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ABSTRACT

The modernization of the infrastructure of Egypt has been given the first priority in the three National Five-Years Plans that started in 1982. A major element is the development of domestic wastewater treatment units for Cairo and other big cities; with a total investment of more than L.E. 10 billion. Small cities and villages did not get the same priority, and the Government is determined to include them in its future plans.

The establishment of an efficient and low cost technology in the area of sullage and septage conveyance and treatment appropriate for villages represents a challenge for the Egyptian RD & E community.

No shortage of information exists planning, designing or constructing on-and off-site alternatives of conventional sewerage and appropriate low cost technologies. In Egypt the predominance of densely-populated large villages precludes the use of the simple on-site disposal methods. Moreover, the large capital and recurrent costs of waterborne sewerage and full

treatment are almost prohibitive on a nationwide basis in the foreseeable future. It has been estimated that the cost of providing wastewater facilities to 60 percent of the population by the year 2010 would be at present day value 2.26 billion dollars. A dilemma exists because neither the conventional nor low cost technologies are wholly appropriate for the situation. Nevertheless solutions must be found in order to alleviate unsuitable conditions in the villages.

One alternative might be to upgrade and improve the present vault system, which with little effort could improve the general hygiene of the collection of septage. The septage should of course be treated rather than being discharged, as at present to an agricultural drain. Work has already been undertaken to investigate the possibilities of composting the septage. In addition, the sullage should also be properly disposed and treated with perhaps a view of reuse for irrigation.

This presents the technical, social and environmental benefits to be gained through implementation of full scale sewerage system for the 10,000 inhabitants in Nawag Village and the impact of extending this technology to all Egyptian villages.

INTRODUCTION

Every community produces both liquid and solid wastes. The liquid portion - wastewater - is essentially the water supply of the community after it has been fouled by a variety of uses. From the standpoint of sources of generation, wastewater may be defined as a combination of the liquid or water - carried wastes removed from residences, institutions, and commercial and industrial establishments, together with such groundwater, surface water, and storm water as may be present.

If untreated wastewater is allowed to accumulate, the decomposition of the organic materials it contains can lead to the production of large quantities of malodorous gases. In addition, untreated wastewater usually contains numerous pathogenic or disease - causing microorganisms that dwell in the human intestinal tract or that may be present in certain industrial wastes. It also contains nutrients which can stimulate the growth of aquatic plants, and may contain toxic compounds.

For these reasons, the immediate and nuisance-free removal of wastewater from its sources of generation, followed by treatment and disposal, is not only desirable but also necessary in any society.

Conventional Wastewater collection systems if they exist at all in rural areas are designed to meet the high standards used in the developed countries, standards too expensive for Egypts limited budgets.

As to wastewater treatment, rural areas rely mainly on vaults (septic tanks with no drain fields). In areas with high water tables; and this includes most of the densely populated

Delta area, roughly bounded by Alexandria, Cairo, and Port Said, pumping of vaults is expensive and often not done. Conditions in most village streets provide hard evidence of the magnitude of the problem and its attendant hazards.

A pilot wastewater treatment plant and a pilot collection system using small bore sewers were constructed in Nawag and are in operation.

A major objective of this study is to provide low cost, low technology, simple to operate, plants producing an acceptable waste water effluent. In the case of sewers, it is important to use locally available materials and design standards appropriate to the limited available funding.

This paper will first discuss the work at the pilot wastewater collection facility and conclusions drawn, and then wastewater treatment will be addressed.

WASTEWATER COLLECTION TECHNOLOGY

Sewage is the liquid conveyed by a sewer. It may consist of any one or a mixture of liquid wastes which will be separately defined. Sanitary sewage, also known as domestic sewage, is that which originates in the sanitary conveniences of a dwelling, business building, factory, or institution.

A sewer is a pipe or conduit, generally closed but normally not flowing full, for carrying sewage. A common sewer is one in which all abutting properties have equal rights of use. A sanitary sewer is one that carries sanitary sewage and is designed to exclude storm sewage, surface water, and groundwater. Usually it will also carry whatever industrial wastes are produced in the area that it serves. It is occasionally, although improperly, called a separate sewer. A storm sewer carries storm sewage, including surface runoff and street wash. A combined sewer is designed to carry domestic sewage, industrial waste, and storm sewage.

Figure 1 illustrates the components of the conventional collection system.

The haphazard layout of streets in rural Egyption Villages make construction of a typical sewerage system prohibitively expensive. Since most houses have vaults with no liquid outlet, it was obvious that collecting the tank effluent in small bore sewers would be economically sounds. Since solids are retained in the septic tank, self cleaning velocity in the sewers is no longer a design factor and almost flat gradients can be used. The sewer depths are controlled basicly by the cover required to protect them from damage, with the provison that the vaults are higher than the point of discharge at the treatment facility. Figures 2,3 illustrate the small bore sewer collection system components.

In addition expensive manholes are eliminated and they are replaced by clean outs for inspection and rely on water pressure

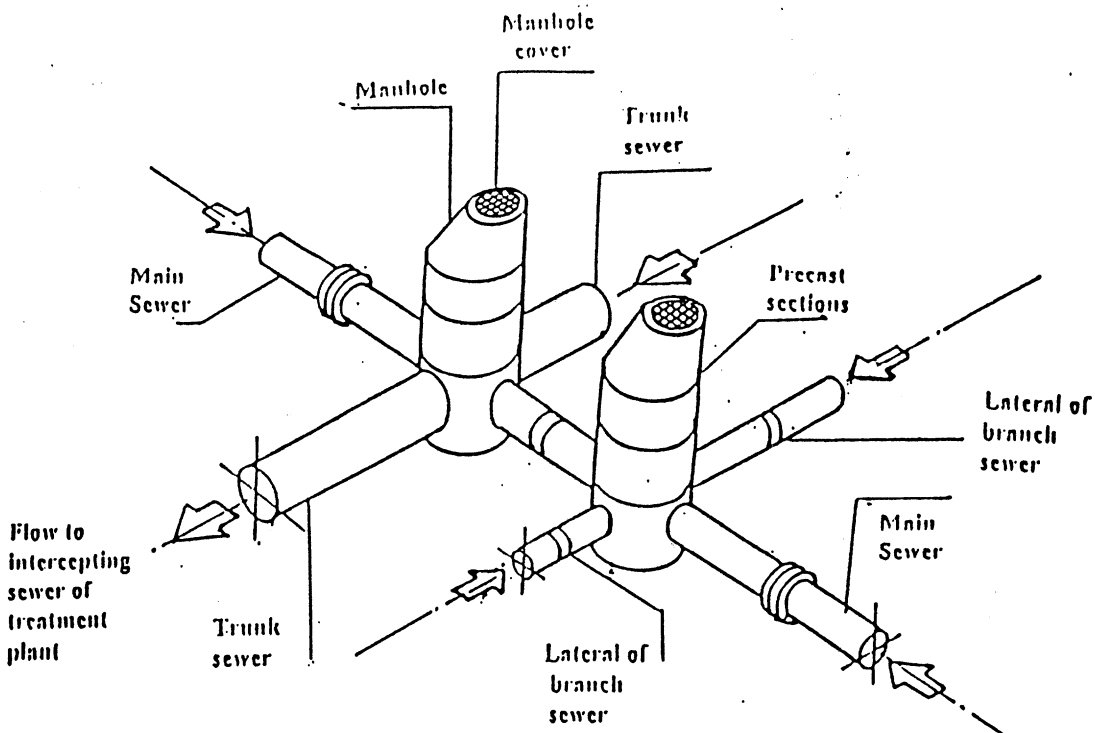


Figure 1:- Conventional Sewerage System Components

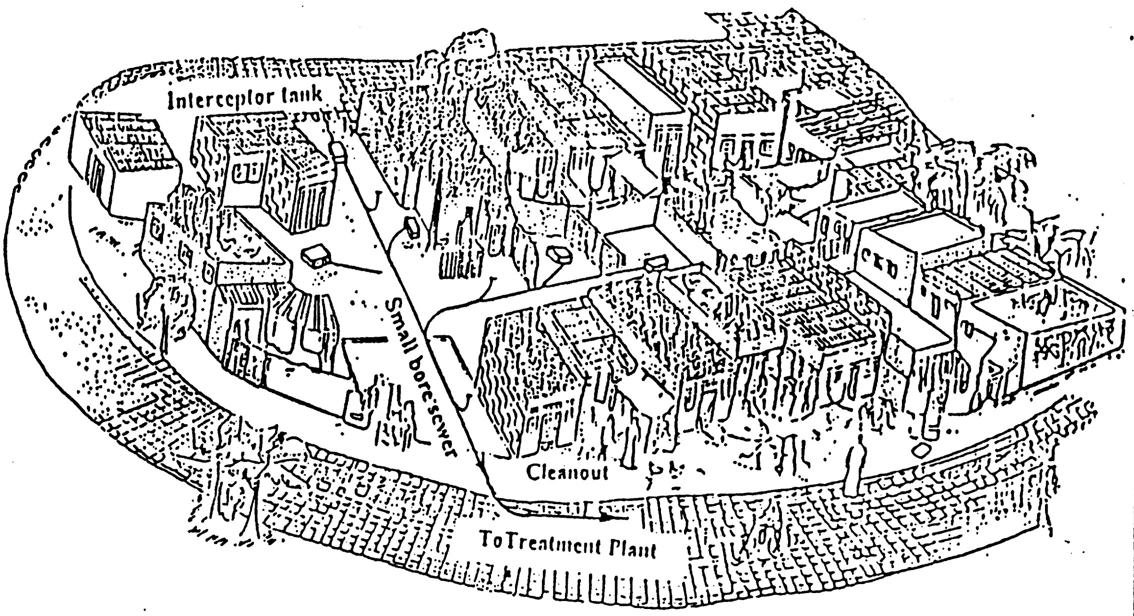


Figure 2:- Small Bore Sewers Components

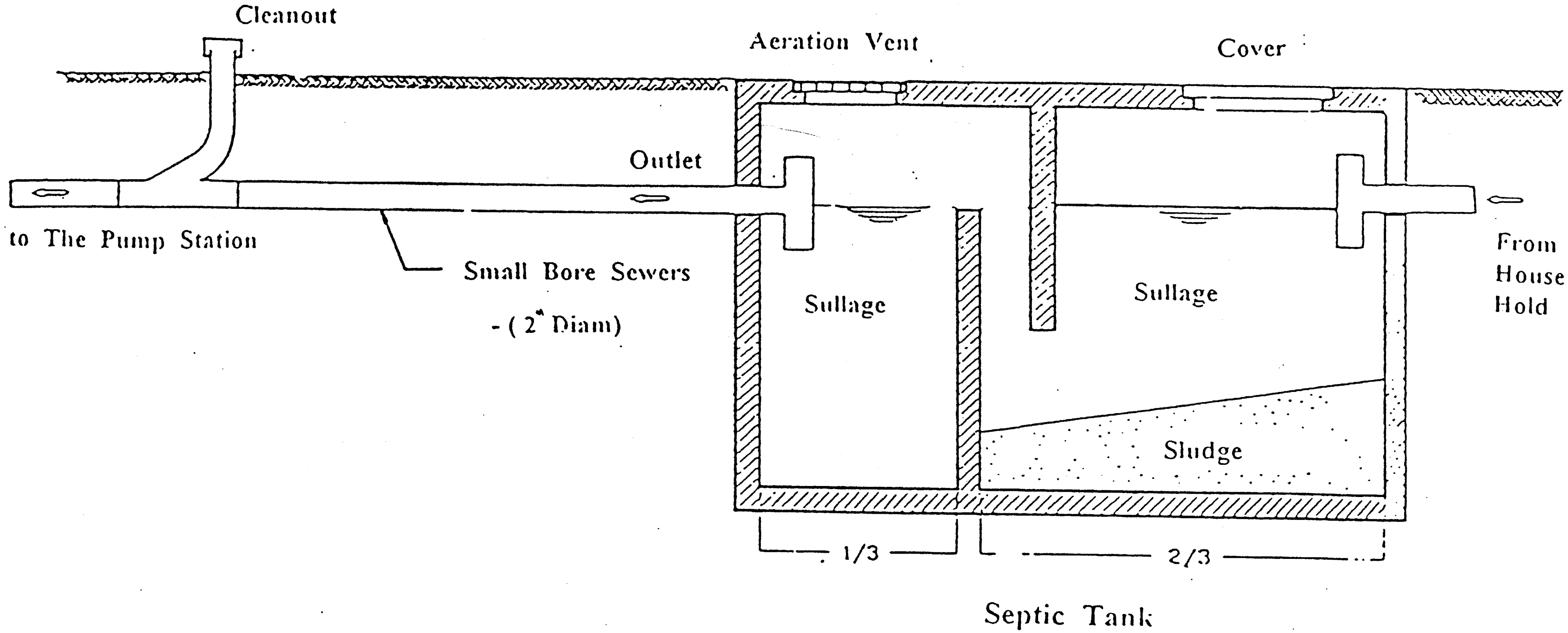


Figure 3:- Schematic Drawing Presents the Small Bore Sewers Components.

for clearing blockages and cleaning. The system has not been in operation long enough for clear cut results but we are confident that the system will prove to be highly cost effective and the villagers will benefit from this low budget technology.

It should be mentioned that small bore sewers have been successfully used in a number of places: The United States, England, and many others.

WASTEWATER TREATMENT TECHNOLOGY

In the small bore sewer system, septic tanks recieve household wastewater and retain it up to 24 hrs. Therefore, a complete primary treatment (which traditionally implies a sedimentation procees) is taking place. The septic tanks effluent will then requires secondary treatment.

BACKGROUND

Secondary treatment systems are intended to remove the soluble and colloidal organic matter which remains after primary treatment. While removal of this material can be effected by physico-chemical means, secondary treatment is usually understood to imply a biological treatment process.

In order to carry out this natural process in a reasonable time it is necessary that a very large number of microorganisms be available in a relatively small container. Biological treatment systems are designed to maintain a large active mass of bacteria within the system confines. While the basic principles remain the same in all secondary processes, the techniques used in their application may vary widely, but may be broadly classified as either attached (film) growth or suspended growth processes.

Attached growth utilize a solid medium upon which bacterial solids are accumulated in order to maintain a high population. The area available for such growth is an important design parameter, and a number of processes have been developed which attempt to maximize area as well as other rate limiting factors. Surface growth processes include intermittent sand filters, trickling filters, rotating biological contacters, and a variety of similar proprietary devices.

On the other hand, suspended growth processes maintain an adequate biological mass in suspension within the reactor by employing either natural or mechanical mixing. In most processes the required volume is reduced by returning bacteria from the secondary clarifier in order to maintain a high solids concentration. Suspended growth processes include activated sludge and its various modifications, oxidation ponds, and sludge digestion systems.

Another type of waste treatment is the oxidation pond . Oxidation or stabilization ponds are a relatively low-cost treatment system which has been widely used, particularly in rural areas. The ponds may be considered to be completely mixed biological reactors without solids return. The mixing is usually provided by natural processes (wind, heat, fermentation) but may be augmented by mechanical or diffused aeration.

Aerobic ponds are generally constructed to operate at a depth between 1 and 1.5 m (3 to 5 ft). Shallower levels will encourage growth of rooted aquatic plants, while greater depth may interfere with mixing and oxygen transfer from the surface.

Aerated ponds are aerobic systems in which the natural oxygenation afforded by wind and algal action is supplemented by mechanical or diffused aeration. High-speed floating aerators (Fig. 24-20) with anti-erosion devices are used in this application in shallow ponds which have reached an overloaded condition. In ponds initially designed to be aerated both high and low speed aerators and atatic-tube aerators are employed.

One of the recently developed system of wastewater treatment is the Floating Aquatic Plant System, Aquatic plant systems are engineered systems in which aquatic plants are used for the treatment of domestic and industrial wastewater. They are desgined to achieved specific wastewater treatment and water quality objectives. The principal floating plant species used in aquatic treatment systems include water hyacinth, duckweed, and pennywort. Submerged aquatic plants such as waterweed, water milfoll, and water cress seldom used, but are discussed for completeness in the the section on aquatic plants.

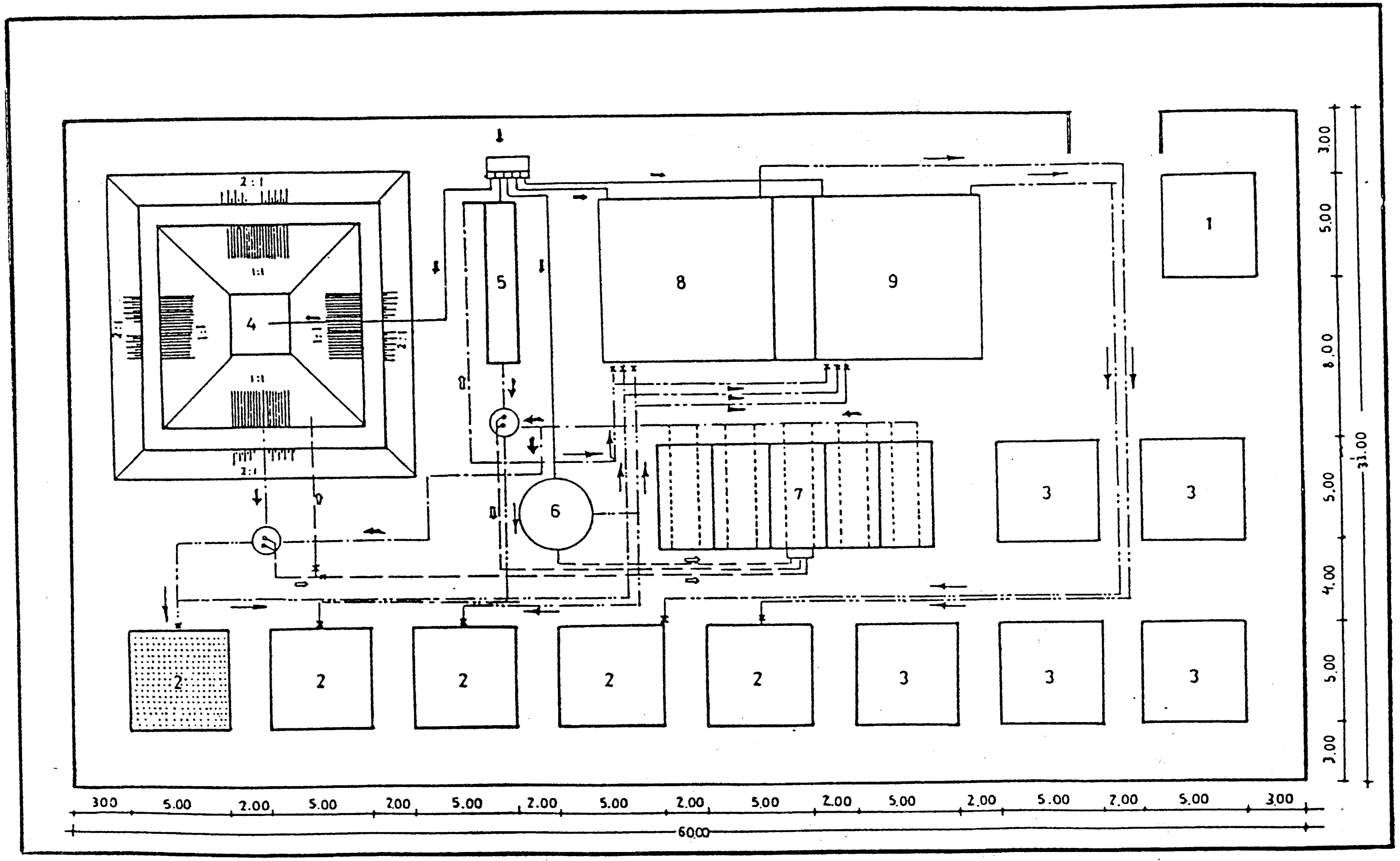
Water hyacinths have been used in a variety of experimental and full-scale systems for treating wastewater. The use of water hyacinths has been limited in geographic location to warmweather regions because of the sensitivity of water hyacinth to freezing conditions. Duckweed systems have been developed in colder climates because of the greater temperature tolerance of duckweed species. Both duckweed and water hyacinth systems have most often been used for either removing algae from oxidation pond effluents or for nutrient removal following secondary treatment.

In the period between 1970 and 1988 aquatic treatment systems have been used successfully in a variety of treatment applications including secondary, advanced secondary, and tertiary treatment. Most of the performance data reported in the literature for these systems, however, have been observational rather than quantitative. Hydraulic detention time, hydraulic loading rate, and organic loading rate are the most common parameters used to design aquatic plant systems.

NAWAG PILOT PLANT

The pilot wastewater treatment plant in Nawag Village involves a comparison of five methods of treatment. They are aerated lagoon, activated sludge, trickling filters, and two types of aquatic life units. The goal is to establish the most appropriate technology for conditions in rural Egypt.

The plant can be described as follows: (Figure 4)



LEGEND

1- Reserchers rest room

2- Area of land irrigated by treated water

3- Area of land irrigated by ordinary water

4- Aerated lagoon

5- Extended laeration

6- Trickling filter

7- Drying beds

8- Aquatic Life (1)

9- Aquatic Life (2)

Figure 4:- Pilot Treatment Plant Layout

The pilot waste water treatment plant has a design capacity of 125 M^3 per day to treat a very septic waste with a BOD of about 175 mg/L. The plant comprises an influent tank of about 40 m^3 sufficient for about 8 hours storage. The septage (effluent from septic tanks) is the pumped to a splitter box where the flow is distributed to the five treatment units. The treated effluent flows by gravity to agricultural test plots or a small pumping station and discharge to a nearby drain. Sludge is recirculated or pumped to sludge drying beds.

The first treatment unit is an aerated lagoon system. The aerated lagoon will treat about 10 M^3/day (0.12 L/s) in a 5 x 5 meter tank with 1 on 1 side slopes, and a maximum water depth of 3.5 meters. Provision has been made for return sludge. Aeration is conducted by a hydraget aerator (Mode in Egypt). Effluent is settled in a 1200 mm diameter circular clarifier. Provision has been made for final polishing by either of the two aquatic life units if this proves to be necessary or desirable.

The second system is an activated sludge unit, it consists of a rectangular tank 1.5 meters wide, 8 meters long and with a water depth of 2.75 meters. It is designed to treat 50 M^3/day (0.58 L/s) the activated sludge tank has a hydraulic retention time of about 24 hours, volumetric loading of 0.27 kg (BOD/M^3) and a recirculation ratio of from 0.75 to 1.5. Aeration is by air diffusers supplied by an electric air compressor. Effluent is settled in a circular clarifier 1.5 meters in diameter and 2.75

meters deep with an over flow rate of about 40 $M^3 M^{-2} D^{-1}$ and a loading rate of about 5 kg/D.

Polishing will be by one of the aquatic life units if required, and sludge recycled by pumping from the clarifier.

The third unit is a trickling filter system. The system consists of a 3 meter diameter steel tank above a 3.4 meter diameter concrete clarifier. The flow rate is 50 M^3/ day with a hydraulic loading of 7.8 $M^3 M^{-2}$ day $^{-1}$ (M/D). The clarifier provides for an overflow rate of 17 $M^3 M^{-2} D^{-1}$.

The trickling filter is fed by a rotary distributor with provision for a roughing filter if it is found to be necessary. The filter media is locally available crushed rock and recirculation of effluent from the trickling filter at varying rates is provided.

The aquatic life (1) unit is a concreted rubble tank 6 x 6 meters in plan with a water depth of 1.25 meters. Flow rate is 5 M^3 per day. A hydraulic detention time of 9 days is provided and the system is not mechanically aerated. Water hyacinth (Eichhornia crassipes) has been selected as the most appropriate plant species since it is readily available, fast growing and has good removal rates. The harvest will be monthly at first, and revised based on our operating experience.

The aquatic life (2) vegetated submerged bed unit is similar to the floating bed but has a water depth of 0.5 meter and a sloping bottom for drainage and treats 5 M^3 per day. A gravel media supports the reed bed (Phragmites australis) with a hydraulic residence time of about 6 days and a hydraulic loading of about 11 cm/D.

The pilot collection system and treatment facility has not been in operation long enough to draw technical conclusions. However, based on our research studies and considering the shortage of available land in the Delta area the aerated lagoon and both methods of aquatic life treatment may well be eliminated. Activated sludge may well prove to be too difficult for the comparatively unskilled local labor to operate.

This would leave the trickling filter as the candidate for treating wastewater. This process was in use many years ago, but has been generally replaced. It may be that a technological step backward will be recommended to help in solving this pressing problem in Egypt.

SOCIAL AND ENVIRONMENTAL ASPECTS

The establishing of the infrastructure projects does not mean in itself the expected benefit to the local people, experience gained over the years in water supply and sanitation projects shows that best results are obtained only when communities participate in the planing and execution of projects..

Such participation can not be achieved without diffusing an adequate knowledge about the projects among community inhabitants to ensure their support for these projects.

The acceptance of a given project or any new idea is a complex process involving a sequence of thought and actions. Usually decisions are made after multiple contacts through communication channels. There contacts are made over a period of time. Once an idea has been introduced and the process initiated in any given community, some people can be found in all stages of the acceptance process, which may be broken down into five stages, these stages begin with awareness and come to an end by adoption through interest, evaluation and trial respectively.

An integral part of the acceptance process is the communication of information, training and extension research at these various stages. Information is communicated through various channels. The effective training programs are those made to integrate the training with the needs of the situation and help alleviate shortage of manpower, besides using local capabilities in collecting and providing social and environmental data for project design.

Sanitary systems do not in themselves, result in a more hygienic environment or reduction of disease. The consumers of these new facilities must use them properly and then adopt new behaviors that will maximize the health benefits, therefore it is necessary to study their behavior in getting rid of human wastes and the present level of sanitary services.

As in any development activity the sanitary project has its environmental impacts. It is necessary to have some idea of the likely impacts of this project on the environment. In general, an Environmental Impact Assessment (EIA) of a project is a study of the probable changes in various socio-economic, biophysical and ecological characteristics of the environment which may result from a proposed or impending action. This step begins by identifying the housing, hygienic, living facilities and so on.

In Nawag a comprehensive socio-economic and environmental study was conducted and a public awareness campaign inaugurated.

Social and Environmental studies indicated that:

1. The problem of sanitary services represents the most important problem facing Nawag Village. No significant differences were found in this aspect between categories, economic activities or living area.

2. The sanitary project was chosen as the most urgently required project for the village. No significant differences were noticed in the degree of precedence of this project in the sub-areas or the social and economic categories.

3. 57.7% of householders and 6.7% of their wives were infected with various diseases during the last year before data collection. Stomach disorders and diarhea were among common diseases in children. No significant differences in infection rates between sub-areas or categories were found. Improved sanitary services would reduce the incidence of disease.

4. 80% of sample families householders and about 14% of their sons contributed to the previous projects in the village, financial support was the most common type of support.

5. There are a very good indications for project support in money and labor.

The study also showed that the majority of village inhabitants see that the best method of projects achieving is by co-operation between the people and governmental bodies.

SUMMARY

In summary, the lack or inadequacy of wastewater collection and disposal systems in rural Egyption villages results in unacceptable living conditions and is a factor in the spread of disease, in short, a major public health hazard.

In Nawag an attempt has been made to solve wastewater collection and treatment by introducing new technologies, a small bore sewer system for collection and evaluation of the most appropriate method for treatment.

The need for technological change has been exacerbated by several negative factors:

1. The financial situation in Egypt and previous Governmental emphasis on urban projects, at the expense of the rural areas. This attitude has now changed

2. The intertia of Governmental authority, and consulting engineers which works against change.

3. Undue reliance on manufacturers' performance claims for their equipment combined with a failure to verify the application of these products against actual conditions in the areas they are destined to serve.

On the positive side is the willingness of international agencies to assist in recognizing the need for change, and providing both technical assistance and funding. On this projects USAID has played an important role.

The socio-economic and environmental studies show a positive attitude on the part of the villages in support of this project. This is further evidenced by the contributions the Governate and village have made for carrying out the work.

The next challenges are to:

1. Complete the studies and verify that the technology proposed is in fact, low in capital cost, simple to operate, and more cost efficient in operation than currently used processes.

2. Convince Governmental authorities and the Engineering professions that the proposed methods of wastewater treatment should be taken from the pilot plant stage to full size field demonstration projects. This may be accomplished by publishing of technical papers, seminars and workshops, and direct appeals to concerned public authorities.

This will not be easy, however the overall social and health benefits to the rural citizens of Egypt will be well worth it.