two main plants and an extension facility. The company is located in Kafr El Dawar in Alexandria Governorate. The company's major activities consist of finishing, dyeing, and printing of raw cotton, wool, and yarn. The company is considered a major source of pollution within Alexandria Governorate because of a total of 10-18 million cubic meters of wastewater discharge from its facilities into Abu Qir Bay.

Initially, the subproject team conducted a fully fledged industrial audit in the two plants and the adjoining extension facility. Based on the audit results, a housekeeping program was designed. The audit assessed in detail the cotton preparation processes which are described in the following paragraphs.

O1a. Singeing

The aim of this process is to obtain a smooth surface for and to remove fuzz from grey cotton cloth. This is done using two singeing machines operating with a direct flame technique.

O1b. Desizing and Washing

Using a desizing enzymatic solution that contains a solvent, a detergent, and a nonwetting agent, starch present in the cloth is converted into sugars. After conversion takes place, the solution is discharged via a valve and the cloth is washed.

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O1c. Scouring

This is an operation whereby cotton wax, dirt, and grease are removed. The operation depends on the use of alkali to form soap with any fat-free acids and/or decompose fats. The soap then acts as an emulsifying agent and removes oils and waxes.

O1d. Bleaching

The objective of bleaching is to remove the natural yellowish colors of cotton fibers. This is done using the bleaching agent hydrogen peroxide added to traces of sodium silicate, sodium carbonate, and sodium hydroxide, magnesium sulphate, and an organic stabilizer. Washing takes place using hot and then cold water. The resultant wastewater (80 percent of cloth weight) is discharged through a drain. Following that, the cloth is washed, squeezed, and scutchered into open width form and then dried.

O1e. Mercerization

The dried bleached cloth is impregnated in two series tanks containing 27 percent caustic soda. It is then washed in a special machine that contains chains to stretch the cloth to the desired width. Most important in the process is to ensure that all alkali is removed from the fabric before the tension is relaxed or the fabric will shrink again. The cloth is washed in three steps: two using hot water and the third using cold. Neutralization of the cloth takes place using sulphuric acid. The acidificiation step is followed by three more washings.

O1f. Drying

Mechanical and/or thermal techniques are used to remove water.

The cotton preparation processes described above take place similarly in the two plants and their extension facility with differences only in the scouring and bleaching steps. Both plants use fabrics in rope form until the bleaching step. The preparation processes performed in the extension plant use the fabrics either in rope or open-width form.

As indicated in the subproject's technical reports, wastes from these processes contain a high percentage of natural impurities present in the fibers and process chemicals used. For years, these heavily polluted effluents have had serious environmental impacts, particularly on biological systems in Abu Qir Bay where they are currently discharged. In their assessment of pollution levels at Misr Beida Company, the subproject team reviewed data for the following parameters: total suspended solids (TSS); BOD; phosphates; temperature; toxic chemicals such as phenol, chromium, and heavy metals; PH; oil and grease; sulfides; and coliform bacteria.

Following the assessment, the subproject team conducted a series of bench-scale experiments in order to identify optimum operating conditions for a chemical wastewater treatment system to be built as a pilot plant. The selected flocculants for these series of experiments comprised mixtures of Al/Fe Cl3, and non-ionic and cationic polyelectrolytes. The selected optimum doses were 30 mg/l for inorganic agents and 3 mg/l for organic polymers. Listed below are the experiments that were conducted at this stage of the subproject:

- Suspended solid removal using coagulation and flocculation
- Heavy metals removal by chemical precipitation
- Color removal by adsorption and ozonation

Based on the results of their experiments, the subproject team proposed a design for an integrated chemical treatment system that involves oil and grease separation, neutralization, flocculation, coagulation, adsorption, and sedimentation. The function of the proposed system is to reduce the chemical load of highly and moderately polluted wastewater in order to increase the efficiency of further required biological treatment. This technique will serve to reduce the harmful impact on the biomass likely during the short retention time of the contact stabilization method.

The detailed design of the pilot plant prepared by the subproject team included unit sizing, equipment selection, connections, and instrumentation for a valves and pumps control system. A prototype of the plant was manufactured at the company's workshops under the supervision of the subproject team.

The treatment efficiency of the pilot plant was assessed over a period of two weeks. A number of eight-hour runs at a maximum flow rate of 4 m3/hour were conducted to determine the conditions necessary for achieving the highest removal efficiency rate for COD, BOD-5, and suspended solids for each flocculant.

O2. Financial Analysis

This project explores treating highly polluted textile wastewater generated from Misr Beida Dyers Company at Kafr El Dawar-Alexandria using a chemical treatment plant.

The projects suggests two options for treating wastewater discharged from the factory. These options are:

1. The first option is based on the separation of streams into three kinds: high, moderate, and low-polluted wastewater. The high and moderate-polluted streams are to be chemically treated and pretreated prior to biological treatment. However, both low-polluted streams and domestic sewage are to be biologically treated directly.

2. The second option is based on the separation of streams into two kinds: mixed high/moderate and low-polluted wastewater, where the high/moderate type is to be chemically treated and then mixed with the low-polluted stream (i.e., industrial and sewage) before biological treatment.

A comparative cost analysis was conducted to select the most appropriate option. Results revealed the following:

Description	Alternative # 1	Alternative # 2
Capital Expenditures	LE 8.075 million	LE 8.500 million
Annual operating expenses	LE 1.794 million	LE 1.908 million
Cost of treatment LE/m3 wastewater	1.00	1.07

Although option 2 costs more, the company preferred it because it does not require more infrastructure modifications, and the company seeks to minimize technical supervision. This section tests the feasibility of the project using the Net Present Value method. In order to evaluate this project financially, its capital expenditures and annual operating expenses have been tested against the expected annual gains over the project's lifetime (10 years) to determine the net present value of the project.

According to the data obtained from the fifth technical report of the project, the capital investment costs for the proposed treatment plant is estimated at LE 8.500 million. Annual operating expenses consist of the ongoing expenses such as raw material, utilities, labor, and so forth. Total operating expenses reach LE 1.908 million per year.

The annual revenues (financial returns), however, would not be realized, except after the biological treatment. This is because the level of pollution of the final effluent, after chemical treatment, is still higher than the required standard limits. Therefore, biological treatment is recommended only after the chemical treatment so that the treated water will be suitable for industrial process reuse. As a result, the total revenues have been estimated as follows:

1,740 x 24 x 330 x 0.37 = LE 5.099 million

The projected annual operating costs and financial returns are increased by 5 percent annually to account for the inflation in raw material, energy, salaries, and maintenance.

Results of the above calculations yielded a positive net present value indicating the feasibility of the project.

The calculations and assumptions related to the above analysis can be found in the appendix to this document.

O3. Subproject Achievements

O3a. Economic Benefits

The benefits gained from the recovered water and its reuse in industrial process exceed the cost incurred in the construction and annual operation of the proposed treatment plant. The simple payback period of the plant is thus 28 months. This means it is an economically feasible project and will pay off its costs in a short period of time.

O3b. A Tailored Housekeeping Program for Misr Beida Dyers Company

The program designed by the subproject team is made up of a number of schemes. If these schemes were to be implemented, the pollution hazards currently created by the company's wastewater discharges would be significantly reduced. Of those proposed, a water conservation scheme with the objective of reducing current water consumption by 25-30 percent would also result in the reduction of the quantity of wastewater discharged. Also proposed is the reuse of mercerizing or bleach wastewater through the use of continuous techniques. Counter current washings applied to desize, scour, mercerizing, and bleach washers are likely to yield energy and water savings. They can also be applied to dye ranges and print house soapier ranges.

O3c. Establishment of an On-Site Wastewater Treatment Pilot Plant

The success of the pilot treatment operation, as indicated by the results of the assessment and the fact that the pilot plant was manufactured at the company's workshops, indicates the feasibility of undertaking such treatment on a larger scale to accommodate a larger number of dyeing companies' discharges. From the technical, operational, and economic perspectives, the pilot plant designed within this subproject has been proven as a viable intervention, as indicated by the subproject's reports, and has helped to further define the viability of on-site wastewater treatement at Misr Beida Dyers Company.

O3d. Potential for Wider Applicability in the Egyptian Dyeing Industry

The audit procedures undertaken at Misr Beida company could be applied to similar industrial facilities. For those using the same raw material and processes, the waste characterization already conducted for Misr Beida Company can be referred to as the basis for a tailored housekeeping program for minimizing discharges.

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Projected Cash Flow and Financial Returns (in LE 000's)
for the Designed Chemical Treatment Plant

(LE 000' s)

Description	Pre Commissioning	Projected 0	1	2	3	4	5	6	7	8	9	10
						4 years						
CAPITAL EXPENDITURES												
Installed equipment cost	6600											
Measurement & control instrument	90											
Piping	180											
Land	0											
Site development	60											
Contingency	180											
Engineering & supervision	180											
Size factor	811											
Total Cap. Exp.	8101											
O&M EXPENSES												
Raw materials		333.90	334	334	334	334	334	334	334	334	334	334
Utilities												
Water		27.9	28	28	28	28	28	28	28	28	28	28
Electricity		485.0	485	485	485	485	485	485	485	485	485	485
Maintenance		431.2	431	431	431	431	431	431	431	431	431	431
Services and analysis		50.0	50	50	50	50	50	50	50	50	50	50
Administration		190.8	191	191	191	191	191	191	191	191	191	191
Insurance		81.0	81	81	81	81	81	81	81	81	81	81
Labor		84.0	84	84	84	84	84	84	84	84	84	84
Total O & M Expenses		1,684	1,684	1,684	1,684	1,684	1,684	1,684	1,684	1,684	1,684	1,684
ANNUAL GAINS												
Treated water		5099	5,099	5,099	5,099	5,099	5,099	5,099	5,099	5,099	5,099	5,099
Total Annual Gains		5,099	5,099	5,099	5,099	5,099	5,099	5,099	5,099	5,099	5,099	5,099
Annual Surpluses (Deficits)	8,101	3,415	3,415	3,415	3,415	3,415	3,415	3,415	3,415	3,415	3,415	3,415
NPV (Discount rate 12%) (for 10 years)	19,296											

Assumptions :
The capital expenditures are represented by the estimated cost for chemical treatment plant
for High/Moderate polluted industrial wastewater of Misr Beida Dyers company
Life time of the project is 10 years
Operating expenses are inflated by 5 % annually.
Annual gains are calculated as follows : (1740 X 24 X 330 X 0.37 = LE 5.099 million
Cost of Capital is 12%
All figures are based on data obtained from the technoeconomic study of the project in the 5th technical report
The research team is led by Principal Investigator Prof. Dr. Azza Ibrahim Hafez

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P. Subproject No. 72: Extraction of Chitin from Sea Food Processing Wastes on Laboratory and Semi-Pilot Sectors

Awardee:	National Research Center	
End-User:	El Nasr Company for Auxiliary Chemicals (NCIC)	
Principal Investigator:	Professor Dr. A.I. Waly	
Period:	15/10/1994-14/07/1995	
Budget Breakdown:		**LE**
USAID/STC	$ 0 and LE 113,200	**113,200**
In Cash	GOE None End-user None	**None**
In Kind	GOE 50,000 End-user 50,000	**100,000**
Total		**213,000**

P1. Subproject Description

This subproject aims at identifying local sources of chitin and chitosan in order to determine the possible range of their applications on the local level and to assess potential domestic demand among end-users.

Chitin occurs as a major organic skeletal substance of invertebrates and as a cellular constituent of lower plants such as fungi and green algae. Sources of chitin are available in abundance worldwide and it is considered a renewable natural resource that poses little threat as a toxic pollutant. A limited part of the resource found in crabs, shrimps, prawns and krills is being exploited by the marine food industry mainly in the production of canned crab meat. Shell waste is a considerable source of chitin as are fungi grown in fermentation systems producing citric acid, antibiotics and enzymes.

Chitin can be deacetylated to produce chitosan, a material of some commercial significance. It has found an important application within the medical and pharmaceutical products sector, being a useful ingredient in medicines for enhancing digestion, stimulating tissue healing, and reducing scar formation. Chitosan is also an ingredient in a number of cosmetic products.

Both chitin and chitosan feature the property of bicompatibility, i.e., their ability to break down inside the human body into by-products that can be reused by the body.

Chitin and chitosan products have demonstrated a multitude of uses worldwide. Most outstandingly has been their applications for heavy metal removal from some effluents arising from textile mills, tanning industries, and metal finishing. They have also been successfully applied to ultrapure water production and specific potable water treatment from underground sources.

The subproject team has thus undertaken an extensive literature survey to investigate and compare state-of-the-art technologies used for chitin and chitosan production and application. After

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identifying and assessing alternative technologies for the extraction and useful application of chitin and chitosan, the subproject team conducted an in-depth market study. The objectives of this study were to identify local sources of chitin and chitosan, to quantitatively estimate the possible production from these sources, and, finally, to determine the potential market demand for their various applications.

Local sources of these wastes were categorized into groups as follows: fish processing plants, large urban markets, and significant provincial markets. The subproject team has produced estimates of total and breakdown of fish production by source in Egypt up to the year 2000. The analysis within this subproject was confined to sources of fish and shell wastes where central collection via cooled trucks was feasible.

During the course of the project, chitin was successfully extracted on a laboratory scale from locally available sources. This was based on extensive analysis of locally available shrimps and crab shells. Several experiments were conducted by the subproject team to identify the most feasible extraction technology for chitin production from shell wastes. The technical process developed includes the following steps: dehumidification, drying, and final extraction. The chemical reactions involved in the process are decalcification, deproteinization, and/or pigment or heavy metal removal by repeated solvent extraction.

Based on their various applications and a practical recovery rate of 60 percent from the original chitin yield, the subproject team has estimated the minimum annual demand for chitin-based chemicals (CBCs) as ranging between 220 and 600 tons/year.

The subproject team further identified a number of useful applications of chitin and chitosan in Egypt. They are as follows:

- Heavy metal removal for industrial effluents generated by textile mills, metal works, and tanning industries.
- Decoloration of textile mill effluents.
- Ultra pure water production.
- Treatment of potable water containing iron and manganese from underground supplies.
- Pharmaceutical and medical applications.

P2: Financial Analysis

The financial evaluation of this project has been based on the data obtained from the final report of this project. The principal investigator is Prof. Dr. Ahmed I. Waly. The analysis here is based on constructing a projected cash flow over the life time of the project. The net present value of the project is then reached by testing the capital investment and annual operating expenses against the expected annual revenues in order to test the economic viability of the project .

The initial capital expenditures of this project is calculated by using the local cost data for potential locally manufactured items and on published international prices for imported components . Total capital expenditures for the project reached LE 0.833 million. Annual operating expenses

consist of materials, utilities, labor, maintenance, and so forth. Total operating expenses have been calculated to reach LE 0.205 million annually.

However, the revenues were calculated based on the assumption that the chitosan price is 7US$/kg; accordingly, annual expected revenues amount to LE 0.690 million

The results of our analysis gave us positive net present value of approximately LE 2.342 million over the 15-year projected cash flow. This is because annual operating expenses are less than annual gains leading to annual net surplesses throughout the lifetime of the project. Therefore, the investment costs and the annual operating costs are covered and exceeded by the total financial returns of this project.

The calculations and assumptions related to the above analysis can be found in the appendix to this document

P3. Subproject Achievements

P3a. Economic Benefits

Food processing wastes require considerable effort and expense for safe treatment and disposal. Converting wastes into valuable products provides an opportunity to improve the quality of the environment while creating opportunities for the establishment of new technologies. This project will:

- Introduce new extraction techniques for chemicals which are useful for waste treatment and also for wet processing of textiles.
- Create new job opportunities through the new industry formed.

The economic benefits of chitin recovery are not limited only to reducing the costs of waste disposal in the seafood processing industry. The generated annual financial returns of the process, as shown above, are substantial, as is the reduction of costs to other industries using chitin for their waste treatment.

P3b. Establishment of Framework for Local Market Development

This subproject could be considered a successful initiative toward the development of a market for recovery and reuse of chitin and chitosan, which are currently being treated as wastes in the form of seafood processing by-products. In order to develop this market, the following activities are recommended:

- Raising awareness among identified producer and user groups to the various applications of chitin and chitosan.
- Establishing expertise in processing and application techniques.

P3c. Promotion of Sound Environmental Trends Locally

Through the experimental recovery of chitin and chitosan, this subproject has successfully demonstrated, on the local level, an application of current environmental trends: mainly resource recovery and utilization. The identification of potential producer and user groups together with the extensive literature compiled within this subproject should facilitate future work pursued in this field.

Science and Technology Cooperation Project

Subproject No. 072 -

Extraction of Chitin from Sea Food Processing Wastes on Laboratory and Semipilot Scales

Projected Cash Flow and Financial Returns (in LE 000's)

(LE 000' s)

Description	Pre-commissioning	Projected 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CAPITAL EXPENDITURES																
Equipment	470															
Installation	56															
Piping	14															
Electrical Installation & Instrumentation	38															
Civil Works	47															
Others	0															
Deferred Revenue Expenses	156															
Working Capital	51															
Rehabilitation							134					216				
Total Capital Expenditures	833	0	0	0	0	0	134	0	0	0	0	216	0	0	0	0
O&M EXPENSES																
Materials		114	114	114	114	114	114	114	114	114	114	114	114	114	114	114
Utilities		35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
Labour		30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Maintenance		16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
Administrative		10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Others		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total expenses		205	205	205	205	205	205	205	205	205	205	205	205	205	205	205
EXPECTED REVENUES																
Financial Returns		690	690	690	690	690	690	690	690	690	690	690	690	690	690	690
Total Revenues		690	690	690	690	690	690	690	690	690	690	690	690	690	690	690
ANNUAL CASH FLOW	(833)	485	485	485	485	485	351	485	485	485	485	269	485	485	485	485
NPV (Discount rate 12%)	2,342															

Assumptions :

The capital expenditures are represented by the actual investment cost of the project proposed for extracting Chitin

Life time of the project is 15 years

Annual cost and revenues are assumed constant over the life time of the project

Cost of Capital is 12%

Rehabilitation valued at 10% of initial investment cost every five years inflated by 10% /year (compounded)

Revenues = Expected price x Quantity produced (Chitosan price = 7 $/Kg , Exchange rate = 3.45)

All figures are based on data obtained from the economic feasibility study in the final report of the project

Q. Subproject No. 79: Treatment of Liquid Gaseous and Solid Wastes of El Nasr Company for Intermediate Chemicals

Awardee:	National Research Center	
End-User:	El Nasr Company for Intermediate Chemicals (ENCFIC)	
Principal Investigator:	Dr. Souhair Abuel Ella, Water Pollution Control Department, National Research Center	
Period:	11/01/1994 - 30/06/1995	
Budget Breakdown:		**LE**
USAID/STC	$5,500 and LE 689,562	**708,262**
In Cash	GOE None End-user None	**None**
In Kind	GOE LE 200,000 End-user LE 180,000	**380,000**
Total		**1,088,262**

Q1. Subproject Description

This subproject aims to identify feasible alternatives for the control of the different types of waste resulting from the industrial activities at El Nasr Company for Intermediate Chemicals.

El Nasr Company for Intermediate Chemicals is a military-owned enterprise. The company's industrial complex is located along the Cairo-Alexandria Desert road, and comprises four units that produce chlorine, caustic soda, acetylene, and rodenticide, in addition to mixing and formulating aerosols and pesticides.

Production processes at the chlorine and caustic soda plant results in the generation of slurry and wastewater discharges. The mixture is conveyed to large primary sedimentation tanks where it is left to dry naturally. Resulting solid waste is then scraped off the tanks, collected, and dumped outside the plant.

Another example is the production of acetylene, which is formed as result of a reaction between calcium carbide and water. The reaction produces a slurry mainly composed of calcium hydroxide (85 percent). The slurry is collected and transported outside the plant to dry off its natural content.

The wastes generated from these two production lines constitute the major bulk of solid waste generated within the industrial complex. An additional contribution to the solid waste problem at El Nasr Company is the stacks of cellulose formed on the company's premises, which constitute a serious fire hazard.

The company also produces rodenticides through a combustion process that uses zinc and phosphorus. The process takes place in steel vessels, and the resulting gaseous emissions (P2O5) are extremely hazardous to the working environment.

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However, production of pesticides at this particular facility is done by mixing ingredients that have no complex chemical reactions. Nevertheless, the resulting wastewater from the mixing process is described as a hazard containing stream that is discharged on the factory premises, leading to groundwater pollution of the surrounding neighborhood.

The subproject team initiated their activities with a detailed characterization of liquid, solid, and gaseous wastes generated within the industrial complex. The quantity of wastewater discharged from the chlorine and caustic soda factory is 400 m3/day. The content of the slurry discharged from the factory was analyzed and the results indicated that its total hardness was 358 g/l and that it was composed of 41 percent solid and 12 percent volatile ingredients.

The pH of the liquid waste generated was 11.5 as revealed by the results of the analysis. In terms of its composition, it was loaded with inorganic contaminants and salts as indicated by the results yielded by electrical conductivity testing.

Investigation and analysis of the slurry generated at the acetylene plant showed 83 percent moisture content. Further analysis of the dried slurry indicated that it was made up of 83.3 percent calcium hydroxide, 1.1 percent silicate, 5.6 percent iron, and 2.8 percent carbon. It was also reported in the subproject's technical reports that the use of this slurry as low grade raw material had been successful at El Maliya Phosphate Fertilizer Company.

The subproject team also characterized the liquid waste from the pesticide formulation unit. Quantities generated range between 1-2 m3/day. Reports indicate that the resulting liquid waste is treated by the addition of sodium hydroxide. The function of this alkali is to hydrolyze any pesticide content in the water so as to render it biodegradable. This type of treatment is effective in reducing 25 percent of the pesticide content of wastewater that is discharged. The subproject team further emphasized the importance of referring to the Environmental Impact Statement prepared for this factory to determine the exact impact of these discharges on the quality of the groundwater.

With respect to the gaseous emissions resulting from the production of rodenticides (zinc phosphide) at El Nasr Company, the subproject team estimated a 10.7 ton/year yield of P2O5 emissions as a result of the processes involved. This type of emission is characterized as being highly irritant, corrosive, and toxic. It reacts strongly with steam water producing heat as a result of incomplete combustion. To this end, the subproject team recommended means to ensure more complete combustion and also to control emissions using wet scrubbers and sand filters.

Because of the likely presence of occupational health impacts, the subproject team conducted a full health appraisal of 300 employees and workers at the pesticide formulation unit to detect clinical and subclinical manifestations of toxicity as a result of gaseous emissions. The appraisal included a full clinical examination and structured interviews using questionnaires.

The team then investigated a number of alternatives for the reuse of cellulose waste accumulating at El Nasr Company. A number of analytical procedures were carried out to produce different grades of cellulose methylene carbamate (CMC) from cellulose wastes. CMC can be applied usefully within the textile industry. Four samples of CMC were produced using a dissolution-precipitation technique and a washing technique using water and alcohol mixtures. Samples were tested against commercial samples and a comparison of their physical and chemical properties was undertaken.

Q2. Financial Analysis

The objective of this project is the management of wastewater, solid wastes, and air pollutants by the company in order to protect the environment and to gain as many benefits as possible from the waste materials. Another objective is to introduce a new technology in Egypt for the production of water-soluble local CMC products.

In the case of El Nasr Company, it is confronted with different types of wastes (liquid, gaseous emissions, and solid wastes) resulting from the company's industrial activity. As mentioned before, the company consists of four major factories each of which produces a different type of waste. This section will therefore deal with each problem separately. Some of them may be evaluated financially (reuse of wastes can result in a financial gain to the company), and some of them may be subjected to a comparative cost analysis in order to choose the most feasible method for the wastes' disposition or reuse.

Q2a. The Chlorine and Caustic Soda Factory

Liquid and solid (slurry) wastes produced from this factory contain inorganic pollutants such as sodium, chloride, sulfate, calcium, and magnesium. Solid waste is dried using sand drying beds that were designed and manufactured for this purpose.

For liquid waste, efforts were directed at minimizing the waste at the source, i.e., reducing the sulfate content in the brine waste. A comparative cost analysis between the conventional method (purging) and the modified method (adding BaCl2 to precipitate the sulfate) was conducted. It revealed the following:

Description	Conventional Method	Modified Method
Operational cost	$179/day	$460/day
After-treatment cost (reverse osmosis)	$330/day	$740/day

Q2b. The Acetylene Factory

The dried waste from acetylene production is mainly Ca(OH)2. The possibility of its reuse as a coagulant for acidic wastes has been proven to be successful. Samples from El Malyia Co., Kafr El Zayat, were subjected to chemical treatment using Ca(OH)2 and the results obtained revealed that Ca(OH)2 is almost as efficient as the laboratory grade lime except that the quantity needed is 50 percent greater.

Testing the feasibility of the Ca(OH)2 reuse requires two steps:

1. Conducting a comparative cost analysis to select the most appropriate scheme for the drying of the slurry.

   Scheme I: Diluted slurry is passed through a settling tank, then the thickened slurry goes on to the furnace for final drying (total cost at 120 km distance = LE 54/ton)

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Scheme II: The thickened slurry from the settling tank is passed through a sand bed filter (total cost at 120 km distance = LE 60/ton)

Scheme III: Drying thickened slurry in a sand bed filter, then passing the filter cake to a furnace for complete drying (total cost at 120 km distance = LE 57/ton)

The results revealed that the best method is drying the thickened slurry in an oven at 105 degrees C (Scheme I) for the following reasons:

- The cost of construction of drying beds is high (LE 25,000).
- The dried sludge will be mixed with some sand which will make it unsuitable for reuse.
- This method would avoid the formation of calcium carbonate in the sand bed filter.
- The cost of transportation is relatively low compared with the other drying techniques.

2. Estimating the financial returns generated for the seller (El Nasr Co.) and the cost savings justification for the buyer (El Malyia or any other company) by using Ca(OH)2 produced at El Nasr Co.,.

Calculations showed that the sale price for one ton of dried lime from acetylene production in El Nasr Co. for intermediate chemicals is (1.5 ton[4] x LE 54 = LE 81. This would result in a cost saving of LE 39/day and LE 11,700/year for the buyer (El Malyia Co. or any other company outside Cairo). The cost savings will be much higher if the produced lime is sold to companies inside Cairo (LE 19,800/year).

Q2c. The Zinc Phosphide Factory

This section tests the feasibility of implementing the phosphorous pentaoxide recovery unit using the Net Present Value method. To evaluate this project financially, its capital expenditures and annual operating expenses were tested against the expected annual gains over the project's lifetime (10 years) to determine the net present value of the project.

The total capital expenditures amount to LE 1.494 million. Annual operating expenses consist of the running expenses, such as raw material, shipping and packaging, labor, and so forth. Total operating expenses reach LE 2.175 million per year.

The annual revenues (financial returns), however, would amount to LE 2.773 million annually.

[4] The dried lime from the acetylene production plant contains some impurities. Therefore, the required quantitity of lime is increased by a factor of 1.5.

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The projected annual operating costs and financial returns are increased by 5 percent annually to account for the inflation in raw material, energy, salaries, and maintenance.

Results of the above calculations gave a positive net present value of LE 4,056 million. This means that annual financial gains cover and exceed both capital expenditures and annual operating expenses over the lifetime of the project.

Q2d. Cellulosic Waste Materials

CMC samples were prepared using two different techniques: namely, aqueous and non-aqueous. Analysis of the product indicated that the non-aqueous technique is the most suitable one because it utilizes the equipment available in the company. The other technique needs a shredder which is not available and costs LE 250,000.

The production cost of CMC has been calculated using three different assumptions. It has been found that production costs for one ton of pure or crude CMC is much less than the prevailing market prices. It is thus recommended that if large quantities could be produced (>500 tons per year), detergents grade should be produced because the market price is not very high and thus profit per ton is small. However, if smaller quantities are to be produced (18-20 tons/year), efforts should be directed at producing high grades that could be marketed at elevated prices (LE 10,000-40,000 /ton).

The calculations and assumptions related to the above analysis can be found in the appendix to this document.

Q3. Subproject Achievements

Q3a. Economic Benefits

This project has many economic benefits that can be classified by factory as follows

- **The Chlorine and Caustic Soda Factory**

  Liquid and slurry wastes produced from this factory are discharged on land thus, affecting the economy by causing pollution problems. As a result, reducing sulfate content in the brine waste and treating the resulting liquid by applying reverse osmosis would help reduce the negative effects of the polluted water, thus reducing the costs for the entire economy.

- **The Acetylene Factory**

  In this factory, Ca(OH)2 results from the reaction as a wasted material. A solid pollution problem has occurred because of the accumulation of 500 tons/year of calcium hydroxide. Reusing Ca(OH)2 as a coagulant for acidic wastes would save the cost of accumulation and disposition of this waste, reduce pollution problems to groundwater, generate annual financial returns to the company, and reduce costs to the buyer of this material because its price is much cheaper than the commercial price of lime.

- **The Zinc Phosphide Factory**

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Phosphorous pentaoxide vapors are emitted into the vicinity of the company at a rate of 10-15 tons/year, causing air pollution. Results obtained revealed that recirculation of H_3PO_4 is very efficient in the absorption of P_2O_5. The payback period for the control system if the plant operates at 100 percent capacity is 1.21 year. As a result, financial gains are generated by the implementation of the proposed control unit.

- **Cellulosic Waste Materials**

  The cellulosic waste materials constitute a dangerous source of fire, and occupy a large space for their storage. Therefore, utilizing these wastes to produce CMC (one of the most thickening agents) would save costs and generate profits to the company, especially because it is a highly demanded material by many industries, e.g., petroleum, textile, detergents, and so forth. In addition, producing this material locally would reduce imports and save hard currency.

Q3b. Assessment and Characterization of Forms of Pollution and its Levels at El Nasr Company for Intermediate Chemicals

The subproject has facilitated the identification of the quantity and types of pollution occurring within the company. Subproject results could be widely applied among similar companies. Using the subproject's technical reports, the company should be able to identify its priority problem areas and the subsequent anti-pollution actions and measures that need to be taken.

Q3c. Baseline Appraisal of the Status of Workers' Health

The result of the health appraisal conducted by this project will serve as a tool for monitoring the health of workers at the company. It could be used as an indicator of the improvement or worsening of working conditions. It also serves to alert company management to the dangers that their workers are exposed to and could possibly enhance the implementation of health and safety precautions and control measures.

Q3d. Identification of Pollution-Reduction Measures at El Nasr Company for Intermediate Chemicals

The subproject has identified a number of measures that could be implemented to mitigate the various forms of pollution occurring at El Nasr Company. They include methods for ensuring complete combustion and the use of wet scrubbers and filters to control gaseous emissions, in addition to identifying alternative uses for cellulose wastes.

ZINC PHOSPHIDE FACTORY

Projected Cash Flow and Financial Return (in LE 000's)
for the Phosphorous Pentaoxide Recovery Unit

(LE 000' s)

Description	Pre Commission	Projected 1	2	3	4	5	6	7	8	9	10
CAPITAL EXPENDITURES											
Installed equipment cost	747										
Fixed capital investment factor *	2										
Total Cap. Exp.	1494										
O&M EXPENSES											
Raw materials		1,712.0	1,798	1,887	1,982	2,081	2,185	2,294	2,409	2,529	2,656
Shipping and packaging		200.0	210	221	232	243	255	268	281	295	310
Maintenance		200.0	210	221	232	243	255	268	281	295	310
Operating labour		48.0	50	53	56	58	61	64	68	71	74
Supervision		15.0	16	17	17	18	19	20	21	22	23
Total O & M Expenses		2,175	2,284	2,398	2,518	2,644	2,776	2,915	3,060	3,213	3,374
ANNUAL GAINS											
Treated Water		2772	2,911	3,056	3,209	3,369	3,538	3,715	3,900	4,096	4,300
Total Annual Gains		2,772	2,911	3,056	3,209	3,369	3,538	3,715	3,900	4,096	4,300
Annual Surpluses (Deficits)	-1,494	597	627	658	691	726	762	800	840	882	926
NPV (Discount rate 12%) (for 10 years)	4,058										

Assumptions :
Capital expenditures are the estimated cost for the proposed unit
* This factor was assumed to be 2 since some of the facilities needed (building, land,..etc) are available at no additional costs
Life time of the project is 10 years
Operating expenses are inflated by 5 % annually.
Annual gains are calculated as follows : [(Design capacity 462 ton x 50% x (sale price of zinc phosphide LE 12000/ton) = LE 2.772 million]
Cost of Capital is 12%
All figures are based on data obtained from the technoeconomic study of the project
The research team is led Principal Investigator Prof. Dr. Sohair Abo El-Ela

ELNASR.XLS

ACETYLENE FACTORY
Comparative Cost Analysis and Cost Savings

Description	Scheme I	Scheme II	Scheme III
CAPITAL EXPENDITURES			
Installed equipment cost	0	25000	25000
Total Cap. Exp.	0	25000	25000
O&M EXPENSES			
Furnace energy cost	30	0	13
Other operating cost	0	20	20
Transportation within Cairo	6	10	6
Transportation 120 km distance	24	40	24
Total O & M Expenses within Cairo	36	30	39
Total O & M Expenses Outside Cairo	54.00	60.00	57.30
Scheme I is the least costly way for drying the slurry			
Cost Savings in LE	Per day	Per year	
Within Cairo	66	19,800	
Outside Cairo	39	11,700	

Chlorine and Caustic Soda Factory

Comparative Cost Analysis for Reducing Sulfate Content in the Brine Waste

Description	Modified Process	Conventional Process
Quantity	165 m3	117 m3 + 48 m3(purging amount) to b desalinated
Salinity	14,000 p.p.m.	29,000 p.p.m.
Considering operating cost/m3 (without power)	$0.90	$1.20
Operating cost	$148.50	$198
Cost of power consumption	$132	$132
Capital cost for 165 m3 capacity	$206,250	$206,256
Material cost/day	$473	$0.00
Total Operating Cost / Day	$753.50	$330