WASTEWATER MANAGEMENT

by

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INTRODUCTION

The growing concentration of both population and factories in local and limited area is part of urban development. As varied impacts arise from this development, one major impact which has received wide public concern is that on water environment and water quality.

Water quality deterioration first received attention as a public health problem. Wastewater treatment processes were thus developed to prevent the entrance of water-borne disease pathogens in water streams intended for human consumption.

As more product have to be supplied to an ever expanding city, new processes and operations were developed. The result is the introduction of "new residuals" to water bodies. The rivers and other water courses have natural capability to assimilate pollutants. However, this is limited only to certain type and quantity of pollutants.

A sound wastewater management program should be conceived to prevent further deterioration of our water bodies. Since at this stage of national development, an integrated wastewater management scheme both on the national and regional level is unattainable, wastewater treatment on generation source seems the viable strategy for wastewater management. The industries are now confronted with the problems of meeting the stringent effluent/stream standards set by regulating government agencies for effluent discharges to water bodies.

Although appropriate technology has been established to deal with every particular waste, the major constraint is one of economics. In developing countries, the engineers are faced with the problem of finding a suitable wastewater treatment process that is characterized by low facility and operational costs, minimal instrumentation, use of cheap chemicals and high efficiency of pollutant removal.

This paper attempts to discuss the strategy for wastewater management, technology for wastewater treatment and present a case study on the plating industry and how a new treatment method was established for its toxic waste.

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TYPES OF WASTES AND THEIR SOURCES

The most useful classification of wastes distinguishes between nondegradable and degradable substances based on their behavior on receiving stream. Nondegradable wastes are usually diluted and may change in form, but they are not appreciably reduced in weight in the receiving water. Degradable wastes are reduced in weight by the biological, physical processes which occur in natural waters.

The source of nondegradable substances-mainly inorganic chemicals such as chlorides, synthetic organic chemicals and suspended solids—are many and widespread. Industrial waste discharges account for most of the nondegradable wastes. Nondegradable pollutants not only accumulate but are often "biologically magnified" as they move in the biogeochemical cycles and along the foodchains. The enumeration of all these nonbiogradable substances thrown in the water streams would go into thousands.

The most widespread source of degradable organic materials is domestic sewage. The highly unstable, putrescible organic waste can be converted into stable organic materials (bicarbonates, nitrates, sulfates, and phosphates) by the action of bacteria and other organisms found in the natural bodies. If the water is not too heavily loaded with pollutants, the process commonly but somewhat deceptively known as self-purification will proceed aerobically by the action of bacteria and will not produce offensive odors. If the receiving waters are loaded excessively, the process of degradation will proceed anaerobically by the action of bacteria not utilizing free oxygen and hydrogen sulfide and other gases are produced.

WASTEWATER MANAGEMENT STRATEGY

We have options in dealing with waste materials

1. Dump them untreated in the nearest convenient environment
2. Reduce waste generation by —
   changes in type of raw material input
   changes in production process
   changes in product output
3. Reduce waste after generation by —
   materials recovery
   by product production
   effluent reuse (including ground water recharge)
   waste treatment

Apparently, the first alternative which is based on the philosophy that, "the solution to pollution is dilution" is no longer tenable. The second option has already found its application in several industries, e.g. steel, pulp and paper and food industries. However, the waste load reduction achieved is not substantial to meet the effluent requirements set by the regulating agencies in most cases.

Having left the last alternative, that is reduction of waste after generation, selection will have to be made on the appropriate technology necessary to achieve the desired level of treatment. Normally, materials recovery, by product production and effluent reuse become an integral component of a thorough and complete wastewater treatment.

PHASES OF WASTEWATER TREATMENT

It is customary to consider the treatment of degradable waste in three stages:

- — primary treatment, mechanical screening and sedimentation of solids (unit operations)
- — secondary treatment, a biological reduction of organic matter (unit processes)
- — tertiary or advanced treatment, the chemical removal of phosphates, nitrates and organics

The term tertiary or advanced treatment was only recently applied for operations and processes used to remove contaminants not removed in the primary and secondary treatment. It should be noted, however, that the term primary and secondary are arbitrary and are of little value. A more rational approach is first to establish the degree of contaminant removal required before wastewater is reused or discharged and group them together on the basis of fundamental considerations, the required operations and process necessary to achieve that required degree of treatment.

A schematic representation of treating sewage, domestic waste is given in Figure 1.

The treatment of industrial waste could not be phased similarly with degradable wastes. Treatment methods to effect various degree of contaminant removal is given in Figure 2.

TREATMENT ALTERNATIVES

The succeeding discussion will focus on several treatment operations and processes which are presently being used for domestic and industrial wastes. Depending on the degree of treatment, a process/operation can be applied singly with the combination of processes/operations. Disposal alternatives for sludge are also given.

Screening and Grit Removal — Coarse screening removes large objects from wastewater. Grit chambers remove sand and gravel. Both processes provide protection to pumps and other mechanical equipment, but provide little or no organic pollutant removal. Communition or grinding of screenings is sometimes practised when secondary biological treatment and sedimentation do not follow a screening process, however, the screenings should be collected and removed from the wastewater to avoid appearance of floating objects in the vicinity of waste discharge.

Sedimentation — Sedimentation is a common way of removing coarse suspended particles that are denser than water by gravitational settling. It is a widely used unit operation in wastewater treatment and often includes the skimming of floatables. Liquid effluent from the primary treatment basin is discharged to downstream processes or receiving streams. The sludge that is collected must be separately treated and disposed of. Often, sedimentation tanks with 90-120 min. detention time are used. Substantial sedimentation, however, can be obtained using a 30-40 min. detention (accelerated primary sedimentation). The accelerated sedimentation process removes less of the organically degradable material than a conventional primary system. However, this organic material is readily degradable in receiving waters like Manila Bay. There is a substantial cost and space savings resulting from the use of accelerated sedimentation process.

Waste Stabilization Ponds — Oxidation ponds, lagoons and waste stabilization ponds are all names for shallow man-made lakes which are designed to treat wastewaters. They are particularly suitable for use in rural communities and tropical countries where land is available. They are constructed with shallow earth basins, and the excavated earth could be used for constructing the dikes and berms. They are simple to operate and maintain, as they require no mechanical or electrical components. Their main disadvantages are the relatively large areas of land required and the high level of suspended solids in the effluent. They would not meet the NPCC removal limits for secondary treatment.

Aerated Lagoons — This is a compromise between ponds and the activated sludge process. The detention time in the aerated lagoon is shorter than that of the stabilization pond but longer than that of the conventional activated sludge treatment process. Aerated lagoons require smaller areas than ponds but the presence of mechanical equipment in these treatment systems increases capital and operating costs. Several aerated lagoon systems are currently being operated or installed in the Philippines.

Oxidation Ditches — The oxidation ditch is a variation of the extended aeration activated sludge process. It consists of a shallow ring or oval shaped channel with an aeration rotor which also moves the liquid around the channel. Operation of the ditch may be intermittent or continuous. Area requirements for an oxidation ditch are much lower than that of waste stabilization ponds or aerated lagoons but higher than for conventional secondary treatment plants. Energy costs for oxidation ditches are relatively high.

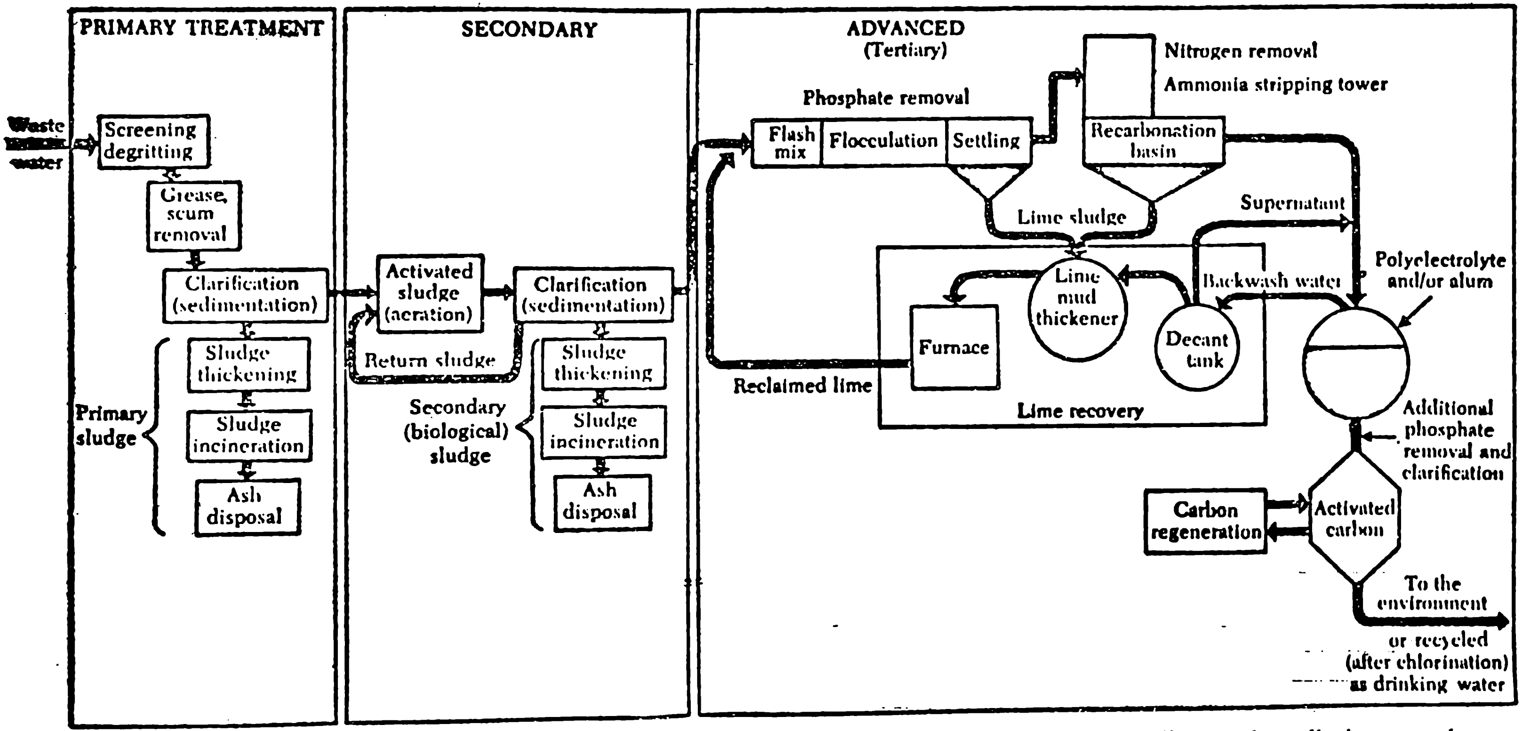

Fig. 1. The three stages of treatment for sewage and similar organic wastes as of 1970. Many metropolitan and small city areas have yet to complete even primary treatment facilities, although most have plans to achieve secondary treatment in the next few years. Tertiary treatment must be added as rapidly as possible or cities will either choke in their own wastes, ruin the quality of the countryside, or both.

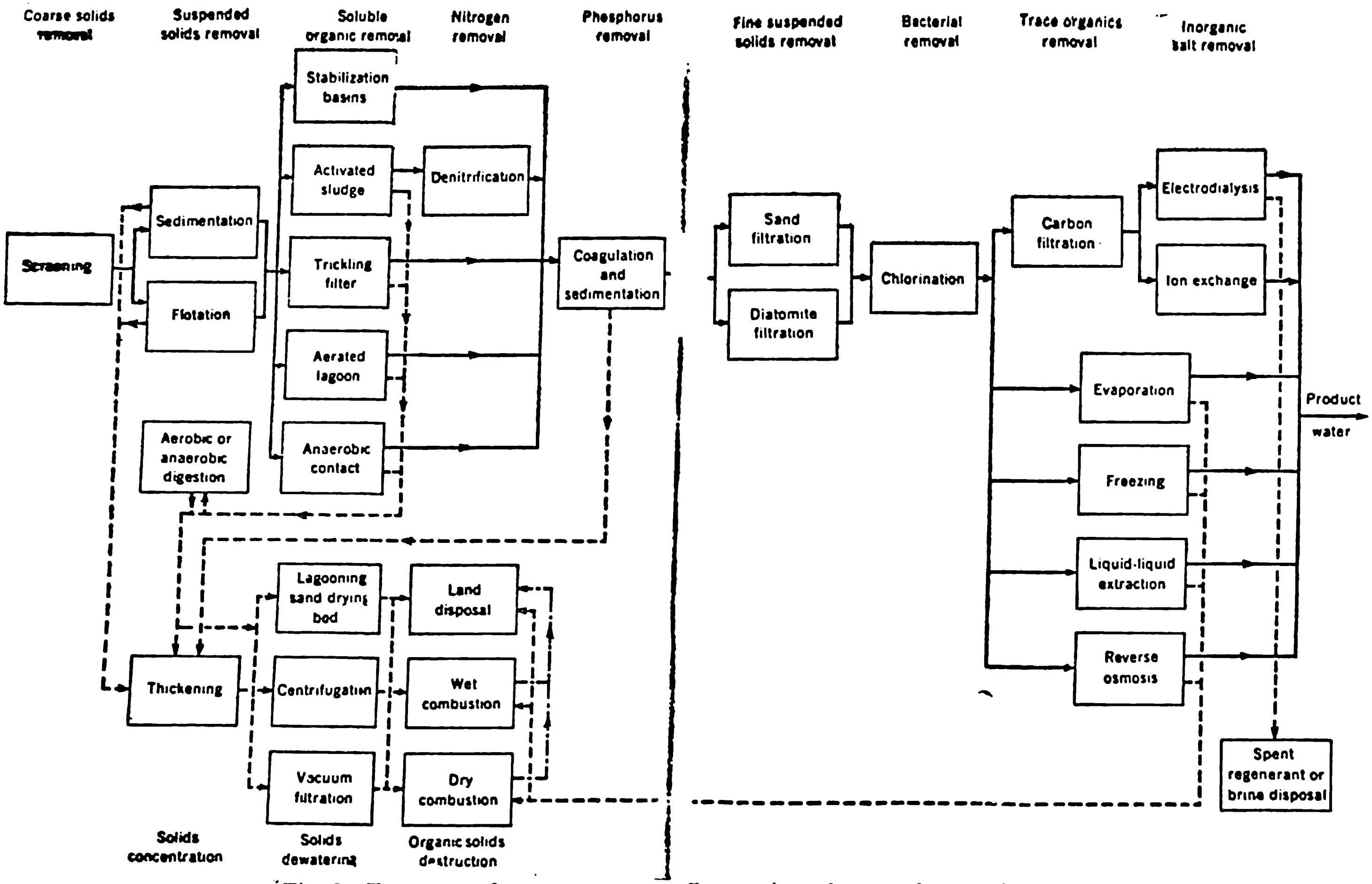

Fig. 2. Treatment of waste waters to effect various degrees of contaminant

Trickling Filters — A filter treats settled sewage or other organic wastes by microbiological oxidation. It consists of a dead of coarse aggregate or synthetic, plastic media usually 1.5 m deep. Wastewater is distributed over the bed and trickles down over the surface of the media. A microbial film develops on the media and oxidizes the degradable materials as they flow past. The bacteria in the microbial film continually grow and slough off, washed away by the hydraulic action of the wastewater. Treated water and bits of the microbial film called humus are carried to a sedimentation tank where the treated effluent is separated from the humus or sludge.

Biological filters occupy considerably less land than either lagoons or oxidation ditches. Other advantages include simplicity of operation, low operating costs, low energy requirements, low maintenance costs and resistance to shock loadings.

Activated Sludge — The activated sludge process provides secondary treatment with considerable flexibility. BOD removals can be high and various modifications on the systems are possible. It consists of a tank into which sewage or organic wastes and air are introduced and in which aerobic conditions are maintained by introducing diffused air or through mechanical mixing or some combination of two. Latest modifications of the activated sludge process involves the use of pure oxygen instead of diffused air. Claims of lower area requirements through shorter detention with this modification have been made. The conventional activated sludge systems have similar land requirements to trickling filter systems. Effluent from the activated sludge basin goes to a sedimentation tank where the sludge and treated effluent are separated. Sludge is wasted from the sedimentation tank and a portion of it is returned to the activated sludge tank to assist in the treatment. The activated sludge unit has the advantage of high BOD removal, flexibility and minimal land requirements. Unfortunately, it requires a mechanically complex plant that is difficult to operate and is more sensitive to shock loading than bio filter and usually products a high volume of sludge and has high energy requirements.

Sludge Treatment Disposal — There are multitudes of sludge treatment schemes applicable to sewage sludge. These include mechanical methods of thickening and dewatering sludge, biological anaerobic digestion, methane fermentation, physical, chemical treatment and incineration. With the exception of anaerobic digestion all sludge treatment methods mentioned above are energy-and equipment-intensive. Anaerobic digestion requires specialized equipment but yield energy in form of bio gas. The solid treatment and disposal connected with wastewater treatment represents a major part of capital and operational expenditures for secondary wastewater treatment schemes. In addition it represents a majority of operational problems.

Landfill — Sludge may be buried in a landfill in a wet condition, dewatered or may be buried after digestion or sludge incineration. In general, the highest disposal cost is associated with untreated wet sludge and the disposal cost declines as smaller volumes of sludge are produced after increased length of treatment. Sludge after being dried can be used as a soil conditioner. The most significant impact of this method of disposal is the cost of hauling the sludge to a suitable site. The cost of hauling, for example, for areas within Metro Manila areas is expected to be very high as suitable rural areas are distant from the city. Other disadvantages of using sludge as a soil conditioner include pathogenic organisms, helmiths and heavy metals that may be deposited with the sludge in the soil. Extensive studies of sludge application to land materials and their entry in the food chain are underway.

Incineration — Incineration of sludge is increasing in developed countries. This process is capital—and energy—intensive. It is possible to dewater and incinerate raw primary sludge in a well designed process that could realize a small amount of net energy. The reason for incineration is generally to avoid the high cost of hauling to land disposal when landfill sites are a long distance from treatment plants, or where landfill sites overlay a drinking water aquifer without an aquaclude.

Anaerobic Digestion — Sludge which would be disposed of to landfills can digested anaerobically prior to landfilling. The process would require the sludge to be kept in tanks that are oxygen free. Two processes normally take place in the tank. Anaerobic microorganisms hydrolize and ferment the complex organic compounds to simple organic acids. The second type of microorganisms convert the acids formed into methane and carbon dioxide. Methane produced being insoluble departs from solution and this represents actual waste stabilization. Such reactions normally take place after 10 to 30 days of sludge detention.

RECOMMENDING TREATMENT PROCESS

To identify the most effective and efficient wastewater plan for a specific waste problem, several considerations have to be made.

1. Statutory Regulations — The degree of wastewater treatment that would be required for a particular wastewater problem will depend on the disposal point of the treated effluent. As required by the NPCC, a minimum of secondary treatment will be required prior to discharge to rivers and esteros within Metro Manila area for degradable wastes. Primary treatment may be required for discharges to ocean outfalls, e.g. Manila Bay. The performance expected by the NPCC of these two treatment processes are as follows:

	Primary	*Primary Plus Secondary*
Floating Solids Removal	95–100%	95–100%
Suspended Solids Removal	50– 65%	80– 95%
Settleable Solids Removal	90– 95%	90– 95%
BOD_5 Removal	25– 40%	80– 90%

The Water Quality Criteria for waters pertaining to Metro Manila Areas as promulgated by the NPCC is given in Table 1. Since this criteria represents stream standards, the concentration of contaminants from discharging effluents must not exceed the value specified in the criteria. The criteria has been established to maintain the beneficial use of the water bodies.

2. Available Technology — It is reiterated that there is an available technology for specific pollutant removal. The choice would be governed by the ability of the process to achieve the pollutant removal required by statutory regulations, effectiveness and compatibility with ongoing systems and its capacity to adjust to any expansion programs of the systems involved.

3. Operational Effectiveness — This factor measures the relative power requirements of the proposed treatment process. It looks at the manpower requirement (availability of skilled personnel) and the relative degree of component required to properly operate the proposed system. It also considers the reliability of the system in case of shock loads and operational break-downs.

4. Investment Impacts — The major factor in wastewater plan considerations is economics. The capital costs and operational costs have to be evaluated. Equipment and civil works become integral part of the plants investment (in case of industrial waste). Operational costs include chemical cost for the treatment, energy requirements, maintenance costs and manpower requirements.

It has been estimated that any secondary treatment endeavor will require twice the cost to treat the waste on the primary level. Likewise, another twofold increase is expected for tertiary treatment to remove nutrients. If additional treatment will be required to produce water of potable quality the cost would be increased to another twofold.

The Metro Manila Sewerage Project has come up with a Master Plan for wastewater management for the entire Metro Manila. This project involves a 20 year (1980-2000) plan for collection and disposal of sewage generated by the 12.5 million population in the study period. It is estimated that 125 (.25 million cubic meters per day of the maximum cumulative wastewater flow for the Metro Manila area for the year 1980) comes from industrial waste. The percentage is expected to go down by year 2000 as the per capita water supply is being hiked. Although the percentage of the industrial waste by volumetric comparison is low, its loading is high. The organic loading of the industrial wastewater represents around 40 percent of the total wastewater loading. An ocean disposal has been singled as the best alternative to managed all of Metro Manila's wastewaters. Domestic and industrial waste will be collected and discharged to Manila Bay by an outfall. Industries will also be required to treat their wastes to certain levels before they could join the centralized collection system. The cost for such scheme would be around ₱9564 million as first cost and an adjusted ₱256 per capita to include industrial and commercial users.

TABLE 1
NPCC WATER QUALITY CRITERIA (1978)
(Abbreviated)

Quality Parameter	*Water Classification*			
	Fresh Surface Water	*Marine & Estuarine Waters*		
	C	*SB*	*SC*	*SD*
Color, units	50	50	–	–
Temperature °C	3(b)	30	3(b)	3(b)
Transparency	(a)	–	–	–
Dissolved Oxygen	3	5	5	3
5-Day BOD at 20°C	20	15	20	–
Total Dissolved Solids	1000	1000	1000	–
Total Solids	2000	2000	2000	–
pH	6.5–8.5	6.5–8.5	6.5–8.5	6.0–8.5
Coliform, MPN/100 ml	5000	1000	5000	–
Phenolic Substances	0.02	0.002	0.02	–
Synthetic Detergents (MBAS)	0.5	0.5	0.5	–
Oil and Grease	5	2	5	5
Persistent Pesticides	See source			
PCB	–	0.01	–	–
Trace Elements				
Arsenic	0.05	0.05	0.05	–
Barium	0.05	–	0.05	–
Cadmium	0.01	0.01	0.01	–
Chromium	0.05	0.05	0.05	–
Copper	0.02	–	0.02	–
Cyanide	0.05	0.05	0.05	–
Lead	–	–	–	–
Mercury	0.002	0.002	0.002	–
Selenium	0.05	0.05	0.05	–
Silver	0.05	0.05	0.05	–
Zinc	2	–	–	–

Notes: (a) Secchi disk shall be visible at a minimum depth of one meter.
(b) Rise in temperature.
All values are maximum permissible except for Dissolved Oxygen which is minimum permissible.
All units in mg/1 except those indicated.

Sources: NPCC Rules and Regulations, Official Gazettee, 5 June 1978.[1]