"Industrial Wastewater Survey in and around Bangkok Area"

A Report Submitted to The Thai American Technical Cooperation Association

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Environmental Engineering Unit

APPLIED SCIENTIFIC RESEARCH CORPORATION OF THAILAND

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December 14 , 1972

Chairman,
Thai American Technical Cooperation
Association
(TATCA)
BANGKOK

Dear Sir,

We have pleasure in submitting our report on "Industrial Wastewater Survey in and around Bangkok Area", prepared in fulfilment of our obligation. This report presents detailed information on industrial waste problems and other pertinent aspects of some 21 factories in the Metropolitan area. The limited time available has prevented us to deal in great depth, with the problems. However, the information contained in the report would acquaint you with the existing problems and their various feasible solutions.

We hope that the report will be of value to your association in planning and promoting the environmental pollution study in future. We are most grateful for the financial and moral support you rendered to us for this particular study. It has been a privilege for us to have been associated with your esteemed association and especially your committee. We will be very much obliged if you will give a favourable consideration to us in future supporting the study of this nature.

With best regards,

Yours faithfully,

(S.M.A. DURRANI M.Eng)

(SERMPOL RATASUK Ph.D.)

Acknowlegements

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Finally, the authors wish to express their appreciation to the management of the various factories named in this report, for their helpful cooperation in providing the requested information.

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Abstract

In order to assess industrial water pollution problem in and around Bangkok area, 21 industrial plants were visited. These factories included 6 soft drink plants, 2 textile mills, 2 abbatoirs, 2 breweries, one distillary, one cement factory, one ice factory and one tannery. Each factory's and its treatment plant's working data were sought through interviews and samples of raw, treated and stream water were analysed for their physical, chemical and biological characteristics.

The results of this study indicated that 50 % of the industrial plants including the large ones do not have wastewater treatment facilities. Out of the remaining only 40 % of the factories have efficient treatment systems when existing effluent standards were applied. The treatment systems were found to reduce total pollution load of 168.6 tons of BOD per day by only 3 tons of BOD/day or a mere 1.75 %. Bang Yee Khan distillary, 2 breweries, Lever Brothers, Union Live stock and Thai Tannery were found to be major contributors of the present pollutional load. Bad house-keeping was often observed to be practiced by various factories thus causing shock loads on the existing treatment plants. Similarly insufficient working knowledge of the activated sludge treatment system often encountered during visits, was one of the reason of bad performance. A total amount of 10.35 million ฿ was invested during past 5 years in the wastewater treatment. This figure when compared with total investment of 2729 million baht in these factories was found to be only 0.38 per cent. With this amount of investment in antipollution work, no change in the present pollution problems is anticipated.

I. INTRODUCTION

Disposal of domestic and especially industrial wastewater is a problem of global importance. Water pollution caused by industrial wastes is of serious nature mainly because of the fact that characteristics of these wastes varies with the type of individual industry. While most of industrial wastes contain mainly organic substances thus classified as organics, some industrial wastes may contain toxic inorganic and organic chemicals such as salts of mercury, cadmium, pesticides, etc. It has recently been proved that many aquatic animals such as fish, prawn, shellfish etc. can store these toxicants in concentrations considered to be too dangerous for human consumption. Apart from this, hazardous effect industrial wastes are practically responsible for the increase in costs of water treatment and public health care spendings, and loss of revenue due to fish kill and damage done to conventional agricultural crops. In addition, industrial wastes are also associated with the physical as well as visual destruction of recreational areas.

Industrialization is considered by many developing countries including Thailand as the only way of improving their economy. During the past decade Thailand has made a remarkable progress in industrial development. Number of factories has considerably increased with most of them concentrated in or around Bangkok. These industries represent a wide spectrum of manufactured products such as textile, brewery, distillery, tannery, soap, detergents, soft drinks, dairy, paper, pharmaceutical, food, metal etc. Presently some 50,000[(1)] factories of light and medium sizes are registered with the Ministry of Industry. However, a great percentage of these factories can be regarded as family industries due to their small production. At present, the increased inclination towards industrialization has resulted in gross environmental pollution problems in some places in the country but the problems are most serious in Bangkok area as would be expected. This report discusses the results of an intensive survey of industrial wastes in and around Bangkok area conducted during the months of October and November, 1972, to evaluate the overall picture of industrial wastewater control and its impact on present pollution problem.

1.1 Purpose of Study

Very little work has been done in Thailand to evaluate the extent of water pollution caused by industrial wastewater. Some wastewater surveys have been conducted by the Department of Health but they were too general in scope and objectives. Few similar surveys were also carried out by Camp Dresser and Mckee[(2)]. However, all the surveys did not include vital data of industrial waste treatment such as process of treatment, cost of treatment, receiving stream water characteristics and evaluation of the practicability of the present effluent standards based on both recipients and polluters. Since a large number of industrial waste treatment plants have been installed during the last three years a complete survey including all the factors mentioned above was deemed necessary to evaluate the extent of pollution problem, assessment of progress made in antipollution work and necessity of future planning and control. Therefore the purposes of this study were as follows.

1. To compile information on industrial wastewaters produced by various consumer goods factories (mainly food products) in and around Bangkok. This information dealt with type of treatment, cost of treatment (operational and construction), handling, years of operation, technology employed, characteristics of water etc.

2. To assess the impact of individual or group treatment systems on overall water pollution problem.

3. To estimate the total investment in antipollution work as percentage of overall industrial capital spent by the industrial sector.

4. To assess the practicability of the existing standards of effluent discharge set up by the Ministry of Industry by taking into consideration stream and wastewater characteristics.

1.2 Approach to the Study

Since the proposed study had to be completed within six weeks, only 21 factories were visited. They were 6 soft drink factories, 3 milk and ice-cream factories, 2 slaughter houses, 1 tannery, 2 textile mills, 2 breweries, 1 distillery, 1 cement factory, 2 soap manufacturing factories, and 1 ice factory. The study was divided into two parts. The first part dealt with collection of such data as type of factory, total capital investment, total labour employed, production capacity, years of operation, wastewater flow, type of treatment, cost of treatment in terms of both operation and construction costs, disposal point and problems associated with wastewater disposal; through interviews with the management of the concerned factories. The second part involved the laboratory analysis of the 500 ml. grab samples each of raw waste water, treated wastewater and receiving stream water for Biochemical Oxygen Demand (BOD), Chemical oxygen Demand(COD), suspended solids (S.S) and ammonia nitrogen (NH_3- N). Dissolved Oxygen (D.O) temperature and pH were recorded for each wastewater source at the factory's site. All the analyses carried out conformed with the methods given in the Standard Methods (1965)[3].

1.3 Analysis of Data

The data collected through laboratory analyses, respective visits, and interviews were interpreted as follows:

1. Size of the factory and its polluting capacity.
2. Process of treatment, degree of efficiency, and the cost of treatment in comparison with the total investment of the factory.
3. Total weighted average invested in antipollution work as per cent of the capital investment in the factory.
4. Receiving stream uses its relationship with the flow of wastewater coming in, effects of wastewater treatment on stream water quality.
5. Assessment of the proposed effluent standards in conjunction with the receiving stream water's existing quality.

6. Assessment of the present antipollution drive and the possibility of environmental clean up with the present rate of antipollution investments involving both the government and the industry.

II. INDUSTRIAL WASTE TREATMENT

2.1 Nature and Characteristics of Liquid Industrial Wastes

By nature, industrial wastes can be either inorganic or organic depending very much on their major contaminants, which in turn, are governed by the raw materials, and other intermediatary substances used in the manufacturing process. It is rare to find any industrial waste purely organic or inorganic in nature. Industrial wastes with high organic fractions are more common and are found in many industries such as food processing, beverages, milk, food canning etc. Inorganic wastes, on the other hand, are contributed by industries such as, steel, metal finishing, mining industries etc.

Almost all kind, of industries have to use water, often in large quantities, for processing, washing and cooling purposes. A large portion of the water is generally discharged as water-borne waste into natural water courses. In, most industries, pollutional strength of the process wastewater is highest, followed by spent washwater and cooling water.

Disposal of both organic and inorganic raw wastes into streams is deterimental to aquatic life. While organic wastes are susceptible to biological degredation causing depletion of dissolved oxygen in stream water leading to fish kills and nuisance condition including bad odours and offensive appearance, inorganic wastes due to their high concentration of chemicals render the stream unfit for human as well animal use. Organic pollution in general is evaluated by the determination of the oxidisable carbon or by measurement of the oxygen consuming power of the waste. On the other hand, inorganic wastes are evaluated by chemical impurities inherent in them.

The most generally accepted single criterion of pollution is the dissolved oxygen content of the stream. Under favourable unpolluted conditions, this may approach a saturation value depending on the stream water temperature. Since stream water temperature in the tropic is about 30°C, the dissolved oxygen content in unpolluted waters under saturated conditions is about 8 mg/l. This implies that reserve of available dissolved oxygen, to take care of the bio-oxidation of the organic wastes, is not great and is easily depleted. Although dissolved oxygen is restored in water by absorption from the atmosphere and intermittent photo-synthesis, this rate is limited. Thus an overpolluted stream usually becomes devoid of oxygen resulting in dead fish, bad appearance and offensive odours. Although 4 to 6 mg/l of dissolved oxygen are necessary for a healthy population of fish, 2 mg/l of dissolved oxygen maintained in all parts of the stream can avoid nuisance conditions.

Quantitative evaluation of stream pollution is based on the concentration of specific impurities in the stream. These concentrations are related, in turn, to the corresponding concentration in waste discharged into it. These parameters are generally (i) Biochemical Oxygen Demand, (ii) Chemical Oxygen Demand, (iii) Solids, (iv) Nitrogen, (v) Phosphate, (vi) PH., (vii) Population Equivalent.

(i) Biochemical Oxygen Demand. The major pollutional effect of organic wastes in a stream is their consumption of oxygen under the influence of living microorganisms in the stream environments. The rate and extent of dissolved oxygen depletion is customarily evaluated by the Biochemical Oxygen Demand test, which involves measurement of dissolved oxygen initially present in the sample of water containing the waste on the first day and after 5 days of incubation at 20°C. The difference gives BOD of the waste. Since the available oxygen in water is limited BOD test is usually carried out on diluted samples of waste water.

(ii) Chemical Oxygen Demand. Since BOD test involves a longer period of time, the organic strength of waste can be evaluated within few hours by chemical Oxygen

Demand test. This test is based on treating wastewater with a known amount of dichromate, digesting at elevated temperature to oxidise the organic matter, and titrating the unconsumed dichromate. The oxygen equivalent of dichromate destroyed is reported as COD.

(iii) Solids. The total solids in dissolved and suspended forms which may be organic or inorganic in nature are evaluated by means of total solids determination in the waste sample. Total solids test implies to residue left when all the water in the waste has been evaporated at $103^{\circ}C$. Organic and inorganic fractions may be roughly separated by igniting this residue at $600^{\circ}C$, which will yield values for "fixed" and "volatile" residue. Similarly the suspensed solids of organic and inorganic nature can be determined by filtering the waste through asbestos mat filter followed by ignition at $600^{\circ}C$. A portion of suspended solids which can be removed by settling under quiescent conditions and called settleable solids are particularly significant. In a stream, settling tends to clarify the water, but creating a bottom sludge which on decomposition will deplete oxygen in the stream. On the other hand total suspended solids in stream water creates unaesthetic conditions impeding sunlight penetration and consequent oxygen regeneration through photosynthesis.

(iv) Nitrogen. The nitrogen determination gives an approximate indication of the quantity of proteinaecous nitrogen present in water. Nitrogen usually occurs in many forms such as NH_3- N (ammonia nitrogen) organic nitrogen, nitrite nitrogen, nitrate nitrogen and albuminoid nitrogen. Ammonia nitrogen which is a product of microbial activity is accepted sometimes as evidence of sanitary pollution. This is usually determined by distillation of waste keeping the distillation mixture near pH 7.4. Nitrite nitrogen, an intermediate stage in the nitrogen cycle, may occur in water as a result of biological decomposition of proteinaceous matter. Nitrite nitrogen usually present in fractions is determined by photometery or visual comparison technique. Similarly nitrate nitrogen which represents the most highly oxidised phase in the nitrogen cycle reaching important concentration levels in the final stages of biological oxidation is also determined by spectrophotometric techniques. Organic nitrogen which includes albuminoid nitrogen, on the other hand, is related to industrial or domestic waste pollution and is determined by digestion followed by distillation of the waste sample. Presence of nitrogen in waste is deterimental to stream water because it depletes oxygen further through its biodegredation process.

(v) Phosphate. Almost all natural waters contain phosphates in traces but some industrial wastes contain significant amount of phosphate which if disposed into a stream can cause troublesome algal growth. Phosphate occur naturally in ortho and polyphosphate forms and is determined both by chemical as well as photometery techniques.

(vi) pH. One of the most damaging characteristics of many industrial wastes, particularly from inorganic industries is their acid or alkali contents. Industrial wastes, either high or low in pH cause fish kill, and cause general sterility in natural streams. Wastes with low pH tend to be corrosive to steel and concrete structures in waterways. Acidity or alkalinity of the waste can be determined by chemical titration techniques. These titrations indicate the quantity of pH neutralizing agents needed before the waste could be safely disposed off.

(vii) Population Equivalent. Population equivalent of any industrial waste indicate its pollution capacity and is based upon Biochemical Oxygen Demand and flow of the waste. The total waste load from any factory is reported either in gm of BOD/day or kg of BOD/day and transformed into waste produced from number of persons (50 gm of BOD is normally produced by each person per day).

2.2 Industrial Waste Management

Any form of industrial waste treatment, no matter how simple, involves a capital investment with no possible economic returns which most industries try to avoid. The greater the volume of the wastewater to be treated, the higher would be the capital, labour and operation costs. It is therefore, more economical always to reduce the quantity of waste prior to treatment. Several possible techniques of attaining this by utilizing good engineering practices and common sense are as follows.

(i) Process change,

(ii) Material recovery,

(iii) Water reuse,

(iv) Wastewater collection.

(i) Process Change. It is common that waste control engineer would request a change in his company product or manufacturing process in order to ease the pollution problem. This may include substitution of chemicals, modification in process and a minor redesign of the product. As an example, synthetic detergent finally changed over from hard to soft detergents which could be easily biodegraded and thus eased the troublesome water pollution problems.

(ii) Material Recovery. Raw materials and products are of value to the manufacturer, and commonly some fraction of it is lost with the waste. To treat this waste for pollution abatement purposes is an economic loss as well as an added cost. Any salvaging technique enabling this material to be reused back in the process would ensure economic gains. Apart from this any by-product recovery would also be profitable to some industries.

(iii) Water Reuse. Many industries use water of high quality which is costly and most of it is wasted. Sometimes with only partial treatment, this water can be reused back into the process once or several times. Water unsuitable for direct use can be recycled into operations where quality requirements are less strict such as primary rinsing of the product. The purification of water for continuing use canbe performed in the process tank itself, in an "integrated" treatment process without interfering manufacturing process.

(iv) Wastewater Collection. It is a common practice to combine all sources of wastewater into a main stream prior to treatment. Certain type of wastes such as cyanide, acid etc. should be kept separate until they reach treatment site. It is often more economical to treat the strong waste source and then combine it with a weak one prior to disposal. Such mixing often provides equalizing effects to fluctuations in flow or composition. Decision concerning blending of waste or separation should be made as long as there are certain realbenefits.

2.3 Technology of Waste Treatment

Industrial wastes can be treated to various degrees by physical, chemical and biological means depending on the characteristics of the waste.

(a) Physical Treatment. The removal of particulate or suspended matter from wastewater is an important part of a treatment system. Physical techniques for particulate matter removal which are generally employed prior to chemical and biological treatments includes settling, flotation, and filtration. Apart from these, pretreatments such as heat treatment, cooling and pH adjustments of industrial wastes are other forms of operation generally followed in order to expedite chemical or biological treatments.

(i) Settling. Settling or sedimentation is the least expensive technique used for particulate matter removal. Settling of industrial wastes is accomplished either in ordinary lagoons or specially designed tanks. Particulate matter collected in form of bottom sludge is further physically or biologically treated.

(ii) Flotation. Fine particles in industrial wastes which have density close to that of water are easy to remove by floating them with minute air bubbles. The air bubbles are either produced by pressurizing the wastewater and releasing the pressure or by applying vacuum. The solids film is scrapped off from the surface of the water.

(iii) Filtration. Although this operation is expensive than settling, it produces clear water. Sand drying beds are often used as media. This operation is often used for dewatering of settled sludges.

(iv) Heat Treatment. This operation is employed under special circumstances in order to reduce waste volume or increase the efficiency of aerobic as well as anaerobic process.

(v) Cooling. Cooling of hot wastes is usually attempted prior to final disposal into the water courses. It can be accomplished by spraying, cascading or simple holding.

(vi) Adjustment of pH. Wastes with high or low pH require neutralization prior to their release into a natural stream. This operation involves adding acid or alkali into the wastewaters depending on their pH values.

(b) Chemical Treatment. Chemical are often added to an industrial waste in order to precipitate a particular componant such as colloidal or finely divided particles, metallic ions etc. They include chemical coagulation, ion exchange, absorption.

(i) Chemical Coagulation. In this operation cationic chemicals such as alum, ferric chloride, and lime are deliberatly added to the waste to induce settling of fine or colloidal particulate matter.

(ii) Ion exchange. This process is often employed in salvaging valuable metals from wastes of metal processing industries. The principle is same as used in electroplating.

(iii) Adsorption. This operation involve use of carbon on certain wastes to remove trace concentration of troublesome contaminants.

(c) Biological Treatment. Organic wastes which can not be treated physically or chemically, are often prone to attack by microorganisms. In the presence or absence of oxygen, the organic components of waste are destroyed by these aerobic or anaerobic microorganisms by their metabolic processes resulting in stabilized end products In aerobic process, much of carbon source is removed as carbon dioxide, hydrogen as water, nitrogen as nitrate and sulphur as sulphate. On the other hand, end products of anaerobic process are methane gas, sulphur dioxide and hydrogen sulphide.

Aerobic Treatment. Industrial wastes can be treated aerobically by means of trickling filters, activated sludge and lagooning.

(i) Trickling Filter. In this technique of biological treatment wastewater is sprayed on the beds of crushed rocks or stones. Biological growth occurs on rocks or stones. Biological growth occurs as film on stone surface as the wastewater and organisms come into contact with air ventillating through the stones. This film grow with time and sloughs off as it becomes heavier exposing the stone surface for fresh accumulations.

(ii) Activated Sludge. The activated sludge process brings the organic matter in the waste into contact with living microorganisms in large aeration tanks, in which the bacteria grow as flocculant suspended growth. Presettled organic waste flows continuesly into the tank where it meets compressed air supplied through diffuser plates. The detention of waste in this tank lasts for several hours, mixed liquor is settled and a portion is returned to the aeration unit as seed.

Although the process is smooth running with excellent organic matter removal efficiency, it depends very much on factors such as uniform waste load, temperature, pH and other environmental factors. Besides these, it is highly dependent on nutrient supply and non toxicity of wastewater.

Lagoons. Lagoons, holding ponds or oxidation ponds provide several types of waste improvements such as biological removal of organic matter, equalization, sedimentation and opportunity for self-treatment.

Shallow lagoon and avoidance of overload are helpful in maintaining hign dissolved oxygen levels in water. This type of treatment is suitable where land area is available and cost is not high. Usually 1 - 2 meter deep ponds keep a sufficient DO in water. Operation cost is mininal, which usually involves removal of bottom sludge from time to time. These lagoons can be operated in series to minimize hydraulic problems.

(d) Anaerobic Biological Treatment. Although it is desirable to maintain aerobic conditions in the stream water, in most cases treatment of industrial waste anaerobically is prefered for economical handling of concentrated wastes and efficient operation of aerobic process which follows it.

In general anaerobic degradation of wastes is slower than aerobic treatment, therefore it is not recommended for diluted waste in which concentration of organic matter is less than 1 %.

The anaerobic treatment of waste generally employs large covered holding tank. The effluent from the tank is further polished before disposal by aerobic treatment.

2.4 Economics of the Waste Treatment

In designing a practical and economical system of wastewater treatment, it is extremely important to review factors such as wastewater characteristics, flow, labour and land available, degree of treatment required etc. In order to select a particular method of treatment all these factors will have to be carefully weighed and the cheapest form of treatment in terms of capital and operating costs must be selected. Some of the necessary steps to be taken for such selection are as follows;

(i) It should be determind that the present waste from a particular industry needs treatment or modification.

(ii) All the sources of wastewater from the factory should be surveyed by combining or separating a particular source depending upon their characteristics. Attempts should be made to reduce the volume of waste by modification in the manufacturing process such as changing of raw material, water usage etc.

(iii) The possibility of recovery of material from the wastewater should not be overlooked.

(iv) The characteristics of individual wastes should be studied including such factors as variation in strength and flow of wastewater.

(v) The topographic survey of the available site should be made to exploit the natural ground contour to fullest possible extent.

(vi) After site has been selected, all possible forms of treatment should be looked into by considering such factor as funds available,degree of treatment required etc.

(vii) After critical evaluation of monitary and nonmonitary factors, normally only a few competitive processes would remain for final selection. Preliminary design of these technically feasible processes will have to be made to serve as a basis in estimation of the capital and operating costs of each process. The unit costs of treatment of each process will have to be computed. The process with lowest unit cost would then be selected.

To aid the management in selecting the most economical process of treatment, the construction and operating costs of some practical processes of treatment are presented in graphical forms in Figure 1. To use these curves, the population equivalent of the waste and the land cost must be known. It should be emphasized that the curves are applicable only for dilute wastes being solely treated by aerobic processes. For strong wastes for which anaerobic treatment must be used followed by aerobic treatment, the costs are generally lower than these quoted in Figure 1.

An example will be given to illustrate the use of these cost curves. Assuming that the management of a soft drink company is facing with the problem of treatment of its factory's wastewater of which the flow rate is 1000 cu.m./day and the BOD is 1500 mg/l. The land cost is 200,000 baht/rai. The capital cost is to be repaid annually for 10 years at a compound interest rate of 12 %.

BOD load of the waste = 1000 x 1.5 = 1500 kg/day

Based on 50 gm BOD per capita per day, the population equivalent of this waste is 30000. Land required, operating costs and construction costs of oxidation ponds, oxidation ditches, and trickling filters are read off from Figure 1 and shown in Table 1. The computed annual expenditure at unit cost of treatment are also shown in the same Table. It is obvious that in this example, the oxidation ditch would be the most economical choice.

Table 1 - Cost Analyses of Various Types of Treatments

Type of Treatment	Construction Cost (฿)		Land Area Required (Rais)	Land Cost 200,000 ฿/rai	Total Capital Cost	Operating Cost Per year		12 % Interest on loan to be paid in 10 years	Total Cost for 30,000 persons	Total per head Cost ฿
	Per Head	30,000 persons				Per Head	30,000 persons			
Activated Sludge or Trickling Filters	120	3,600,000	2.63	526,000	4,126,000	9.1	273,000	430,000	4,556,000	151.5
Oxidation Ditch	40	1,200,000	2.63	526,000	1,726,000	8.0	240,000	355,000	2,081,000	69.4
Areated	34	1,020,000	5.06	1,012,000	2,032,000	5.8	174,000	360,000	2,392,000	79.7
Oxidation Ponds	12	360,000	38	7,600,000	7,600,000	5.1	153,000	1,200,000	9,160,000	305

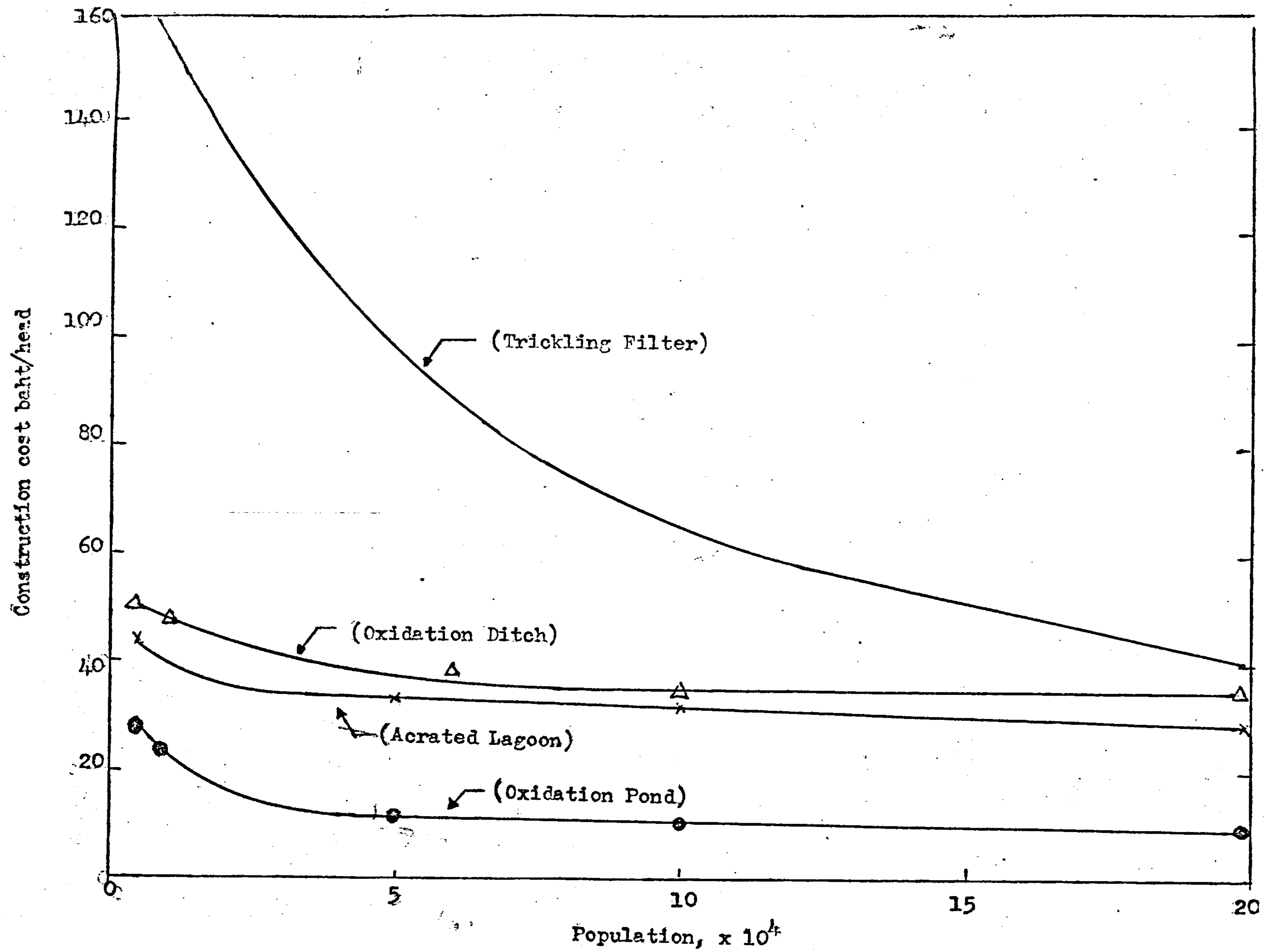


Fig 1 (a) Construction Cost (Excluding Land Cost)

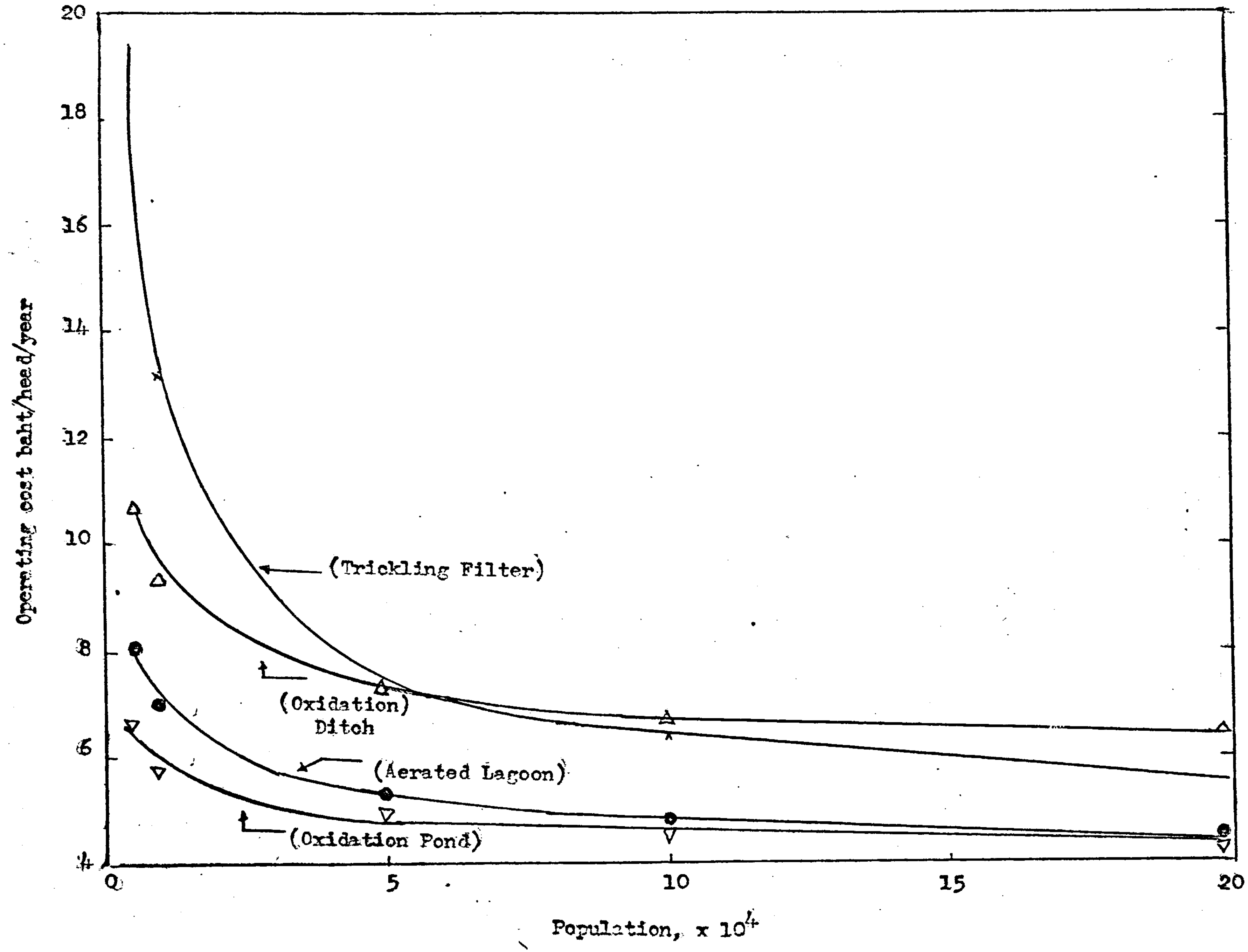


Fig 1 (b) Operating Cost (Excluding Interest Loans)

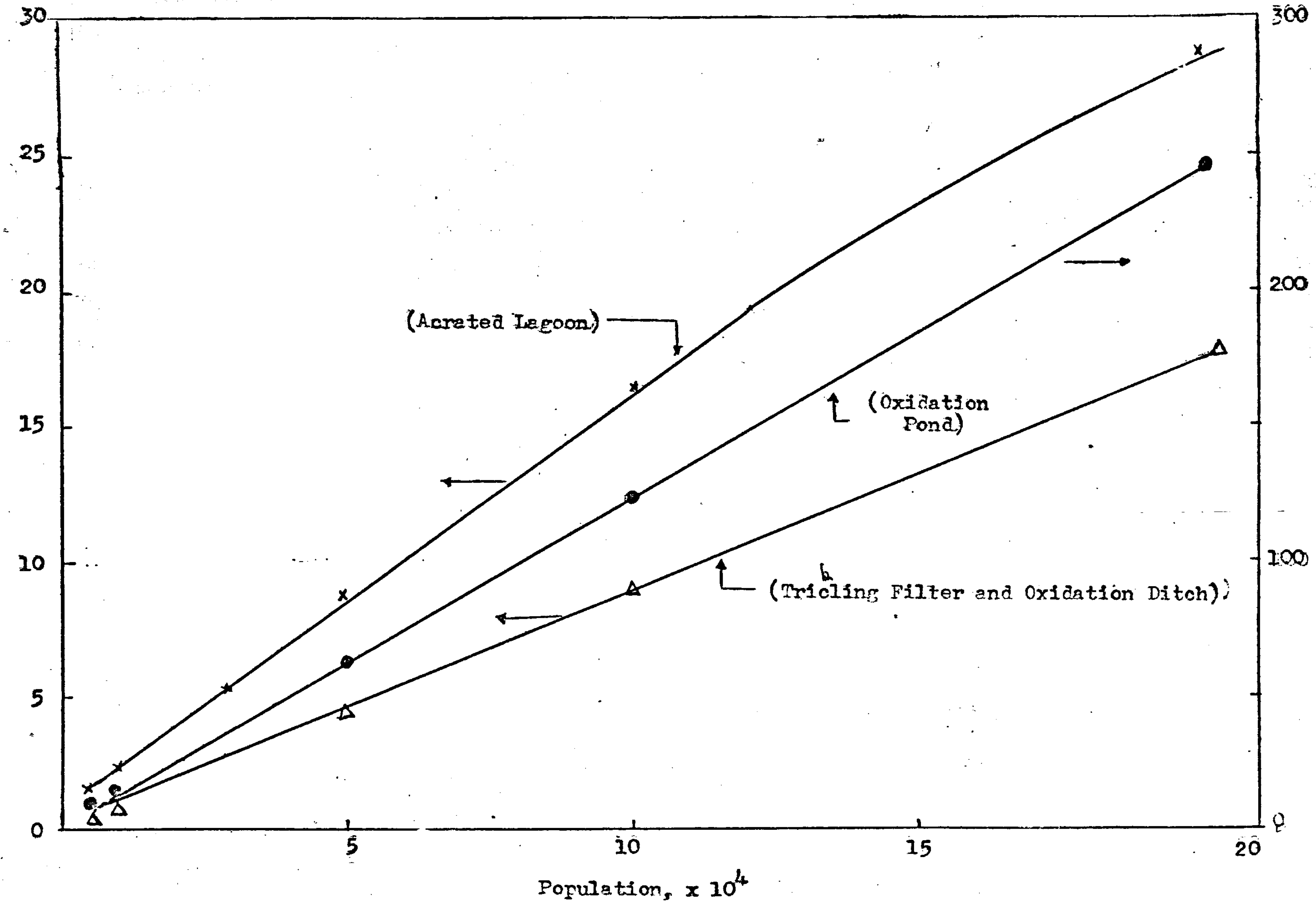


Fig 1 (c) Land Requirement of Various Forms of Treatment.

2.5 Industrial Water Pollution Monitoring and Control

Industrial wastes are one of the causes of water pollution. Due to their ill effects which are in part economic, stream pollution control has become one of the principal problems facing modern civilization. It is roughly comparable in its pollutional effect with sewage and other sanitary and domestic wastes.

The correction or control of stream pollution, as far as it is related to industrial wastes, is a problem with many aspects. It should be therefore attacked by cooperative efforts of industry and the stream regulatory authority. These efforts in effect involves biologists, chemists, engineers and other experts in evaluation and solution of particular pollution problem.

Most industrial wastewaters must be discharged from the plant premises; only rarely it is possible to let them accumulate without discharge. To some degree, the receiving stream has a capacity for assimilating pollution which depends on hydraulic characteristics of the stream, down stream use of water, etc. It is reasonable and proper to use the assimilative capacity of the water body to the full. as long as the water quality will not be impaired below acceptable standards.

One of the principal factor involved in stream pollution survilience is efficient monitoring of the waste disposal from various industries. This monitoring would aid in estimating the total pollution load from industries concerned. By combining this information with the available stream water characteristics, their use, hydrological features etc. a set of wastewater effluent standards based upon beneficial water use and the available waste assimilative capacity of the stream, can then be established. The standards once, established need a strict law inforcement to ensure no violation. These effluent standards in effect will govern the type and degree of treatment of industrial waste and costs of treatment. They will have definit bearing on industrial waste pollution control. Any set of effluent standards which does not include all of these factors such as the one issued by Ministry of Industry, would not be of any benefit in controlling water pollution. The effluent standards also effect both the capital and operational cost of the treatment systems. Too stringent effluent standards will force the industry to spend more money on waste treatment without any justification. Since the concept of effluent standards has evolved from the developed countries where environmental conditions and living standards, are much different from Asia. It is irrational to copy the standards used in the developed countries.

Tropical environmental factors would enable less stingent effluent standards in this region. Therefore, the investment in waste treatment will be in economical reach of the local industries which have been already beset with many technical and financial problems associated with production. A realistic approach therefore, would demand low standards during high flow in the stream and high standards during dry period in order to utilize fully the waste assimilative capacity of the stream.

III - INDUSTRIAL WASTEWATER PROBLEMS

3.1 Causes of Water Pollution Problems in Thailand

Water-borne wastes appear to be inevitable results of all manufacturing industries in Thailand. A large volume of water is often used by industries. However, only a small fraction of the water used is distributed with the finished product. Most and frequently all of the spent water must be discharged from the factory premises as a waste. Such water is always contaminated with small amounts of all materials used in the manufacturing process such as raw materials, unwanted substances accompanying the raw material, manufactured products, intermediate products, by products and other substances. Water is deliberately used to carry away these materials thus contaminating the receiving streams.

Water pollution in Thailand is caused by disposal of untreated liquid and solid wastes of domestic and industrial origins. Several factors responsible for this malpractice of waste disposed are as follows:

1. Industrialization has been planned without taking into consideration its deleterious effects on the environments.

Presently, strictly speaking, there is no industrial zoning in the country. As a result, industries scatter around the country and in most cases they are situated close to polulated areas. The lack of industrial zoning makes industrial water pollution control difficult and uneconomical.

2. Most of the factories due to financial constraints and lack of skilled labour have not yet seriously considered treatment of their wastes. In many cases poor house-keeping results in excessive amounts of wastewater through leaks, spills, washings etc. This source of wastewater can easily be controlled and rectified but is often neglected mainly because of technical ignorance of the factory's management.

3. The present law restricting industrial wastewater disposal is too slack. The standards governing wastewater discharges into streams, issued by the Ministry of Industry, are too stringent and are based only upon the effluent characteristics without taking into consideration beneficial water uses and the waste assimilative capacity of the receiving streams.

4. There is no integrated sewerage scheme in Thailand. As a result domestic wastewaters are discharged after septic tank treatment into the waterways.

5. At present, there is no sole authority to impose and advise the government on antipollution work. Various government agencies such as Bangkok Minicipality, Ministry of Industry, and Department of Health are all concerned with pollution control in one way or another but their duties often overlap.

6. There is virtually no regular checkup of the industrial wastewaters. Ministry of industry which is the sole licensing authority for industrial development in the country is incapable of monitoring effluents from industries mainly because of shortage of trained staff and facilities.

7. The industries are ignorant to wastewater technology. Therefore, when they are compelled to treat their wastes, they often look for quick solutions to their wastewater

problems. They usually fall prey to equipment sellers and engineers unqualified in wastewater engineering, thus the installed treatment facilitas are either too expensives or are technically wrong.

As a result of the above mentioned reasons there seems to be no alleviation in the present worsening water pollution problems in Thailand.

3.2 Seriousness of the Water Pollution Problem

The city of Greater Bangkok is situated on the banks of the esturine reach of the Chaophya River which is the most important river in the country. This river, at present, serves as a mode of transportation, source of water supply, a fish and prawn resource as well as a recreational spot. Branching from this river are many interconnected man-made canals forming a complex network for communication and irrigation purposes. As already been mentioned that Bangkok does not have an integrated sewerage system, these canals in effect, are extensively used as open sewers for domestic wastewater disposal. In addition, these canals also receive untreated or partially treated industrial waste. All these wastes eventually find their way into the river which by itself is receiving directly domestic as well as industrial wastes. Presently all of these canals are so polluted that they remain septic. The Chaophya River [4] itself, during the low flow period lasting from March to June, has been found to be constantly septic near Bangkok Port area since 1966. Industrial wastes were recognized to be solely responsible for septicity of this part of the river during dry season[4].

Similarly[5] industrial wastes were found to be the main source of pollution of the Mae Klong and Tachine Rivers. Wastes from sugar and paper factories in Karnburi and Rachburi have caused depletion of the dissolved oxygen in the Mae Klong River to less than 1 mg/l in the summer. Sugar factories [5] in Supanburi province through their waste discharge have been responsible for reducing dissolved oxygen level in the Tachin River to well below 3 mg/l. In the eastern coastal areas of Chonburi and Rayong, industrial wastes from the sugar, tapioca and fishmeal factories have turned many small receiving streams into anaerobic ditches [5]. Oil slicks caused by loading and unloading of crude oil from boats at Siracha, the site of two large refineries, has virtually forced the ESSO factory's management to hire Asian Institute of Technology for solving their problem.

As more than 80 per cent of the population in Thailand rely on agriculture as a source of their income, water plays an important role in their daily living. The rising level of pollution of some rivers in Thailand is hurting agricultural economy very badly. A great number of complaints concerning water pollution caused by industrial wastes have been reported [6,7]. Villagers living along the banks of the Mae Klong River have protested against the waste discharges from paper, sugar, distillery and various other factories. Presently eight districts especially Ban Pong district, along the Mae Klong River have been reported to be suffering from polluted drinking water and damage ------ exceeding 10 million baht of the cash crops mainly by industrial wastes. Similarly[8] waste discharged from a textile factory in Pathum Thani province has damaged adjacent rice fields, while the poultry farms[8] at Thung Mahamek are listed to be a nuisance to the surrounding environments.

The farmers* living along the banks of Klong Makhamkrong in Nonburi have suffered an economic set back during the past 2 years due to nonavailibility of clean water for their durian plantations. An ice factory located in the vicinity was blamed for water pollution.

Apart from these apparent deletrious economic effects, health hazards caused by industrial wastes are also significant. Wastewater discharged* from Siam Fibre cement factory into a klong in Nonburi province was responsible for severe skin itching of the people living close-by. The Ministry of Health[9] through their analysis of the water from Chaophya River close to the intake point of the metropolitant waterworks found a high count of bacteria. The agency accused two large factories situated nearby to have caused the hazard. During a period[3] of 8 years, 5.6 per cent of the total number of death were found to be associated with waterbone diseases. It is suspected that a significant number of these deaths were caused by industrial wastes owing to the fact that animal processing factories, a potential source of diseases, lack wastewater treatment facilities.

In essence, water pollution problem is quite serious and firm decision involving its abatement is urgently needed.

* personnal interviews.

INDUSTRIAL WASTEWATER POLLUTION IN BANGKOK AREA

4-1 Characterisation of Industrial Wastes

Results of the study conducted to assess the industrial wastewater pollution in and Bangkok area are presented in this section. A format for interviews with various factories management used in the study, is given in Appendix A. Table 2 lists the schedule of visits made to 21 factories. Figure 2 is a map showing location of factories visited during the course of study. The flow diagrams of manufacturing process and waste-water treatment used by each type of industry are given in Appendix A. Each type of industry, representing factories with the same manufactured product are grouped together. The results are as follows:

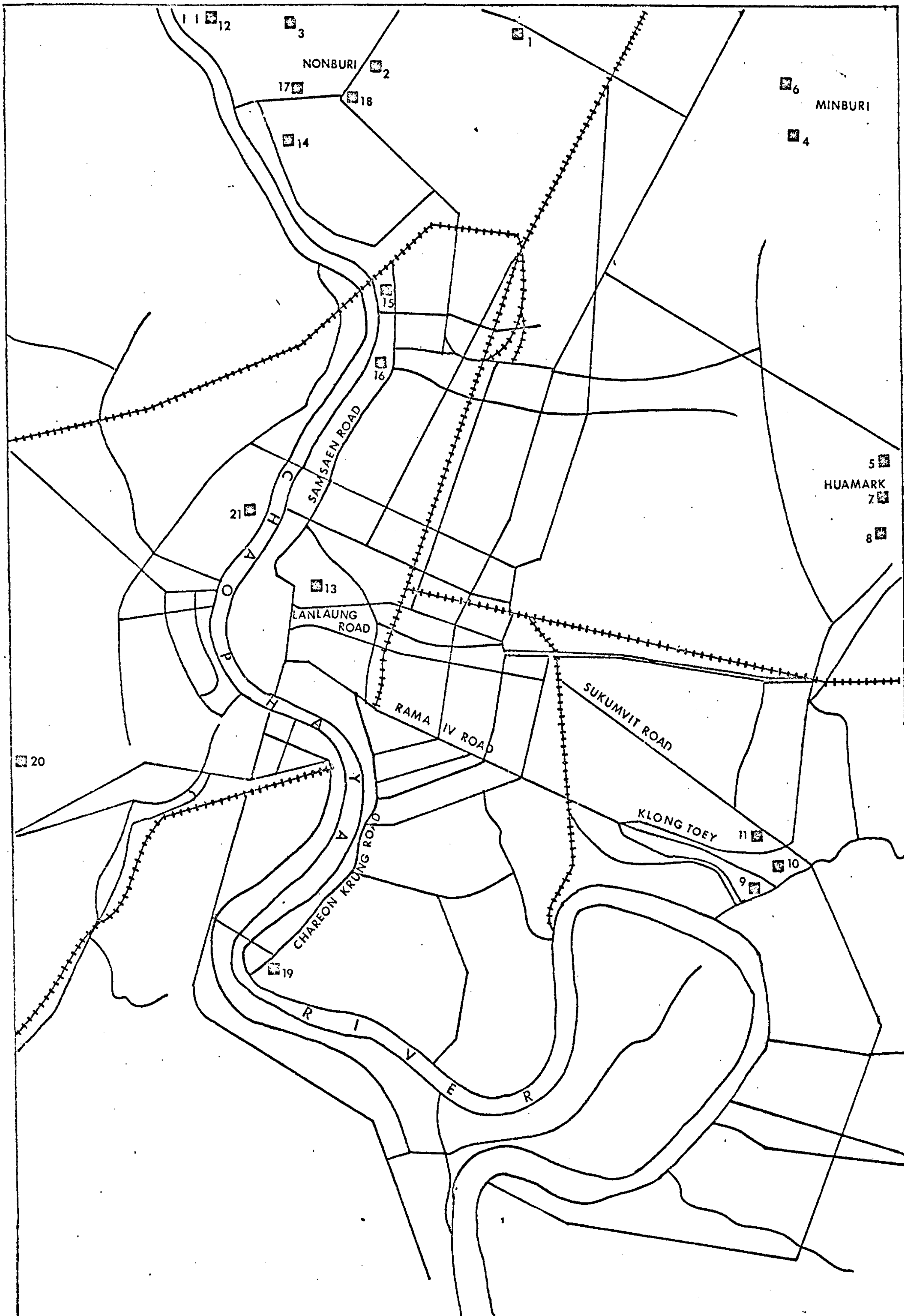
Table 2 - Schedule of visits to Various Factories

No.	Date	Factory	Location	In Situ Analyses of Wastewaters
1	11.10.72	Pepsi cola (soft drink)	Super highway	D.O., pH, temperature
2	12.10.72	7 up (soft drink)	Nonburi	-do-
33	13.10.72	Formost Co. (milk)	Rangsit	-do-
4	13.10.72	Thai milk Co. (milk)	Minburi	-do
5	16,10.72	Green Spot (soft drink)	Hua Mark	-do-
6	17.10.72	Toray Nylon (Textile)	Minburi	-do-
7	18.10.72	Coca Cola (soft drink)	Hua Mark	-do-
8	18.10.72	Pop Ice Cream (ice cream)	Hua Mark	-do-

Table 2 (Continued)

No.	Date	Factory	Location	In Situ Analyses of Wastewaters
9	19.10.72	Union Live Stock (abbatoir)	Klong Toey	-do-
10	20.10.72	Thai Tannery (Tannery)	Klong Toey	D.O., pH, temperature
11	20.10.72	Rubia Industries (Soap)	Klong Toey	-do-
12	24.10.72	Thai Filament (Textile)	Rangsit	-do-
13	25.10.72	Union Soda (soft drink)	Lang Luang	-
14	25.10.72	Bircley's (soft drink)	Nonburi	-do-
15	27.10.72	Thai Amarit (beer)	Sam Saen	-do-
16	27.10.72	Boon Rawd (beer)	Sam Saen	-do-
17	31.10.72	Nonburi (ice factory)	Nonburi	-do-
18	31.10.72	Siam Fibre-cement	Nonburi	-do-
19	2.11.72	Lever Brothers (Soap)	Chareon Krung	-
20	7.11.72	Bangkhay (Abbatoir)	Bangkhay	-do-
21	7.11.72	Bang Yee Khan (Distillary)	Thonburi	-do-

FIG 1. LOCATION OF INDUSTRIAL PLANTS VISITED



Soft Drink Industry

*During the past three years the soft drink industry has rapidly expanded and at present is valued over 750 million baht. As a result, there are some 26 soft drinks plants in Thailand employing about 3,100 persons. Of this number, seventeen factories are located in Bangkok and the remainder in provincial areas. The rise in income levels, increased urbanization, changes in consumer tastes and growth of tourism are mainly responsible for the expansion of this industry. Presently, 1500 million bottles per year are produced for local consumption and for export to neighbouring countries particularly Laos. The bulk of this production is shared by three large firms with external association.

Bottles and the main raw materials used such as sugar, carbon dioxide and water come from domestic sources, while certain flavouring materials amounting to 40-60 million baht per year are imported.

During the course of this study six soft drink factories namely Coca Cola, Pepsi Cola, Green Spot, Seven-up, Union Soda and Bireley were visited. Table B-1 (Appendix B) shows their location and other relevant data.

Sources of Wastewater

All the industrial plants visited use enormous amounts of water for both production and washing purposes. The washing machine in which collected bottles containing left-over drinks are chemically treated with NaOH and washed with clean water, contributed the bulk of wastewater. Apart from this source spilling, container and floor washing also contribute considerable amounts of wastewater. Plates 1 to 8 show various wastewater sources during the visits to the above mentioned factories.

Characteristics of the Wastewater

Table B-2 (Appendix B) lists the characteristics of the wastewaters from the above mentioned factories. The wastewater consisted mainly of sugar, soap and chemical used during washing operation. The colour of wastewater varied with the manufacturing plant. The Biochemical Oxygen Demand

*Economic Evaluation Group, ASRCT, Bangkok.

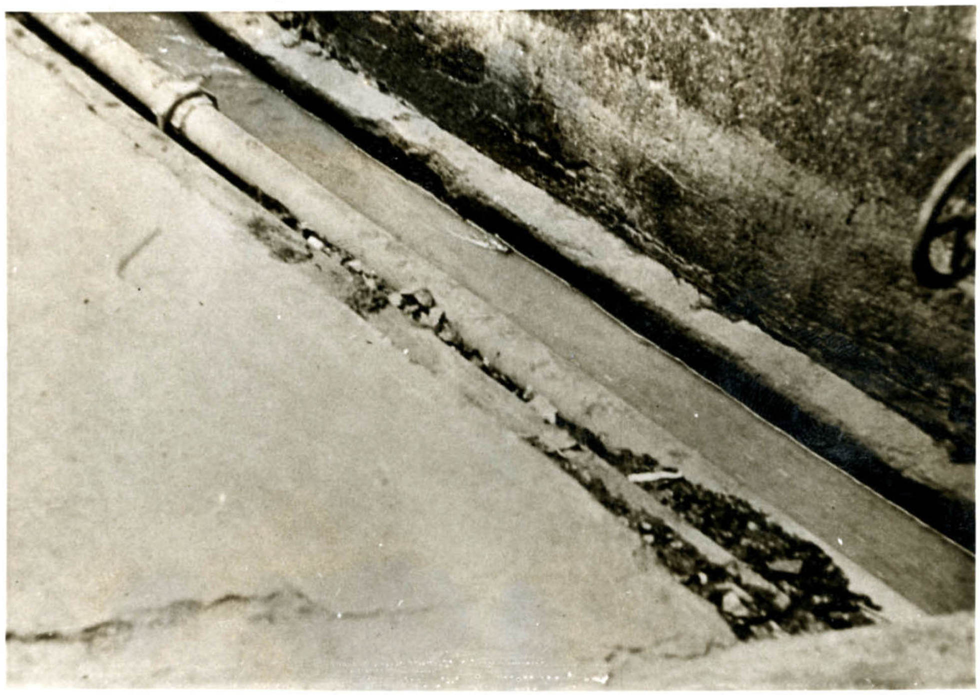


Plate 1 Wastewater from Bireley's Soft Drink Factory at Nonburi

Plate 2 Diffused Aeration Activated Sludge Unit (Bireley's Soft Drink)

Plate 3 Settling Tank of the Bireley's Soft Drink Wastewater Treatment Plant.

Plate 4 Final Disposal Point of Bireley's Treated Wastewater.

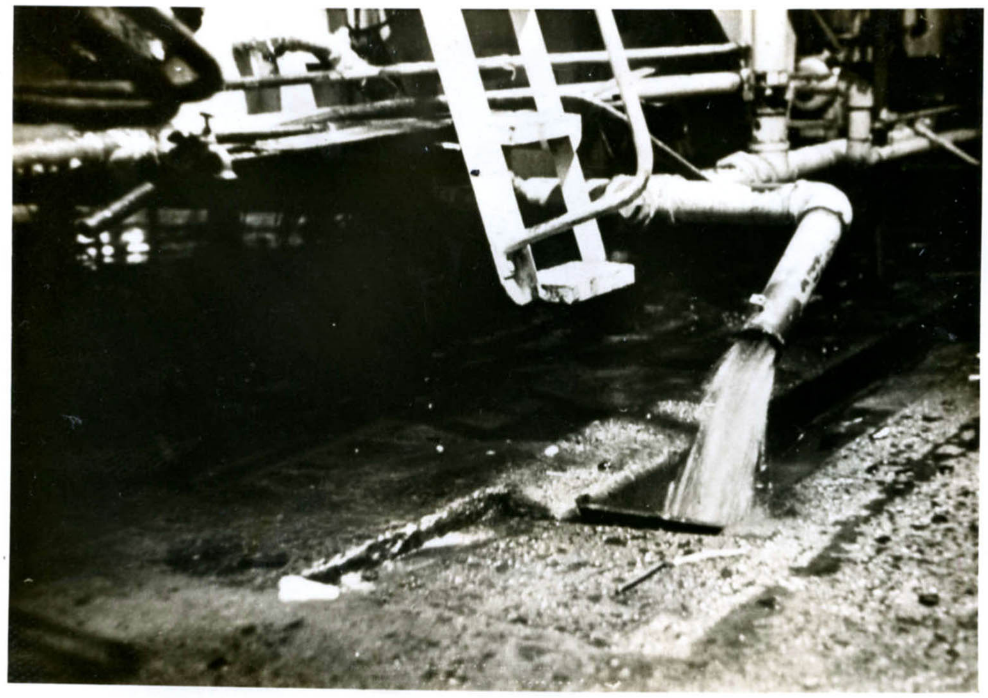


Plate 5 Wastewater from Coca Cola Soft Drink Factory at Hua Mark.

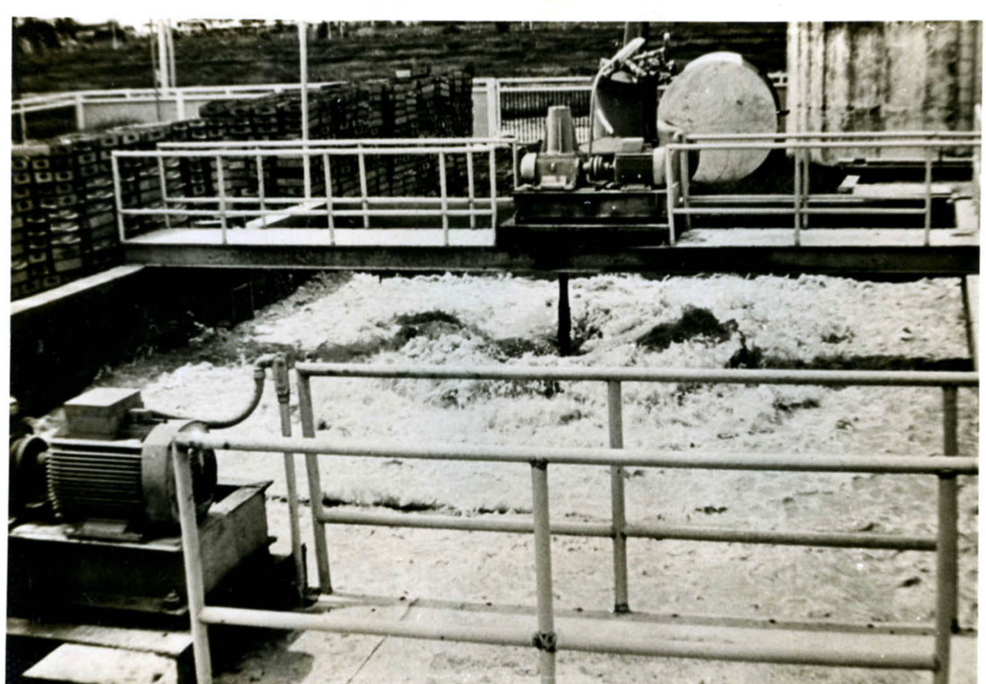


Plate 6 Activated Sludge Treatment of Coca Cola Factory's Wastewater.

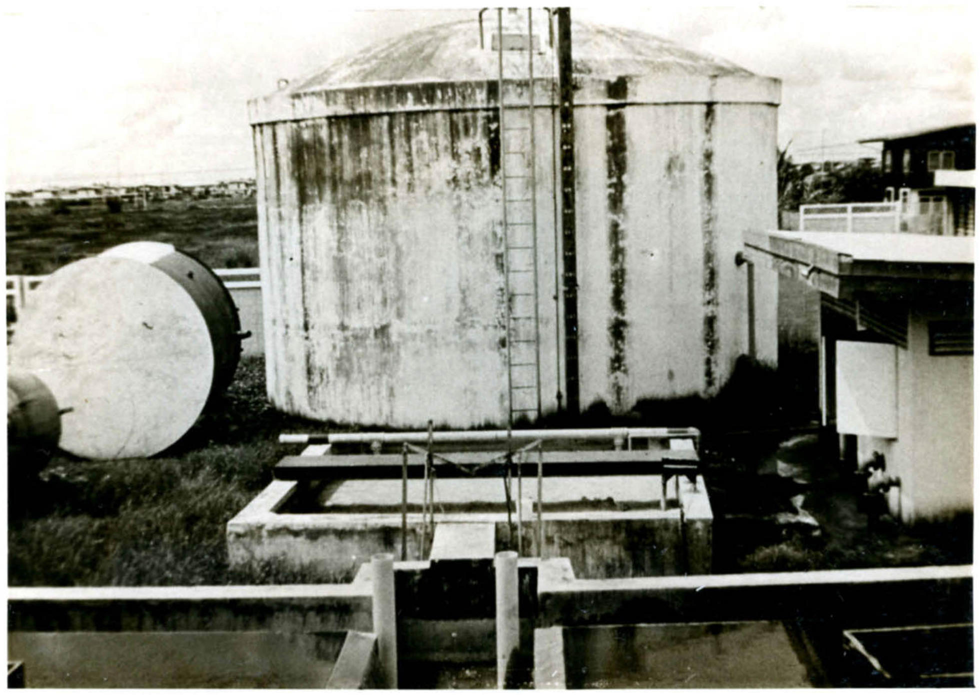


Plate 7 Sedimentation Tanks, Sludge Storage and Digestor of Coca Cola Soft Drink Wastewater Treatment Plant.

Plate 8 Sludge drying Bed at Coca Cola Soft Drink Factory.

ranged from 220 to 1500 mg/l. Other characteristics indicated no nitrogen and phosphorus, low dissolved oxygen, low suspended solids, and high Chemical Oxygen Demand.

Treatment Process

Since most of the pollutional capacity of the wastewaters from the soft drink factories were in soluble state, activated sludge process in various forms were observed to be operating in some of the factories. Table B-4 (Appendix B) lists type of treatment with other associated data collected during each visit. Appendix A gives flow diagram of a typical activated sludge waste treatment plant currently used by the soft drinks industry.

Existing Effluent Standards and Efficiency of Treatment

Table B-3 (Appendix B) lists treated wastewater and receiving stream water characteristics. The existing effluent standards of 20 mg/l and 30 mg/l suspended solids for industrial wastewaters when applied on the existing treatment plants indicates that only Pepsi Cola and 7 up factories have efficient treatment facilities. In all cases receiving stream water was found to be more polluted than treated effluent from above mentioned factories. Existing pollution of the klongs is, at present, mainly due to domestic wastewater, which is disposed untreated into the klongs.

Economics of Antipollution Activity

The six soft drink factories visited have total investment of 183 million bahts both in factory and waste treatment systems. The waste treatment system make up about 7.2 million bahts about 5 % of the total investment. This figure as compared with money invested in developed countries for antipollution work seems to be appropriate.

Breweries

*During the past decade of rapid industrial development consumption of beer rose markedly. Presently 36 million litres of beer valued about 554 million baht are consumed locally. Two large breweries namely Boon Rawd and Thai Amarit meet 99 % of the domestic demand. The raw materials such as malted grains and hops used in production valued about 21 million baht are imported every year. Other materials such as sugar, bottles are supplied locally.

The two large breweries mentioned above were visited. Table B-1 (Appendix B) shows their location and other relevant data.

Sources of Wastewater

Both the industrial plant visited use large quantities of water in beer production. A considerable portion of this water is wasted. The main source of wastewater of highly polluted nature come from cold cellars. The other sources include floor washing container cleaning etc. plates 9-11 show the sources of wastewater from the two breweries.

Characteristics of Wastewater

Table B-2 (Appendix B) lists both physical, and chemical characteristics of wastewater from the two breweries visited. The wastewater consisted of both dissolved and suspended impurities introduced during the process. The wastewater was greyish brown in colour. The Biochemical Oxygen Demand ranged from 1000-3,000 mg/l while Chemical Oxygen Demand was found to be 2,000-4,000 mg/l. No nitrogen and phosphorus was detected, while the temperature of the wastewater varied between 18-31°C. The pH was found to be 7.2 and dissolved oxygen varied from 3.1-13.3 mg/l.

Treatment Process and Economics of Antipollution Activity

At present none of the two factories have waste treatment plants. Thai Amarit factory is using a pH neutralizing tank and then pumps the

*Economic Evaluation Group, ASRCT, Bangkok.

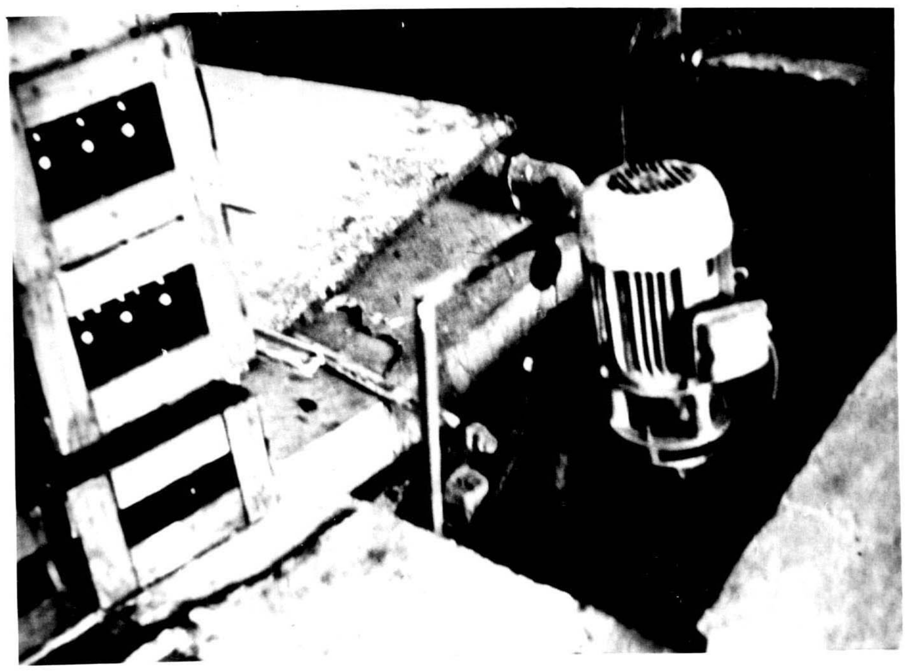


Plate 9 Wastewater sump of Thai Amarit Beer Factory at Pracharad Road.

Plate 10 Waste Disposal From Singha Beer Factory at Samsaen.

Plate 11 Wastewater from Singha Beer Factory after Disposal into the Klong Flowing into the Chaophya River.

waste liquor directly into the Chaophya River. Boon Rawd brewery discharges its wastewater into a klong which is very close to ~~immediately directly into~~ the Chaophya River.

Table B-3 (Appendix B) lists the receiving stream water characteristics. It can be observed that Chaophys River which is receiving a combined raw waste load of 1550 cubic metres per day from these two factories is highly polluted (near these factories).

Although the total capital investment of the two factories amounts to be higher than 1,000 million bahts, no money has uptil now been invested in antipollution work. Boon Rawd brewery which is the largest of the two was found to be responsible for nearly anaerobic conditions of the klong in which it is disposing 1,100 m^3 of waste per day.

Condensed Milk and Ice Cream Industry

*At present, there are six large dairy products factories employing some 655 persons. The present rated capacity of the industry for condensed milk is 4,100,000 cases of 48 cans each, or 78,000 tons per year. Similarly production of 1,000 tons per year of milk-powder based ice-creams is in the hands of four major companies. Powdered milk is imported and other raw material, such as sugar, fats, cans are locally supplied. Table B-1 (Appendix B) shows the location of the factories and other associated data.

Manufacturing Process

The manufacturing for condensed milk and ice cream is more or less the same except for the amount of ingradients used as raw material. Appendix A gives flow diagram for powdered milk based products. The following percentages of raw materials are used in two products.

	fat	sugar	milk powder	water
milk	3.25 %	15.20 %	8.25 %	60.70 %
ice cream	10 %	20 %	11 %	59 %

---

*Economic Evaluation Group, ASRCT, Bangkok.

Sources of Wastewaters

Most of the wastewater in the milk and ice cream industries is produced from containers washings, and cold storage unit. A considerable volume of mildly polluted water is also contributed from floor washing. Plates 12-17 shows the wastewater sources from various factories visited during the course of study.

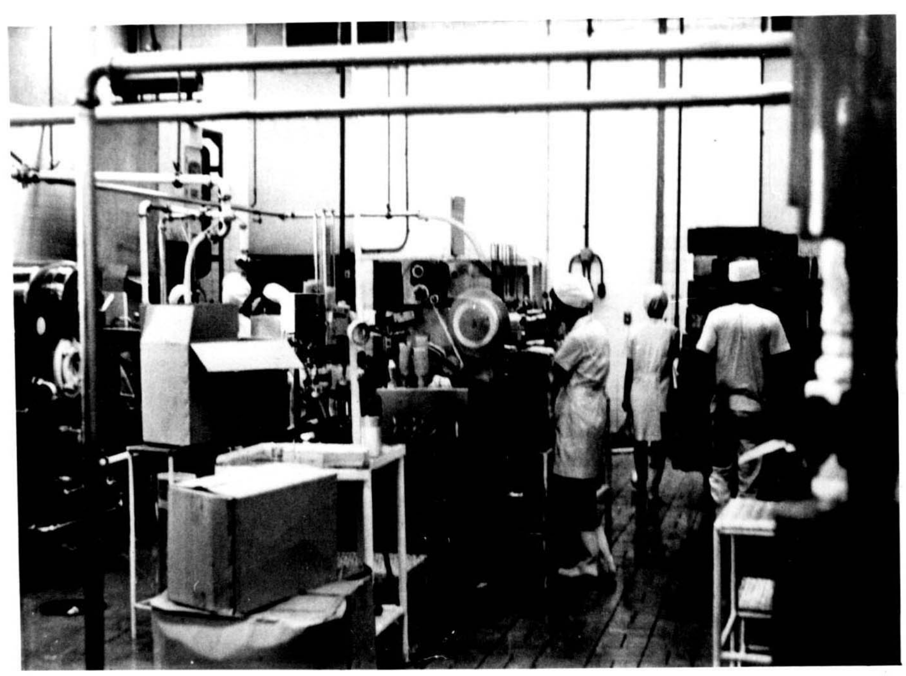


Plate 12 Filling of Manufactured Milk at Foremost Milk Factory.

Plate 13 Treatment of Wastewater from Foremost Milk Factory through Sprinkular Aeration.

Plate 14 Treated Water Flow Through an Overflow Weir into Klong.

Plate 15 The klong receiving Foremost Factory's Treated Wastewater.

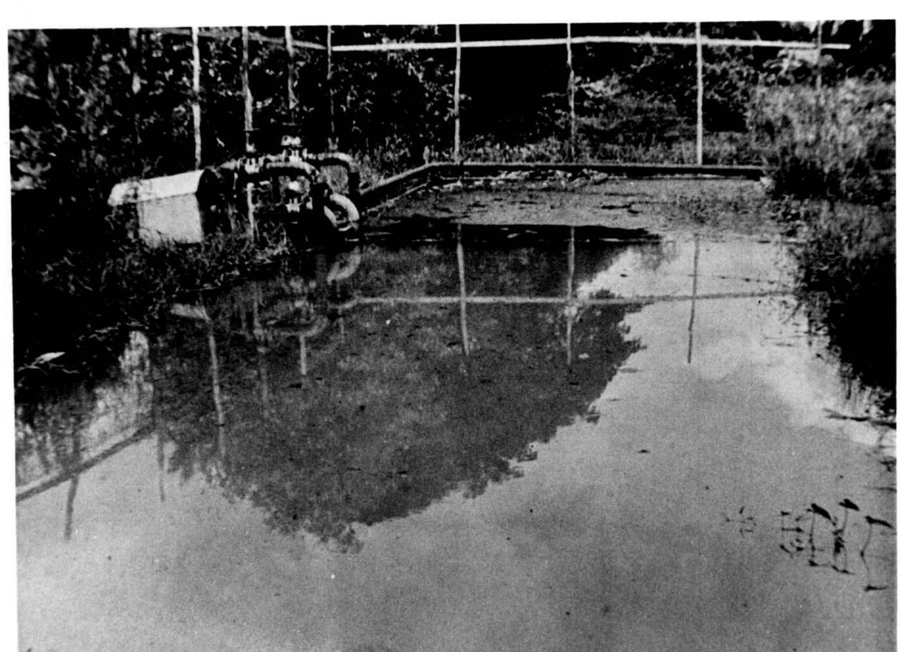


Plate 16 Pop Ice Cream's Wastewater Storage Before Disposal into Klong Saen Saeb at Hua Mark.

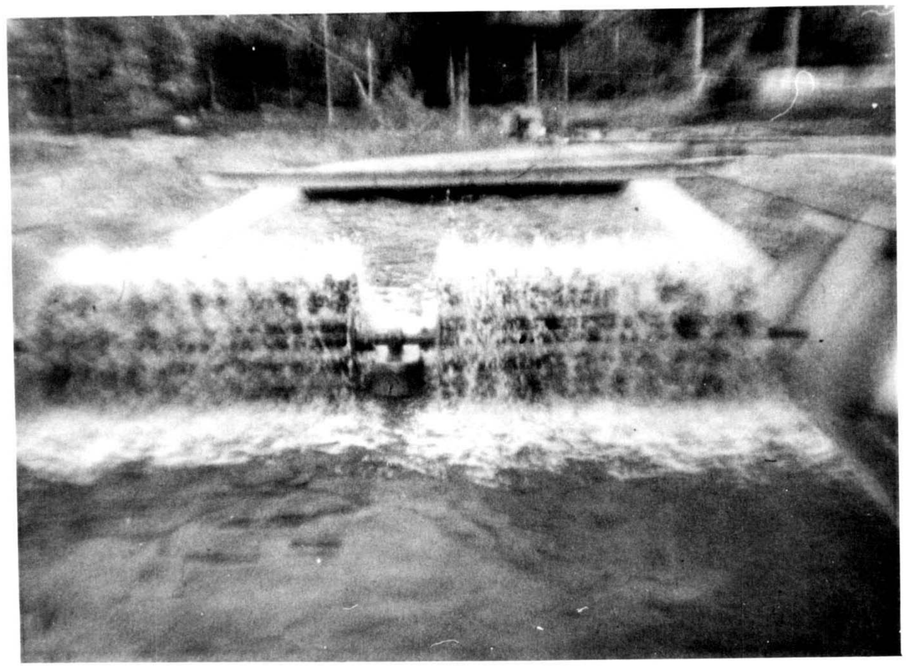


Plate 17 Oxidation Ditch Treatment of Thai Milk Factory's Wastewater at Minburi.

Characteristics of Wastewater

Table B-2 (Appendix B) lists the characteristics of the wastewater from three milk product factories namely Foremost, Thai milk and Pop Dairy Product. The wastewater consisted mainly of sugar, fat, and powdered milk and other minor flavouring ingradients. The colour of wastewater in all three cases was dirty grey with lumps of suspended solid material. The wastewater was devoid of phosphates with Biochemical Oxygen Demand ranging from 340* to 5,400 mg/l, Chemical Oxygen Demand of 640 to 7,100 mg/l and ammonia nitrogen as 0 to 1.8 mg/l. The dissolved Oxygen contents of the wastewater were nil, pH around 7 and temperature varied from 36-38°C. High concentration of suspended solids ranging from 130-860 were also recorded.

Treatment Process

Since most of the organics in the wastewaters from the milk products factories are in dissolved form, activated sludge process was observed

*After Septic tank treatment.

to be in use by the Foremost and the Thai milk factories. The Pop ice cream does not have a treatment system. The Foremost is using diffused aeration type of activated sludge process which is not controlled and as indicated by Table B-4 (Appendix B) was not working well. Thai milk factory using a septic tank treatment of its wastewater prior to aeration in an oxidation ditch was working considerably well but the nutrients consumption was 1.5 time higher than designed capacity. Appendix A-3 gives the detail flow diagram of both treatment processes as mentioned above.

Existing Standards and Efficiency of Treatment

Table B-3 (Appendix B) lists treated water and stream water characteristics for the Foremost and Thai milk factories. Pop ice cream factory data could not be included because it does not have wastewater treatment facilities and receiving stream could not be reached due to over flooding of the land around it. The foremost factory's treated water was found to be high in both BOD (150 mg/l) and suspended solids (270 mg/l), while the Thai milk's treated effluent was considerably close to established standards for effluent discharge. On the other hand BOD's of the receiving streams, as can be seen from Table 12 were consistently higher than those of the treated effluents. This clearly indicated that effluent standards have to be modified by taking into consideration both the stream and the effluent from the factory.

Economics of the Pollution Control

Presently, the three milk products factories visited have a total investment of 55.1 m in both factory and wastewater treatment systems. The wastewater treatment system make up about 500,000 ฿ - less than 1 % of the total investment. This amount of investment in considerably low when compared with the minimum investment of 4 % of the total industrial capital as practiced in most of the developed countries. Therefore, more investment in terms of improving the existing systems is urgently needed.

Animal Processing Industry

*At present no other private company other than the government owned Live Stock Trading is permitted to slaughter cattle and swine in Bangkok area; but nevertheless, there are a number of cladestine privately-owned slaughter houses. This slaughter house which is the largest in the country has a daily working capacity of 200 cattles, 200 baffaloes 3,000 swines, and 30,000 poultries. The other factories have fairly small capacities of upto 200 cattle, hogs and buffaloes per day. Apart from the slaughter houses a number of small factories which manufacture 50-150 kg/day of Sausages are scattered mostly in Bangkok and far in the provinces. Total employment in this type of industry is closer to 2000 persons. The Live Stock Trading Company alone makes a daily sale of 40,000-48,000 bahts.

The raw materials are supplied mainly from the provinces of Saraburi and Nakorn Sawan. The hides, bones, and blood from cattles and swine are sold as by-products. About 20 tons each of dried blood and bones are produced daily most of which are exported to Japan to be used as animal feed and fertilizer. The other by products such as chicken feathers, swine hairs are used locally by animal feed and tooth brush industries respectively.

Table B-1 (Appendix B) shows the location of the factories visited and other relevant data such as production capacity total labour employed, years of operation etc.

Sources of Wastewater

Most of the wastewater from an animal processing is mainly produced from slaughtering operation. The factories visited were semi automatic. In the slaughter area, the animal killed and the carcass is drained of blood. Most of the blood, rinse-water from other parts of animal body and dung are discarded as wastewater. Another source of wastewater was from stock yard which consisted of dung, urine and wash water. The plants visited had collection systems for wastewater generated in the slaughter area during production and during clean up operation following production. Plates 18-23 show wastewater from slaughter houses and its eventual disposal into the klong.

*Economic Evaluation Group, ASRCT, Bangkok.

Plate 18 Wastewater from Union Live Stock Factory at Klong Toey after Septic Tank Treatment.

Plate 19 Disposal of Abbatoir Wastewater at Klong Toey into Klong Prakanong.

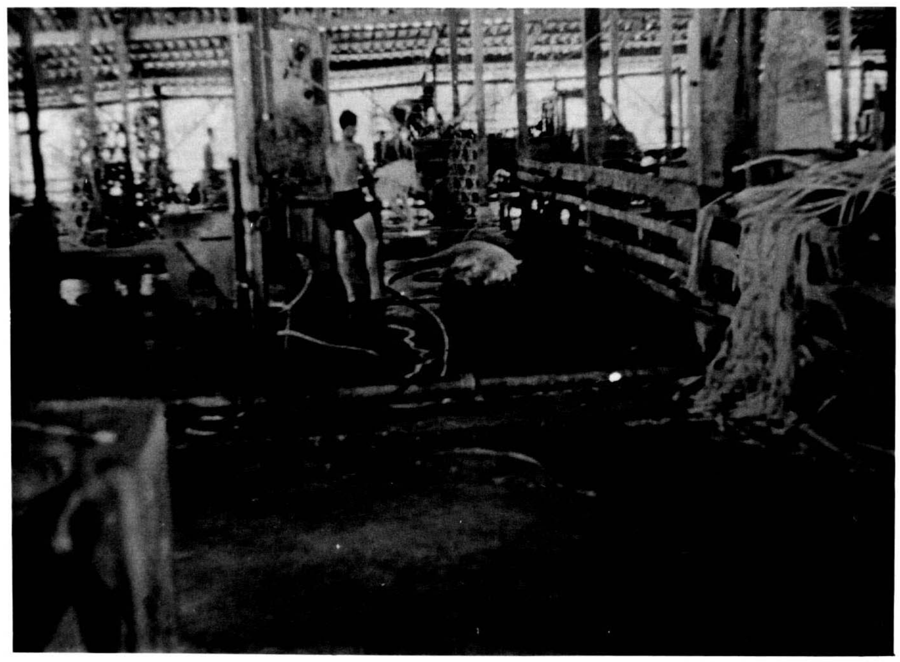


Plate 20 Animal Processing plant at Bangkhay.

Plate 21 Wastewater Manhole of Abbatoir at Bangkhay.

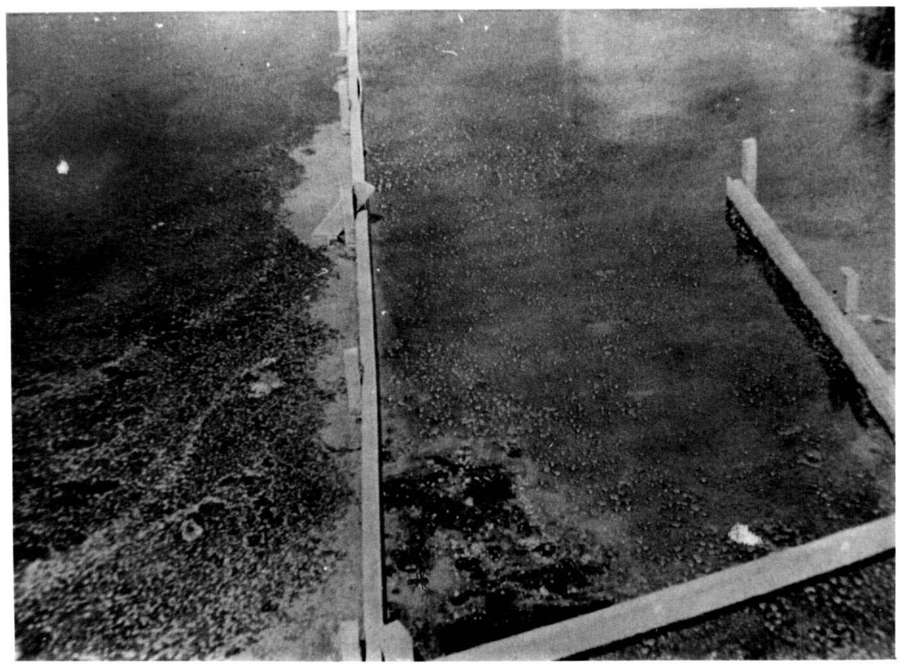


Plate 22 Anaerobic Treatment of Bangkhay Abbatoir's Wastewater.

Plate 23 Treated Effluent Disposal into a Nearby Klong (Bangkhay abbatoir).

Characteristics of the Wastewater

Table B-2 (Appendix B) lists the characteristics of the waste from two animal processing plants visited during the course of this study. The wastewater produced by these factories are reddish grey in colour and very concentrated due to presence of dung suspended during the clean up operations. The wastewater was found to be high in COD (1000-1742 mg/l) and BOD (700-1060 mg/l) and moderatly high in suspended solids (80-600 mg/l). The dissolved oxygen level in the effluent was observed to be low (0-3.7) while pH was found in the range of 6.9-7.6.

Treatment Process

Since the wastewater from animal processing plants are high in solids and high in BOD, initial treatment involving primary anaerobic logooning was observed in both factories. The factory in Bang Khay has a properly designed anaerobic-facultative pond system while Union Live Stock Trading factory in Klong Toey has a short detention period septic tank. It can be seen that treatment process in the second case was not sufficient as the characteristic of the treated wastewater did not change much as shown in Table B-3 (Appendix B).

Existing Standards and Efficiency of Treatment

Table B-3 (Appendix B) lists treated water and stream water characteristic for the live Stock Trading, and Bang Khay slaughter houses. The characteristics of the septic tank treated wastewater discharged by the live Stock Trading is grossly polluted-BOD 600 mg/l. The suspended solids also increase due to incomplete treatment in the septic tank. This wastewater discharge into Klong Prakanong was observed to have resulted in anaerobic condition of no oxygen about 200 meters from the point of effluent discharge. The BOD of the stream water is considerably high (80 mg/l.). The klong is said to be septic during low flow period. The effluent from Bang Khay slaughter house after treatment was sufficiently high in NH_3-N and COD as a result the receiving stream which is considerably small had accumulated COD of 256 and NH_3-N concentration of 1 mg/l. Comparing the effluent discharged from both plants to the existing standards of effluent discharge, the treatment was found to be insufficient. Owing to fact that these wastewaters are potential disease carriers, a careful treatment by taking into considerations the health aspects is urgently needed.

Table B-4 (Appendix B) lists the cost of treatment and other relevant data for the Bang Khay slaughter house. The management has spent about 1.5 % of its capital investment on treatment of wastewater. The treatment system was designed on basis of its low operation cost 2 %. The cost of treatment in a small factory seems to be appropriate provided few basic changes in the design are attempted. The money spent in case of Union live Stock Trading Company is very little compared to the investment in the factory. For factory of that size they would at least need 1-2 million Bahts to treat the waste.

Distilleries

*Distilling of alcohols, spirits and wines is directly controlled by the state which licenses all productions. At present, the largest distillery Bang Yee Khan, situated in Greater Bangkok area, is owned by the Ministry of Industry. This distillery accounts for a major portion of total output of over 134 million litres per annum which is combinely produced by Bang Yee Khan, 35 smaller plants and 6 "farmout" distilleries in the provinces. The total employment in alcohol production is about 8000 persons, out of which a quarter are employed in Bang Yee Khan factory.

Sugar and molasses are the main raw material used. Both they and other materials are obtained entirely from domestic sources. At present capacity the industry is capable to meet 99 % of the domestic demand, bringing in 1340 million bahts in local taxes.

Sources of Wastewater

Water is extensively used in operation such as washing of raw materials, containers, fermentation and distillation units. Although all of these units contribute major sources of wastewater, all except the wastewater from the six distillation tanks in the factory are less contaminated with organics. The wastewater from distillation units at Bang Yee Khan contributes 90 % of the pollutional load. At present, the waste load of 700 m^3 per day is discharged from four of the

*Economic Evaluation Group, ASRCT, Bangkok.

The additional wastewater, 2400 m^3/day in volume is produced as spent water from condensers. This water is taken from Chaophya River and after being used as cooling water in condensers is mixed with the waste load from the distillation unit and discharged into the river. Examples of bad plumbing were observed during the visit and it is suspected that present waste load, which eventually is disposed off into the river, is much higher than conscivable from the results. Plates 24 to 26 shows the sources of wastewater and river water at the disposal point. Table B-1 (Appendix B) shows the location and other associated data of the factory visited.

Characteristics of the Wastewater

Table B-2 (Appendix B) lists the characteristics of both cooling water and wastewater from the distillation unit as obtained during visit to Bang Yee Khan distillery. The cooling water was observed to be colourless with some suspended sediments while wastewater from the distillation unit was a brown concentrated liquid. The Chemical Oxygen Demand of the distillation waste was found to 230,000 mg/l and of cooling water as 96 mg/l. Similarly BOD's of both waters were 225,000 mg/l and 20 mg/l respectively. The suspended solids, were substantially higher (14,910 mg/l) in case of distillation waste and low for cooling water (62 mg/l). The dissolved oxygen of both waters was found to be 0 and 5.4 mg/l respectively. During a test on settleable solids in distillation unit's wastewater 56 % reduction in total suspended solids were also observed.

Treatment Process and Existing Standards

At present, Bang Yee Khan distillery does not have any wastewater treatment system. The 700 m^3 of wastewater from distillation unit is discharged into the sewer where it is mixed with 2400 m^3 of cooling water before final disposal into the river.

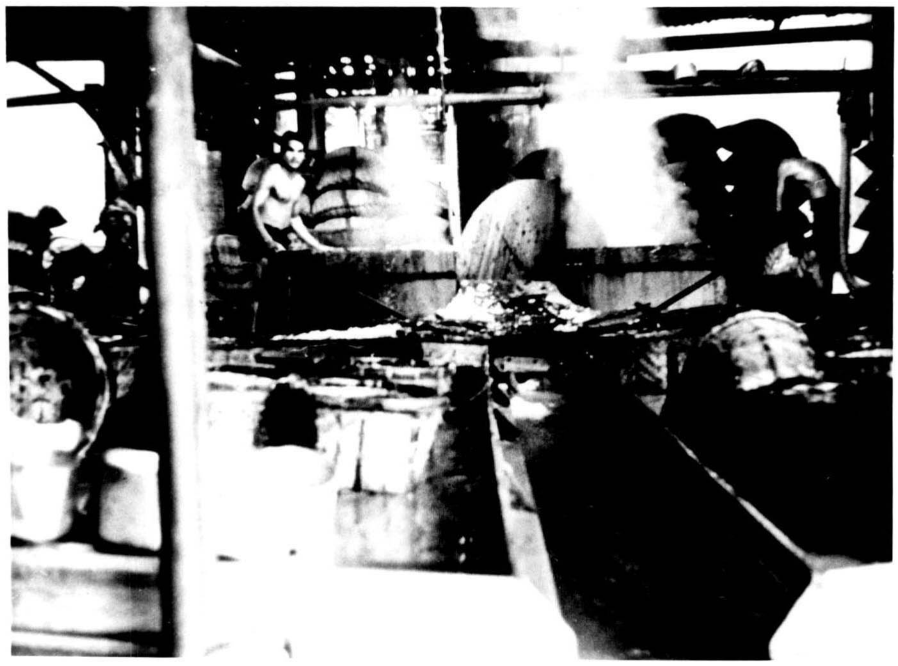


Plate 24 Raw Material Washing in Bang Yee Khan distillery, Thonburi.

Plate 25 Wastewater from Distillation Units in Bang Yee Khan Distillery.

Plate 26 Final Disposal after Dilution of Bang Yee Khan Distillery Wastewater into Chaophya River.

This operation provided some dilution effect as can be seen in Table 3. The BOD load is reduced from 225,000 mg/1 to 50,000 mg/1 which is still quite high. Similarly COD and suspended solids of the waste are reduced to 55,000 mg/1 and 3,420 mg/1 respectively. This indicates that further treatment is necessary.

The impact of wastewater discharge into the river from the Bang Yee Khan distillery can be clearly seen from Table B-3 (Appendix B) which gives characteristics of river water near the factory. The river water was found to be high in COD, BOD and suspended solids. Comparing the existing pollutional load on the river with the stream water standards, the present dilution of waste is unsatisfactory. Since samples were taken during the rainy season, it is expected that in dry season, when dilution and self cleansing capacity of the river is limited, this waste discharge would be much damaging. The existing standards of effluent discharge if applied would make it necessary for the factory to treat its waste before disposal into the river.

Table 3 - Characteristics of the Wastewater after Dilution

Name	COD mg/1	BOD mg/1	NH_3-N mg/1	D.O.	Temp. °C	S.S mg/1
Bang Yee Khan	55,000	50,000	0	4.0	38	3,420

Textile Industry

*At present, excluding 58 large ones, there are over 4,000 wearing factories in Thailand, producing about 715 million square yeards of both synthetic and nonsynthetic product. This industrial sector accounts for 12 % of the total industrial activity in Thailand. It includes fibre spinning and pressing; spinning and wearing of cotton and synthetic fibres; manufacture of apparel and other textile goods; manufacture of knitted goods; gunny bags production and carpet manufacture. Of the activities listed cotton spinning and wearing and manufacture of made up goods contributes the largest share.

The consumption of cotton and synthetic fabric is rising at the rate of 17 square yards per head and stands, presently, over 540 million square yards of which 125 million square yards are synthetic. The local cotton industry dominates 85-90 % of the market while synthetic products share only 35 %. The export of the local industry is 1-2 % of the total production. The present spinning capacity of the Textile industry in Thailand is 771,100 spindles, out of which 21,500 are power looms.

The local raw material contribution is only 15 %, as a result 40,000 tons of raw material are annually imported.

Sources of Wastewater

During the course of this study only two synthetic textile factories namely Thai Filament Co. and Toray Nylon textile were visited. No cotton fabric factory could be visited, therefore only the sources of water from synthetic mill are included. Most of the wastewater is produced during scouring and dying operations. While the scouring operation which includes washing and alkali treatment supplies most of the BOD, the dying operation impart colour to the wastewater. Table B-1 (Appendix B) gives the flow of wastewater and other relevant data. Plates 27 to 31 show sources and treatment of wastewaters from the textile factories.

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*Economic Evaluation Group, ASRCT, Bangkok.

Characteristics of the Wastewater

Table B-2 (Appendix B) lists the characteristic of wastewaters from both factories mentioned above. Wastewater in both cases was highly coloured (dark grey) and very low in suspended solids (10 mg/l). The COD ranged from 300-1232 mg/l while BOD was in the vicinity of 100-300 mg/l. The wastewaters were devoid of nitrogen and dissolved oxygen varied between 0.5-3.0 mg/l. Flow of wastewater ranged from 2,000 to 2,400 in both cases.

Treatment Process

The Thai Filament Co. Ltd. presently is using a chemical biological treatment. The wastewater from the factory is treated with lime and aluminium sulphate and allowed to settle in a sedimentation tank. From there the sludge is taken out and dried on sand beds and supernatent is allowed to stand in two large oxidation ponds. The drainage from the sludge drying beds are also diverted to these ponds. From these ponds the wastewater is finally discharged onto land. On the other hand, the Toray Nylon Co. Ltd, discharges its wastewater into a small unlined canal and forced by means of a pump to sprinkle into a pond and finally disposed off to a nearby canal. Table B-3 (Appendix B) shows the treated and stream water characteristic.

Existing Standards and Efficiency of Treatment

Table B-4 (Appendix B) gives the economics of the treatment of the wastewater from both factories. It can be seen that Toray Nylon, which has total investment of 460 million bahts, is spending only 150,000 ฿ about .03 % on wastewater treatment. The treated water characteristic indicates that the treatment is inefficient. It is estimated that at least 1-2 million investment would be needed to rectify the present state of waste treatment in the factory.

On the other hand Thai Filament has spent 0.67-1.0 % of total investment on wastewater treatment. Although the treatment is efficient enough to bring down BOD and COD of the wastewater within the limit required, its operation is much too expensive. Presently 60,000 ฿ per month alone are spent on running the treatment plant. The biological treatment unit is unnecessary as the wastewater is devoid of nitrogen. A properly controlled biological wastewater treatment can be installed.

Plate 27 Wastewater Canal from Toray Nylon Textile Factory at Minburi.

Plate 28 Textile Factory Wastewater Before Pumping to Treatment Plant. (Toray Nylon - Minburi).

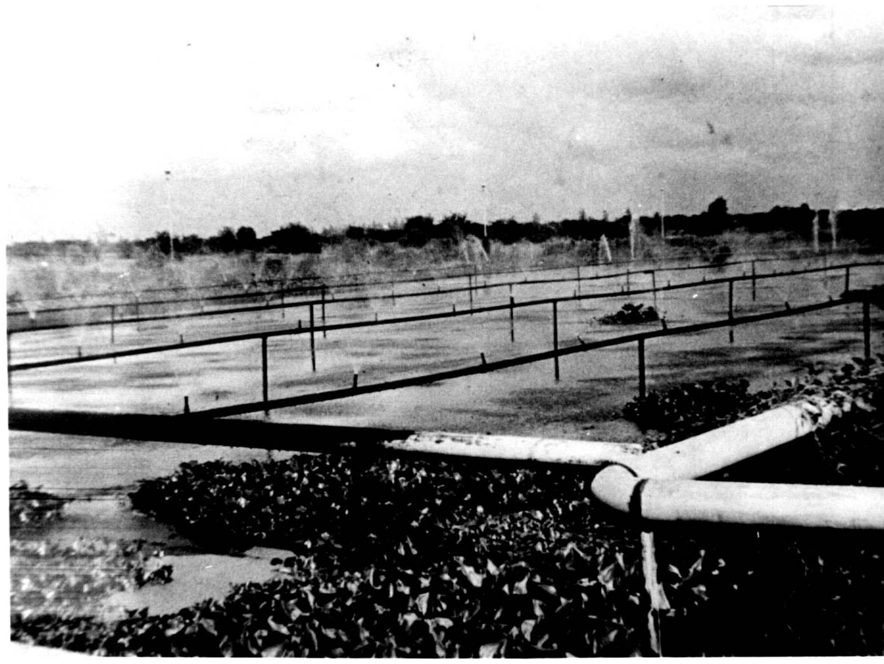

Plate 29 Wastewater Treatment Plant of Toray Nylon Factory at Minburi.

Plate 30 Treated Wastewater Before Disposal into Klong Saen Saeb.

Plate 31 Disposal Point for Toray Nylon Textile Factory's Wastewater.

Soap Industry

At present, there are several local factories involved in manufacture of soap and detergents. Some of these are Lever Brothers, Colgate Seri industries, and Rubia Industries. Lever Brothers and Colgate manufacture cooking oil and detergents besides soap while the remaining two factories produce cosmetics along with soap. The total output from these factories is about 2,000 tons per month.

Lever Brothers and Colgate which are fairly large industries control 90 % of the local market in detergents bases while the remaining 10 % is made up of finished detergent imported from Japan.

Fats and coconut oil used in soap production are supplied locally. The main raw material for detergent manufacture imported are di and tridecyl-benzene amounting to 5,200 to 5,400 tons per year. The price of this chemical presently is 9.3 U.S. cents per lb.

In the course of this study only two of the above mentioned factories namely Lever Brothers and Rubia Industries were visited. Rubia Industries presently does not have any wastewater problem but will start operation of a new factory at Sumlorng, Samutprakarn province very soon. Therefore the data listed in Table B-1 (Appendix B) provides information about the proposed factory.

Sources of Wastewater

The main sources of wastewater in the production of soap were due to purification of fats and oil and production of glycerine. A major to portion of wastewater is produced during dtergents manufacture. The wastewater produced from Lever Brother soap factory which amounts to 50 m^3 per day from all of the above mentioned sources is combined together and collected in a basin for oil scoopping. Plate 32 shows the waste water from Lever Brothers soap factory.

Characteristics of Wastewater

The wastewater produced during soap, glycerine and detergent manufacture is dirty grey in colour and concentrated in nature. The chemical

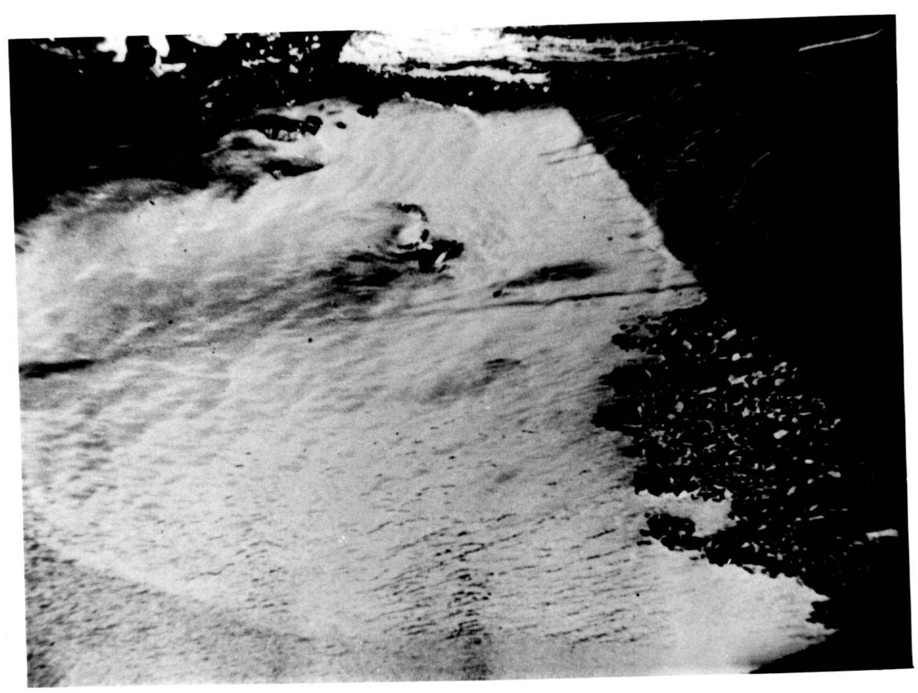

Plate 32 Wastewater from Lever's Brothers Factory at Chareon Krung Road.

Oxygen Demand varied between 60,000 to 80,000 mg/l while BOD ranged from 40,000 to 60,000 depending upon the source of wastewater. The wastewater was found to be high in pH (11.5) and devoid of dissolved oxygen. The suspended solids ranged from 400 to 2000 mg/l Table B-2 (Appendix B) gives the characteristics of raw waste from Lever Brothers soap factory.

Treatment System

At present, Lever Brothers does not have any treatment system except for manual oil scoopping which floats on the surface of water. The wastewater after oil removal is pumped directly into the nearby klong. Table B-3 (Appendix B) lists the characteristic of the stream water. The COD and BOD were found to be 600 and 400 mg/l respectively. The water in the vicinity of the factory was found to be high in pH and low in dissolved oxygen, indicating gross pollution. During the interview, the management gave an impression that waste treatment was handled in the nightshift. No evidence of such treatment was observed.

Tannery Industry

*There are over forty tanneries in Thailand, with most of them concentrated in Bangpoo village, near the coast of the Gulf of Siam. Thai Tanneries which is the largest in the country in terms of production as well as equipment and personnel, is situated at Klong Toey. The present production capacity is 4500 hides per month or 200,000 square feet of both sole and soft leather each. Tanned leather is mainly produced for domestic market. The tanning agent in use is mainly chromium salt, however some vegetable-synthetic tannings are also used. Basic raw material, are the hides of animal which are locally supplied.

During the course of this study Thai Tanneries was visited. Table B-1 (Appendix B) lists information about the factory.

Source of Wastewater

The Thai tanneries is producing 520 m^3 of wastewater polluted both

*Economic Evaluation Group, ASRCT, Bangkok.

with organics and chemicals. The sources of wastewater in this factory includes wastes produced during vegetable tanning of sole leather and chrome tanning of soft leather. Apart from these a substantial amount is contributed during dehairing process with lime and sodium sulphide treatment, Due to the involvement of microbiological standards reusage of water is not practiced.

Characteristics of Wastewater

Table B-1 (Appendix B) lists the characteristics of wastewater from Thai Tanning factory. The wastewater was found to be browish grey in colour and high in suspended solid, (970 mg/l). The COD and BOD of the combined wastewater was recorded as 2,200 mg/l and 1,800 mg/l respectively. The dissolved oxygen was analysed as 4.2 mg/l, and 0.16 mg/l of ammonia nitrogen in the wastewater was detected. The pollutional capacity of the factory was estimated to be 936 Kg/day.

Treatment System and Existing Standards

Presently, the factory which was established 10 years back does not have a wastewater treatment system. The wastewater produced by the factory is directly discharged into Klong Prakanong, which is also receiving untreated wastes from other factories. Table B-3 (Appendix B) gives the characteristics of stream water. It can be observed that the existing Klong water is high in BOD and COD, 80 mg/l and 185 mg/l respectively. Presently the ammonia nitrogen level in the water is 2 mg/l. Since the survey was conducted during rainy season, at this level of pollution going into the Klong, septic condition can be predicted during the dry part of the year.

It seems that the effluent standards even based on wastewater discharged into the klong are not applicable. It is believed that the factory will have to put a treatment system to curtail its present pollution load going into the klong.

Cement Industry

*With total assets of over 3,000 million bahts and producing over 2,000 different products, the Siam Cement Group, which consists of the Siam Cement, the Siam Fibre-cement, the Concrete Products and Aggregate, the Construction Material Marketing, and the Siam Iron and Steel Companies, is large by the standards applied in developed nations. The present sale of the group reach an annual total of 1,700 million baht. The Siam Cement Co. Ltd. is the largest and the oldest of the group. It has four plant, in operation with a working capital of 760 million bahts and 3 million tons of annual output. The raw materials used in the industry are from domestic source.

During the course of this study the Siam Fibre-cement Co. Ltd., was visited. Table B-1 (Appendix B) shows the location of the factory and other relevant data.

Sources of Wastewater

The factory being built about 7 years back has new machaninary. It uses large quantities of water during the initial stages of pipe moulding, but the water is recycled back and used again, the only source of wastewater with low pH is from curing chamber (see flow diagram). Fifteen cubic meters of wastewater is produced from this source. Plate 33 and 34 show the wastewater from the cement factory and its treatment

Characteristics of Wastewater

Table B-2 (Appendix B) lists the characteristics of the raw wastewater from the cement factory. The COD and BOD were 340 mg/l and 5 mg/l respectively.

Treatment Process and Existing Standard

The factory has recently installed a treatment system involving pH adjustment and filtering wastewater before storage into a ditch from where it drains into a nearby Klong. This treatment was installed when

*Economic Evaluation Group, ASRCT, Bangkok.

Plate 33 Wastewater from Siam Fibre-cement Factory of Nonburi Flowing into a Pond Before Disposal.

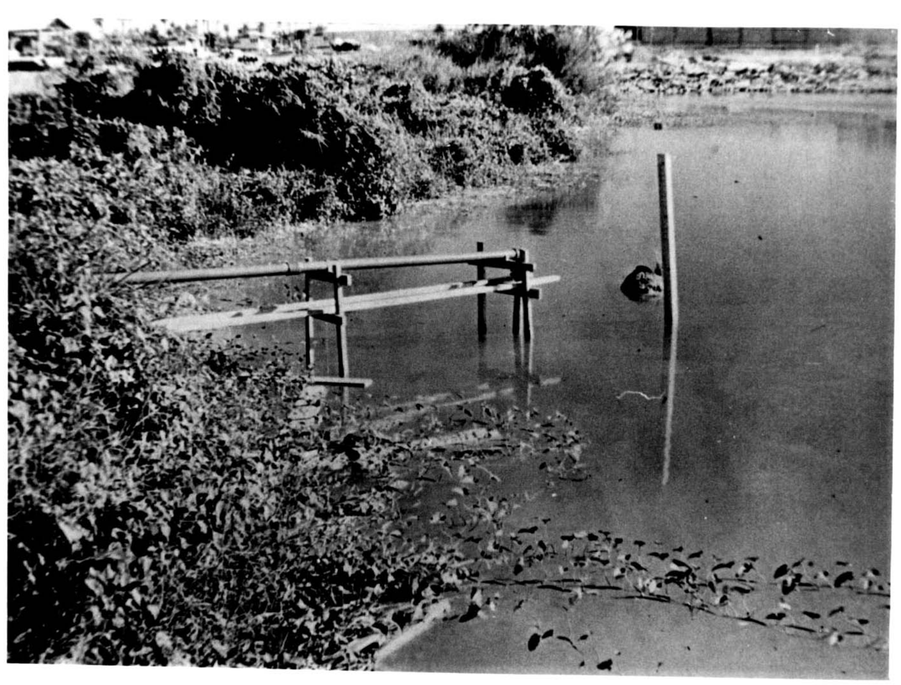

Plate 34 Siam Fibre-cement Factory Waste Stabilization Pond.

people living near the factory complained of skin itching caused when they happen to use klong water. Table B-3 (Appendix B) gives the characteristics of the treated and Klong water. The COD of the treated water was found to be 144 mg/l and the klong as 96 mg/l. The BOD of the treated water being 0, while that of the klong was found to be 16 mg/l. Ammonia nitrogen in the concentration of 1.2 mg/l was also found in the klong water.

The present treatment cost which is .2 % of the total investment in the factory was found to be appropriate as the existing standards of 20 ml/l BOD, and 30 mg/l suspended solids compared well with the effluent discharged from the factory. Table B-4 (Appendix B) gives the type of treatment and associated data involved with disposal of factory's wastewater.

Ice Industry

There are more than thirty ice factories in and around Bangkok area. Most of these factories are members of an ice cooperative. The total investment in ice factories is more than 200 million bahts with production capacity over 2 million tons a year.

All the machinary installed in these factories is imported mainly from Denmark.

The ice factory visited, situated at Nonburi is fairly large in terms of production capacity (168,000 tons/year) and production labour employed. Table B-1 (Appendix B) gives location and other relevant data concerning the factory.

Sources of Wastewater

The main source of wastewater in the factory was found to be cooling water from condensers Plates 35 to 37 shows the source and present from of treatment of wastewater. This water is high in temperature and grossly polluted with oil. Although most of it again used after cooling but sometimes it has to be released into the klong.

Characteristics of the Wastewater

Presently factory is using 250 m^3 of cooling water a day with a pollution capacity 4 kg of BOD/day. The BOD and COD of the cooling water were found to be 16 mg/l and 80 mg/l respectively. The cooling water water was high in temperature (50°C) and low in suspended solids (20 mg/l). Table B-2 (Appendix B) lists the characteristic of wastewater from condensers.

Treatment Process and Existing Standards

The factory has installed wooden weirs to trap oil slick in the water which is disposed off into a narrow ditch where oil is manually scooped off and the water after going through a series of weirs is forced sprinkled through a network of elevated pipe lines. This brings down the temperature but also increases the pollutants in the water. Table B-3 (Appendix B) shows the characteristics of the treated water. Although the factory recycles back this water on a continuous basis but it is strongly believed that eventually part of this water gets released into the klong. The pollution load as can be seen is very little, even if discharged partly into the klong. If the present form of treatment is strictly followed, no further treatment of water is deemed necessary. The factory is spending 2,000 - 2,500 bahts/month in pumping and oil scooping operatinns.

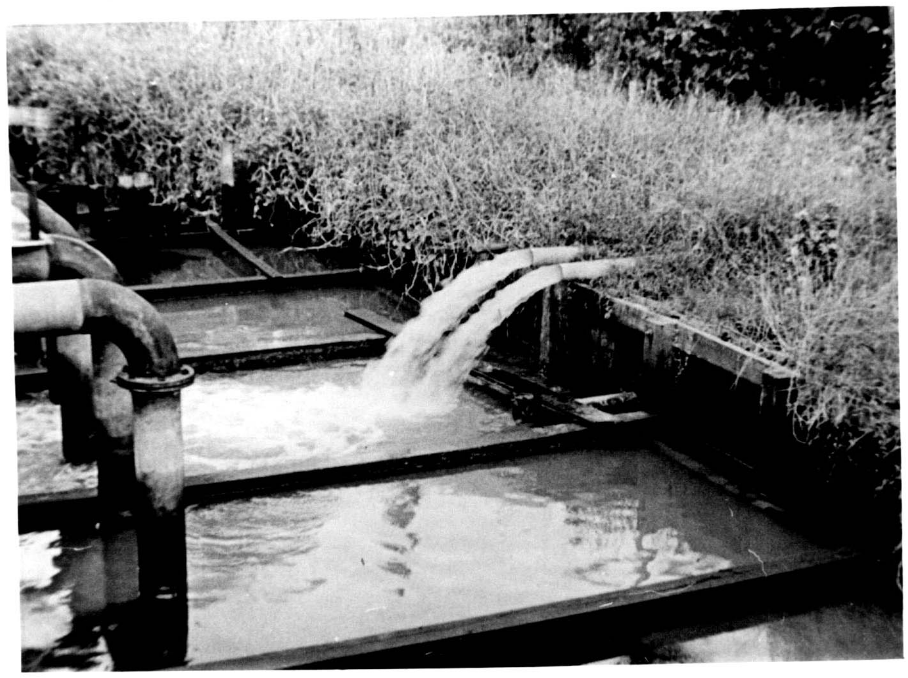

Plate 35 Cooling Water Disposal of Ice Factory at Nonburi.

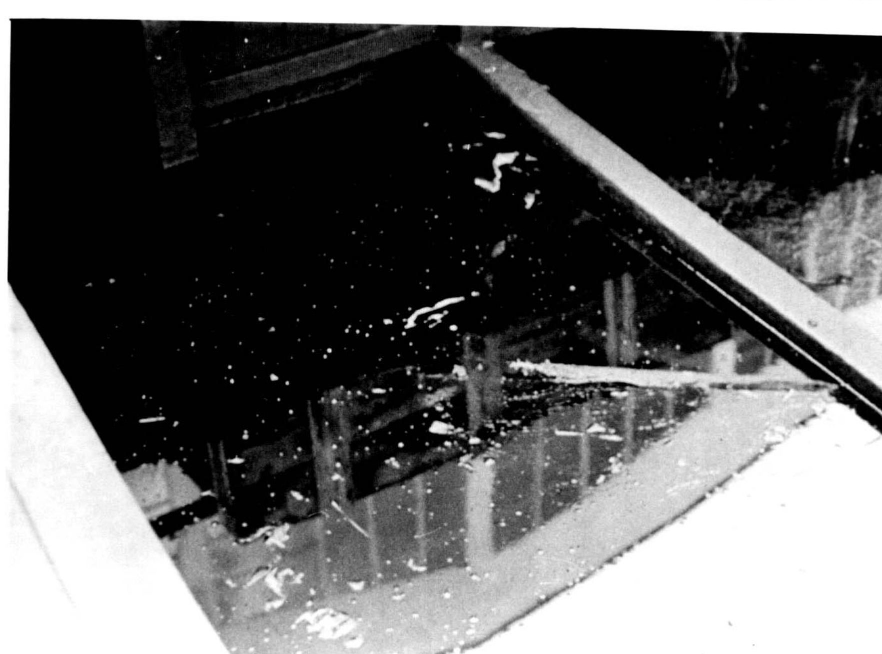

Plate 36 Oil Slick Treatment of Nonburi Ice Factory.

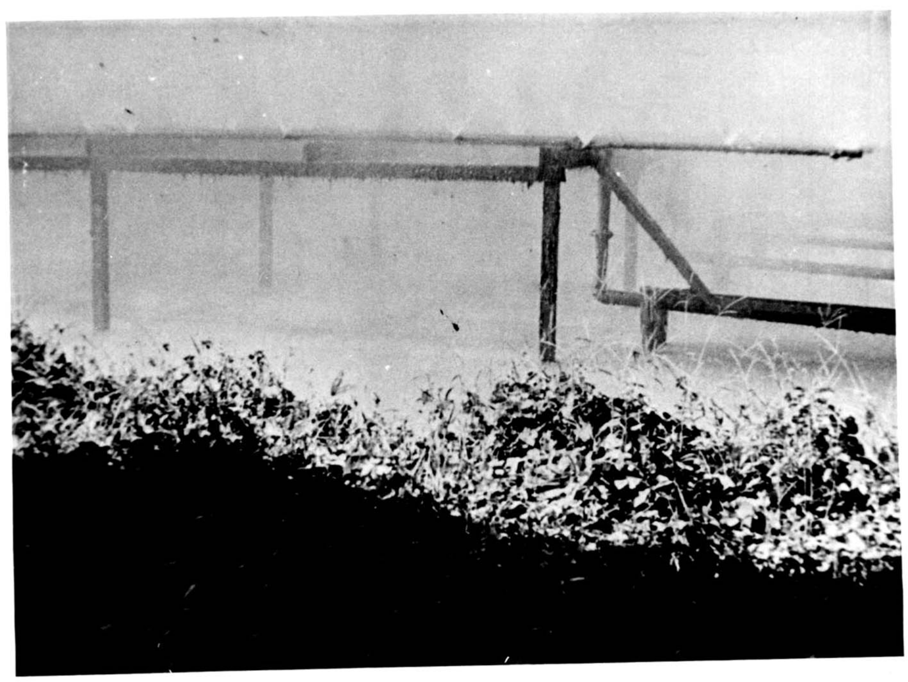

Plate 37 Treatment of Cooling Water from Codensers at Nonburi Ice Factory.

4.2. Total pollutional load, Treatment Efficiency and Economics of Waste Treatment.

(a) Pollutional Load and Treatment Efficiency

Out of the 21 factories visited, only 11 or about 50% have some kind of waste treatment systems. These include 5 soft drink, 2 milk, 2 textile, one cement and one animal processing factories. As can be seen from the results of analyses, made on samples from these factories, that about 40% of the existing treatment systems are working properly. Table 4 shows the total pollutional load from each factory with and without treatment. The total pollutional load expressed as tons of BOD/day from all factories is presently 168.6. After treatment this load is reduced to 165.6 tons of BOD/day or, a mere 1.75%

Taking into consideration the industries with high organic wastes it can be concluded that Bang yee Khan, two breweries, Abbatoir at Klong Toey, and Lever Brothers are contributing about 98% of the pollutional load. These factories presently do not have any treatment system and in effect discharging raw waste into nearby klongs and river. This waste load disposal is highly objectionable in view of the fact that the klongs and river itself are receiving domestic waste of 3.6 million persons. The combined waste load from above mentioned factories is equivalent to that of waste produced by 3.2 million persons. The adverse effects of this combined load was observed near large factories with no waste treatment systems. The receiving bodies of water were observed to be low in dissolved oxygen, high in BOD, COD, NH_3N and suspended solids (see presentation of results). Therefore, it is strongly recommended that these factories should install some kind of waste treatment system.

Table 4 - Pollution load from Various Factories

Name of Industry	Location of factory	Flow of Wastewater m^3/day	BOD, mg/l	Pollution Capacity before Treatment Kg of BOD/day	Pollution Capacity After Treatment Kg BOD/day
Soft drinks					
Pepsi Cola	Super Highway	640	1,500	960	12.8
7-up	Nonburi	45	1,500	67.5	0.9
Bireley's	Nonburi	80	220	17.6	4.8
Green Spot	Hua Mark	700	600	420	28
Coca Cola	-do-	1,370	600	822	191.8
Union Soda	Lan Laung	150	400	60	60
			Total	2,447.1	298.3
Milk					
Foremost	Rangsit	152	1,320	200	22.5
Thai milk	Minburi	14	340	4.8	0.35
Pop ice cream	Hua Mark	45	7,100	320	320
			Total	524.8	342.85
Breweries					
Thai Amarit	Sam Saen	450	1,000	450	450
Boon Rawd	-do-	1,100	2,500	2,750	2,750
			Total	3,200	3,200
Distillary					
Bang Yee Khan	Thonburi	700	225,000	157,500	157,500

ที่ สร.ทม.๑๒๐๑/๓๒๓/๑๖ สถาบันบัณฑิตพัฒนบริหารศาสตร์

๒๕ พฤษภาคม ๒๕๑๖

เรื่อง หนังสือรับรองเพื่อใช้ในการขอขยายเวลาศึกษาต่อ

เรียน อธิบดีกรมประชาสัมพันธ์

ด้วย น.ส.สุนีย์ กุญฐีวิจัย นักศึกษาชั้นปริญญาโทคณะพัฒนาการเศรษฐกิจ ได้ยื่นคำร้องขอให้สถาบันบัณฑิตพัฒนบริหารศาสตร์ออกหนังสือรับรอง เพื่อใช้เป็นหลักฐานประกอบในการขออนุมัติขยายเวลาการศึกษาต่อ

สถาบันขอเรียนให้ทราบว่าในการศึกษา เพื่อให้ครบถ้วนสมบูรณ์ตามหลักสูตรชั้นปริญญาโทของสถาบัน นักศึกษาจะต้องศึกษาให้ได้จำนวนหน่วยกิตไม่น้อยกว่า ๕๑ หน่วยกิต (ไม่นับรวมหน่วยกิตวิชาภาษาอังกฤษ) และจะต้องเข้าทำการสอบข้อเขียนพิสดาร (หลังจากที่ได้ศึกษาวิชาบังคับรวมไม่น้อยกว่า ๓๖ หน่วยกิต) พร้อมทั้งสอบปากเปล่า หรือสอบปากเปล่าวิทยานิพนธ์ (หลังจากศึกษาครบหน่วยกิตตามหลักสูตรแล้ว) อีกด้วย

สำหรับกรณีของ น.ส. สุนีย์ กุญฐีวิจัย ได้ลงทะเบียนเข้าเรียนและศึกษาวิชาตามหลักสูตรชั้นปริญญาโทคณะพัฒนาการเศรษฐกิจ แล้วรวม ๑๕ วิชา (๔๕ หน่วยกิต) ทราบผลการศึกษาแล้ว ๑๒ วิชา (๓๖ หน่วยกิต) และขณะนี้กำลังศึกษาอยู่ในภาคการศึกษาฤดูร้อน/๒๕๑๕ อีก ๒ วิชา (๖ หน่วยกิต)

ในการสอบข้อเขียนพิสดารนั้น สถาบันจะกำหนดให้มีขึ้นประมาณหนึ่งเดือนหลังจากเสร็จการสอบไล่ของแต่ละภาค ส่วนการสอบปากเปล่าหรือปากเปล่าวิทยานิพนธ์นั้น จะได้กำหนดให้มีตามความเหมาะสม

อนึ่ง สถาบันขอเรียนให้ทราบว่าในปีการศึกษา ๒๕๑๕ สถาบันได้เปลี่ยนแปลงข้อบังคับว่าด้วยปีและภาคการศึกษาใหม่ เพื่อความเหมาะสมดังนี้

ภาคหนึ่ง	ตั้งแต่	๑๖	กรกฎาคม	ถึง	๑๑	พฤศจิกายน
ภาคสอง	ตั้งแต่	๓	ธันวาคม	ถึง	๓๑	มีนาคม
ภาคฤดูร้อน	ตั้งแต่	๒๒	เมษายน	ถึง	๒๓	มิถุนายน

จึงเรียนมาเพื่อโปรดทราบ.

ขอแสดงความนับถืออย่างสูง

(นายศรีปริญญา รามโกมุท)
รักษาการในตำแหน่งรองอธิการบดี ปฏิบัติราชการแทน
อธิการบดี

กองบริการการศึกษา
โทร. ๘๘๘๔๐๐ – ๙ ต่อ ๒๑๐

Table 4 (Continued)

Name of Industry	Location of factory	Flow of Wastewater m^3/day	BOD, mg/l	Pollution Capacity before Treatment Kg of BOD/day	Pollution Capacity After Treatment Kg BOD/day
Abbatoir, Tannery					
Union Live stock	Klong Toey	840	1,060	890	890
Bang Khay abba.	Bang Khay	40	600	24	2.4
Thai Tannery	Klong Toey	120	1,480	180	180
			Total	1,094	1,072.4
Soap					
Lever Brothers	Chareon Krung Road	50	60,000	3,000	3,000
Textile					
Toray Nylon	Minburi	2,400	300	720	240
Thai Filament	Rangsit	2,000	100	200	40
				920	280
			Grand Total	168.6	165.6

Activated sludge treatment process in various forms were observed to be operating in factories which have waste treatment facilities. The process although efficient requires careful design, understanding and skilled labour for operation. The conventional activated sludge process is expensive both in construction as well as operation costs. Examples of ignorance and incapability in operating the existing treatment units efficiently were observed. Foremost milk factory at Rangsit is using sprinkular aeration without addition of essential nutrients for bacterial metabolism. Bireley's soft drink's factory at Nonburi and Green Spot factory at Hua Mark both had floating sludge in the final sedimentation tank. This was mainly due to poor settling tank design. Similarly Thai milk factory at Minburi is using more nutrients than computed requirements of oxidation ditch treatment of its wastewater. As a result excess nitrogen and phosphate is discharged with the treated effluent into the klong. In essence most of these treatment plants are operating with efficiencies lower than expected for an activated sludge treatment unit (95%-99%).

In comparing different forms of activated sludge treatments presently in operation, oxidation ditch treatment can be considered more efficient. Table 5 lists the efficiencies of various treatment units and their costs per kg of BOD reduction, presently the factories using oxidation ditch treatment units have fairly small wastewater flow compared to others. Land requirement was cited to be deciding factor in selection of conventional type of activated sludge units installed in factories with large wastewater flows. During interviews, however, it was learnt that large volumes of wastewater were produced mainly because of combining all kinds of waters from these factories. As an example it can be seen that Green Spot soft drink Co. which has about 700 m^3 of wastewater have approximately same production capacity as that of 7-up bottling co. which produces only 45 m^3 of wastewater. The 7-up bottling Co. presently is treating its concentrated wastewater obtained from washing machine where left over in used bottles are washed once. The second and third washings are disposed off directly to the nearby klong as it is mainly clean water. On the other hand bulk of wastewater in Green Spot factory is produced by combination of all the washings.

The main reason of poor efficiency of most of the existing treatment plants is bad house-keeping and non monitoring of the waste load going into the plants. Obviously plants are often exposed to shock load, thus

Table 5 - Costs and efficiencies of Treatment plants

Name of factory	Efficiency	Cost ฿/Kg of BOD		Remarks
		Construction ฿	Operation ฿/monts	
Pepsi Cola	99%	2,200	5	efficient
Foremost	89%	2,000	150	inefficient
Grean Spot	95%	3,500	500	-do-
Thai Milk	98%	6,700	450	efficient
Coca Cola	76%	2,500	500	inefficient
Bireley's	76%	44,000	900	inefficient
Thai Filament	82%	20,000	150	inefficient
Toray Nylon	75%	200	10	inefficient
7-Up	99%	4,500	100	efficient

affecting treatment efficiencies. Poor maintenance of the existing treatment plants was also found to be one cause of their bad performance. Coca Cola factory at Hua Mark which has four aerators, had damaged two of them few weeks prior to visit and they are still unrepaired. As a result two aerators were observed to be taking up load of 4 aerators. Therefore, in order to improve the performance of existing treatment plants following steps are urgently needed,

1. regular monitoring of waste load on treatment units.

2. improvement in house-keeping thereby avoiding shock load by reducing accidental spills, frequency of washing etc.

3. proper maintenance and regular check up of chemical used, sludge requirement of the unit etc.

(b) Economic Aspects of Industrial Waste Treatment

Most of the factories visited had their treatment installed during past 5 years. Table 6 lists total investment in these factories and money spent in treating their wastewaters. It can be observed that the total capital investment in all of these factories is about 2729 million baht while only 10.38 million or 0.38% has been spent on treatment of wastewaters. In developed countries* where antipollution work is gauged by the amount of money spent on water pollution ahatement, a figure of 4%-10% of the total capital investment is considered appropriate.

With the present amount of money spent in antipollution work, it can be concluded that no relaxation in present state of water pollution can be expected in forseeble future.

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* Personnal contact with Prof. M.B. Pescod, Asian Institute of Technology, Bangkok.

Table 6 - Total investment and Wastewater Treatment costs

Name of factory	Total investment million ฿	Construction Costs million ฿
Pepsi Cola	35	2.1
7-Up	30	0.3
Foremost	40	1.0
Thai milk	12	0.1
Green Spot	30	1.5
Toray Nylon	460	0.15
Coca Cola	55	2.0
Pop ice cream	3	-
Union Live Stock	60	-
Thai Tannery	50	-
Thai Amarit	200	-
Boon Rawd	900	-
Bireley's	10	0.8
Union Soda	15	-
Lever Brothers	100	-
Thai Filament	300	2.0
Bang Yee Khan	600	-
Ice factory	12	-
Siam Fibre	100	0.2
Thai Rubia	15	0.3
Bang Khay	2	0.03
	2,729	10.38

4.3. Receiving Streams and Existing Effluent Standards

The existing effluent standards issued by the Ministry of Industry based on 20 mg/l BOD and 30 mg/l suspended solids, were found to be irrevalent as most of the factories with waste treatment systems are incapable of attaining it. These standards, moreover are based only on effluent discharge, without defining the size, flow characteristies, and use of receiving stream. During visits it was observed that a lot of money has been spent to attain these levels in order to discharge the waste into small klong which has no use except for drainage purposes. As an example Pepsi Cola factory has spent 2.1 million baht on its treatment plant. This factory is also spending an additional 46,000 baht as operation cost to attain a BOD of 20 mg/l and 30 mg/l of suspended solids. The treated water is disposed off into a small klong which is more polluted than the water going into it. Table 7 gives the characteristics of stream water in comparison with the treated water from factories with treatment facilities. It can be observed that stream water, in almost all cases, is more polluted than the

Table 7 - Characteristic of Treated and Klong Waters

Name of factory	BOD mg/l		S.S. mg/l	
	Treated water	Klong Water	Treated Water	Klong Water
Pepsi Cola	20	30	20	100
7-Up	20	80	10	50
Foremost	150	180	270	80
Thai milk	25	44	20	50
Green Spot	40	-*	20	-
Toray Nylon	95	24	10	20
Coca Cola	140	100	34	68
Bireley's	60	130	40	60
Siam Fibre	-	16	30	24
Bang Khay abbatoir	60	210	80	22

* Klong was flooded

treated water. This indicates that the klongs are receiving domestic wastes in much large volumes and the present treatment of industrial wastes has virtually no effect in releiving pollution. Similarly the factories with treatment plant were often found to be preceded with ones which do not have treatment facilities. Thus overal picture of the water pollution due to industrial wastes did not change. As an example, Bircley's soft drink factory in Nonburi complained of an ice factory up stream of discharging cooling water into the klong near the factory. This wastewater had thermally polluted the klong, thus treated water from soft drink factory was unable to improve conditions in the klong. Since rainy season in Thailand lasts about 6 months in a year, discharges exceeding set standards are dissipiated by high water levels in the klong. But during dry season, such effluent discharges along with continous inflow of domestic waste often cause these small streams to turn septic. It is therefore suggested that the present standards which are loosely enforced should be based on stream conditions rather than effluent discharges. These standards should be relaxed during high flow periods when sufficient dilution is available and when the stream's waste dissiplation capacity is more, but should have stringent limits during low flow period.

Since all except one or two factories with treatment plants are strictly following effluent standards, a strict law enforcement is urgently needed. In that respect regular check up of the industrial wastewater should be made. Any factory discharging effluent above limits set up by the Ministry of Industry should be given warning followed by a heavy fine. This approach can work only when all the factories imply with the law and install treatment systems. In essence, the present picture of water pollution problem in Bangkok looks grim. It is expected to increase as the large factories in the metropolitan area still do not have treatment systems and their production capacity and waste production capability is enhanced each year. A concentrated antipollution effort combining industrial sector as well as the government departments will be the approach in the right direction.

V. CONCLUSIONS

Based on the data collected during the study conducted the following conclusions can be made.

1. Out of the 21 factories visited, only about 50% have wastewater treatment facilities. The existing treatment systems in most cases were found to be working inefficiently. Only 40% of the treatment plants are operating properly.

2. Total pollutional load discharged daily by these factories into the Choaphya River and the klongs in Bangkok area presently, is 168.6 tons of BOD. Only about 1.75% of this waste load is removed through waste treatment facilities. As a result 165.6 tons of BOD/day or waste produced by 3.3 million persons is finally disposed into the streams. Most of this waste load is contributed by two breweries in Samsaen area, Bang Yee Khan distillary in Thonburi, Union Live Stock and Thai Tannery in Klong Toey and Lever Brothers at Chareon Krung Road.

3. The total investment in the factories visited stands presently at 2,729 million bahts. An additional amount of 10.38 millions bahts or 0.38% of total capital has been spent on anti-pollution work during the past 5 years. This amount when compared with a figure of 4% - 10% as invested in developed countries for the same purpose, is insufficient. With this amount of money no change in the present water pollution problem is expected.

4. The existing treatment systems of the various factories are not operating efficiently. Several causes of this problems were observed. The most important were bad housekeeping, absence of wastewater monitoring and bad maintenance of the existing facilities.

5. Nearly all except one or two factories were obviously discharging effluents with characteristics exceeding limits issued by the Ministry of Industry. This indicated lack of law enforcement and checking of effluents, discharged by the various factories. However, existing standards of waste discharge seem meaningless as large factories do not have treatment systems and are thus contributing a major portion of the pollutional load.

6. Stream water near all treatment plants was found to be more polluted than the treated water going into them. Domestic sewage disposal and factories with no treatment facilities were found to be responsible for this situation.

7. Conventional activated sludge process used by most factories with wastewater treatment facilities when compared with oxidation ditch treatment was found to be inefficient.

VI. RECOMMENDATION

As a result of the study conducted following recommendations can be made,

1. In order to check against shock load on the treatment plants, it is stressed that the factories concerned will have to improve their house keeping. They should also have arrangements for regular monitoring of influent and effluent, of the treatment plants.

2. The Ministry of Industry will have to enforce treatment on factories which uptil now do not have any treatment system. Furthermore, a more realistic approach concerning the effluent standards will have to be considered. This approach would insist on the fact that the standards thus set up should be flexible and enforce present standards only during low flow periods in the klongs and the Chaophya River. A regular check up of the treatment facilities should be made by the Ministry's staff and a warning and fine system should be devised.

3. Industrial sector should be encouraged to spend more money on their treatment systems and any new industry should be given license only, when environmental considerations have been taken into account.

4. Industries should be discouraged to use activated Sludge process, and where ever possible other cheaper and efficient technique of wastewater treatments should be installed.

VII. REFERENCES

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APPENDIX A

Manufacturing Process

and

Treatment Systems Flow Diagrams

Formate (questionaire)

Name of Factory:- ....

Type of Factory:- ....

Total investment:- ....

Total production:- ....

Years of operation:- ....

Total wastewater flow:- ....

Type of Treatment:- ....

Total cost of Treatment:- ....

Operation Cost of Treatment:- ....

Labour employed:- ....

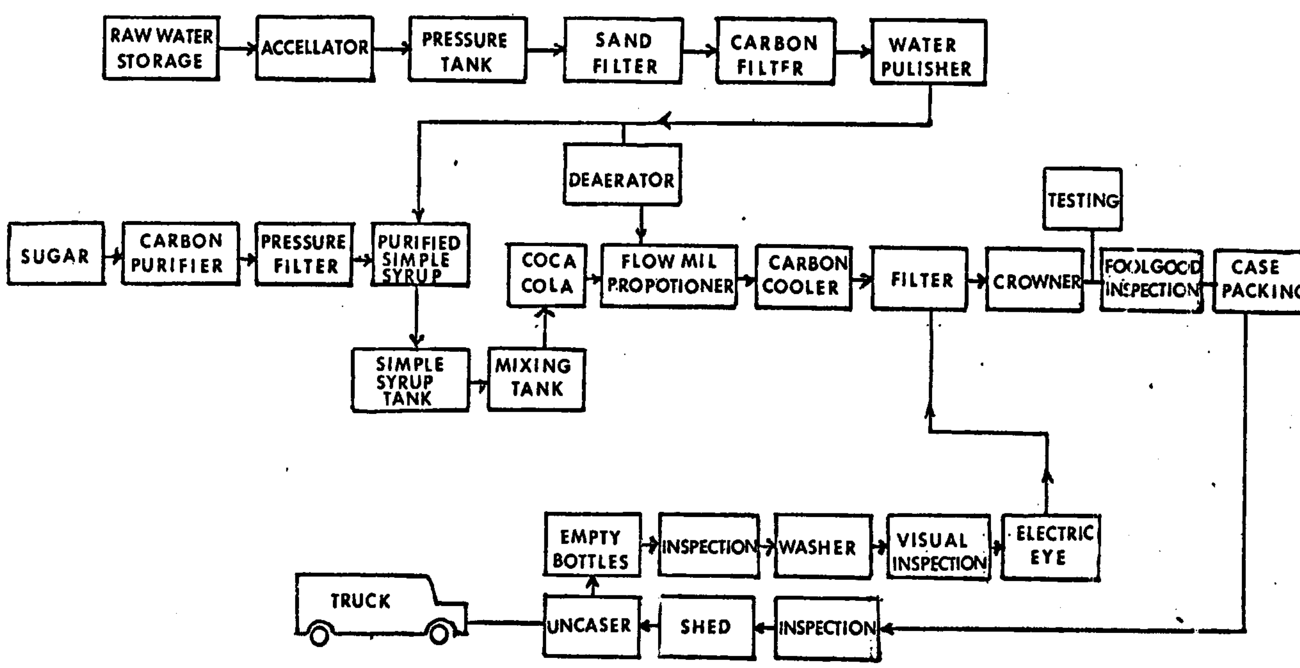
Chemical costs:- ....

Years of operation:- ....

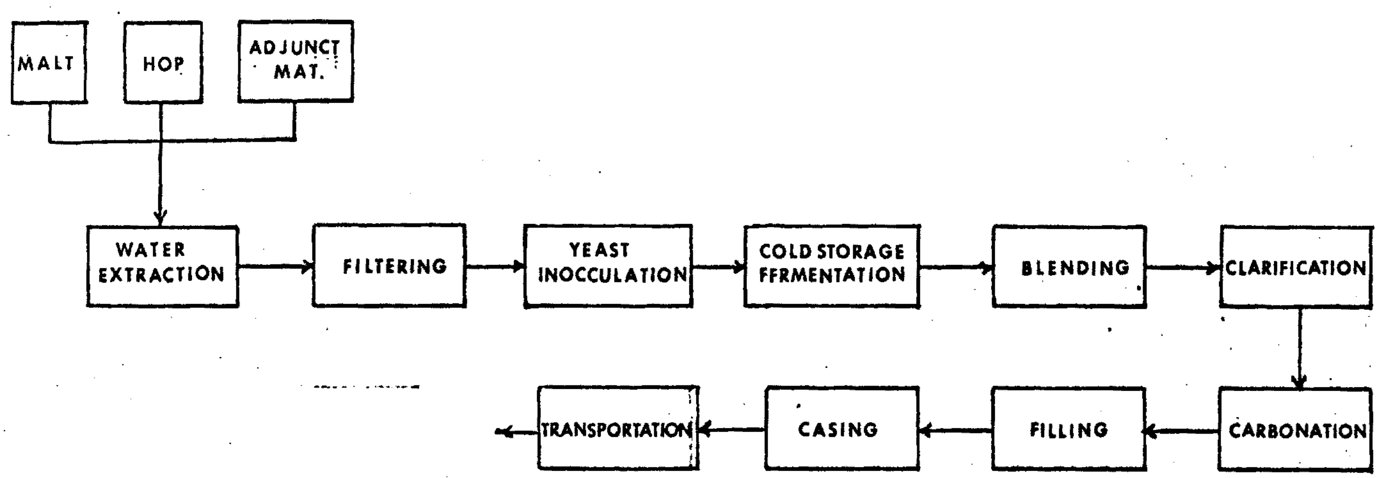
Method of liquid waste disposal:- ....

Method of sludge disposal:- ....

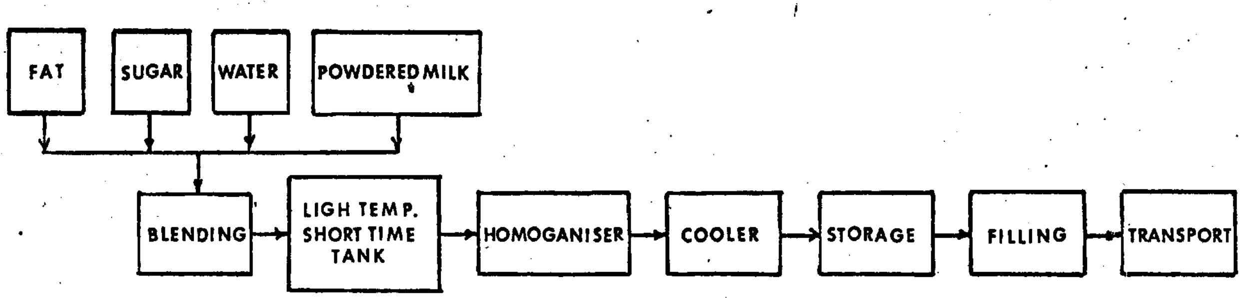
Problems if any: ....



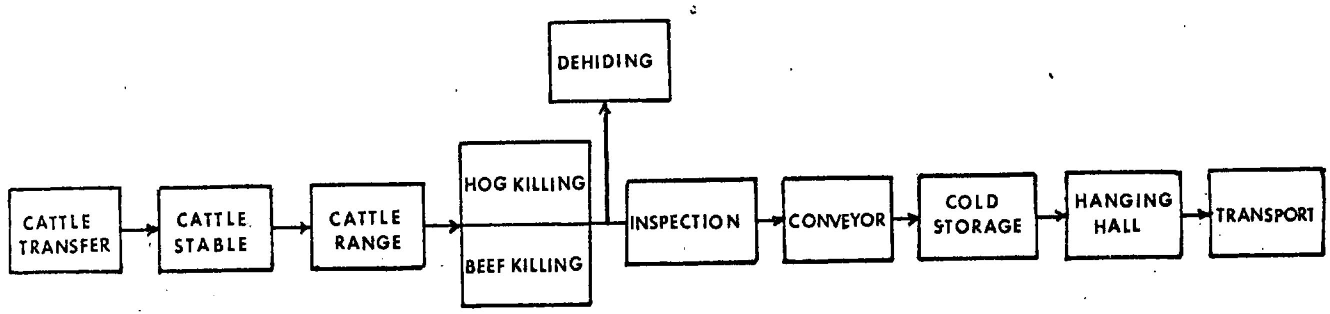
TYPICAL MANUFACTURING PROCESS OF SOFT DRINK



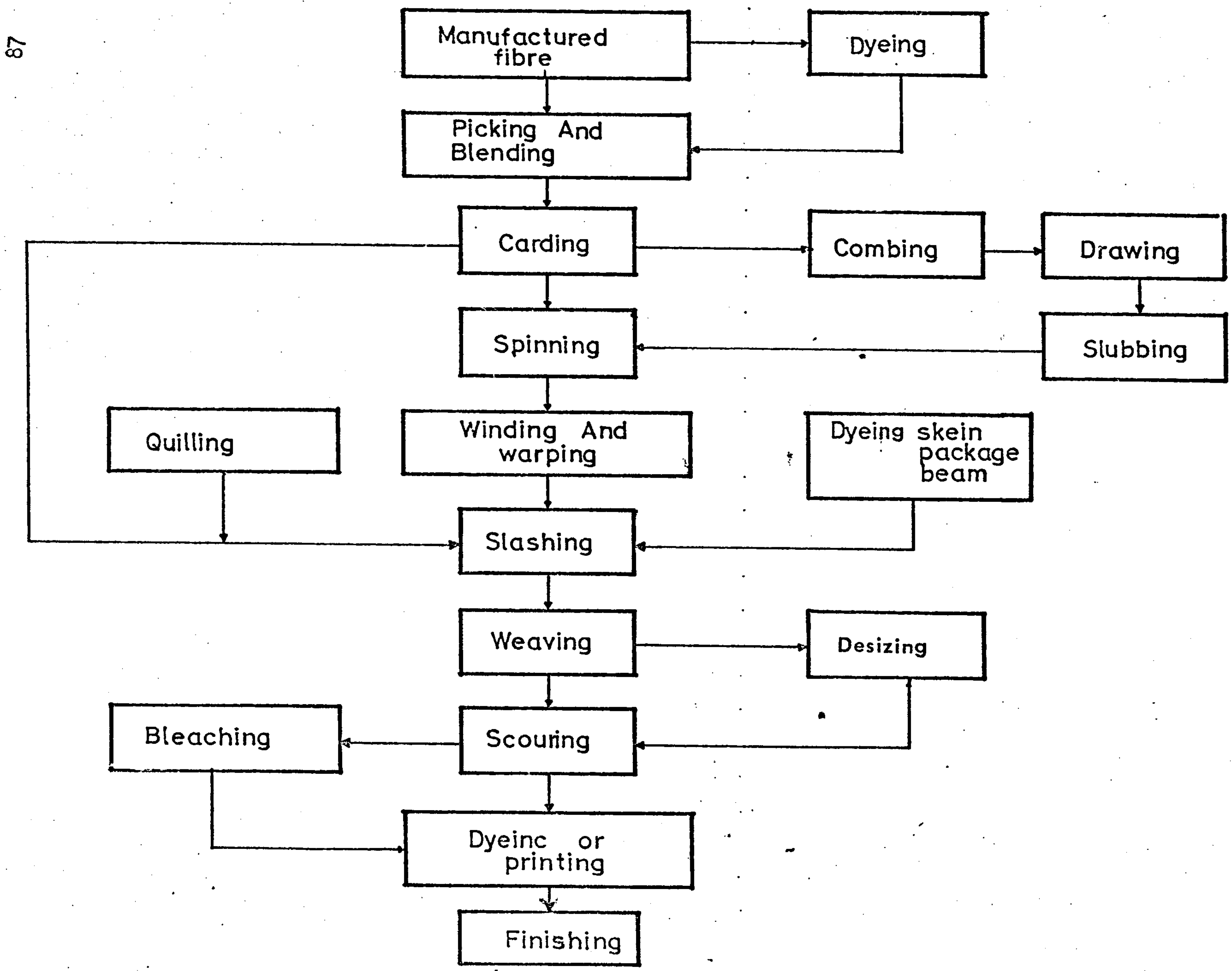
TYPICAL MANUFACTURING PROCESS OF BEER



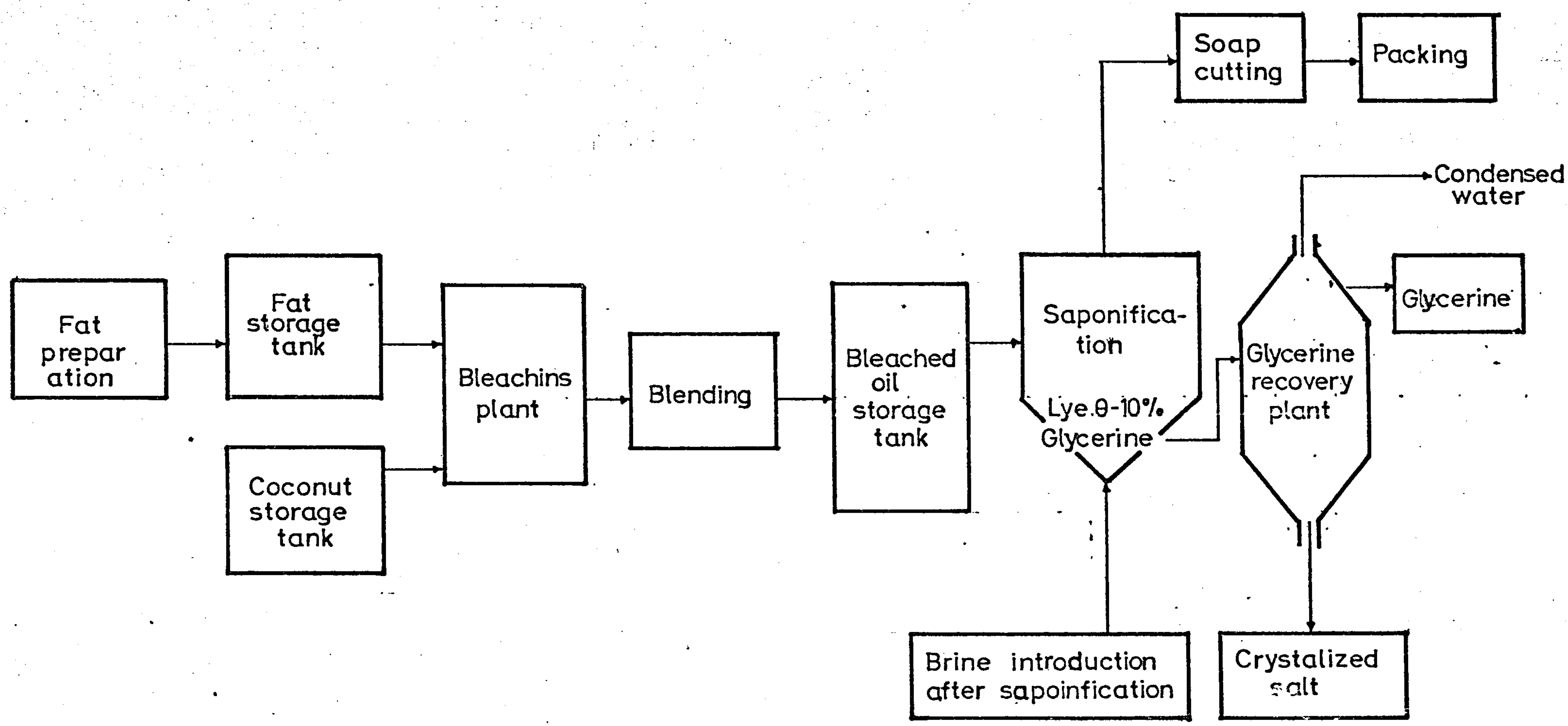
TYPICAL MANUFACTURING PROCESS OF MILK AND ICE CREAM



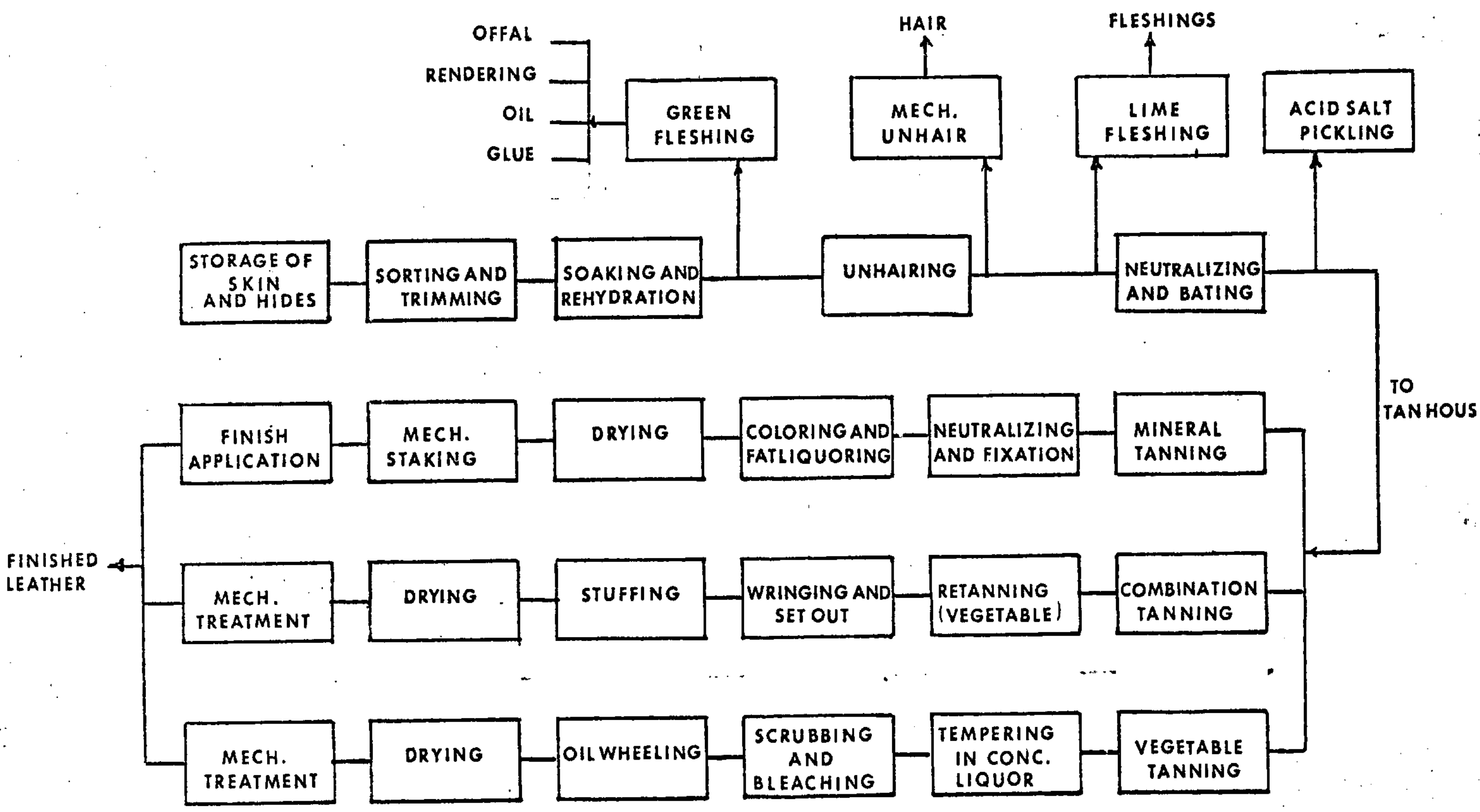
TYPICAL OPERATION OF A CATTLE PROCESSING PLANT



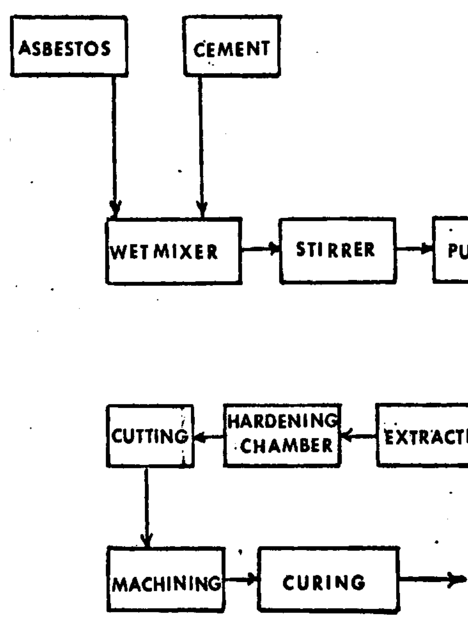
Typical flow chart of manufacture of synthetic textile



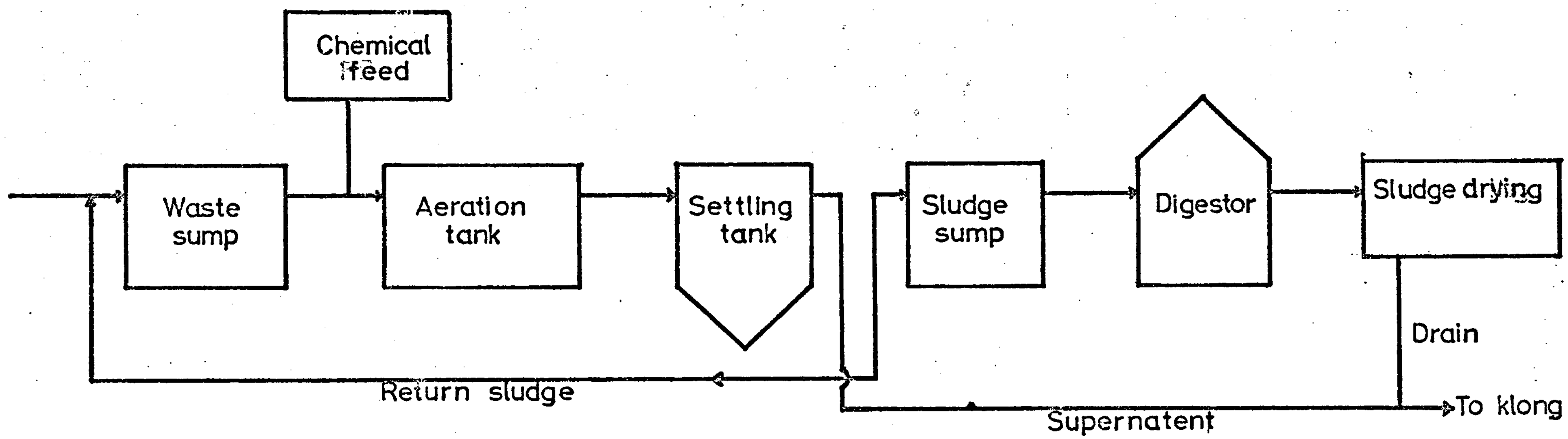
Typical flow chart of soap and glycerine production



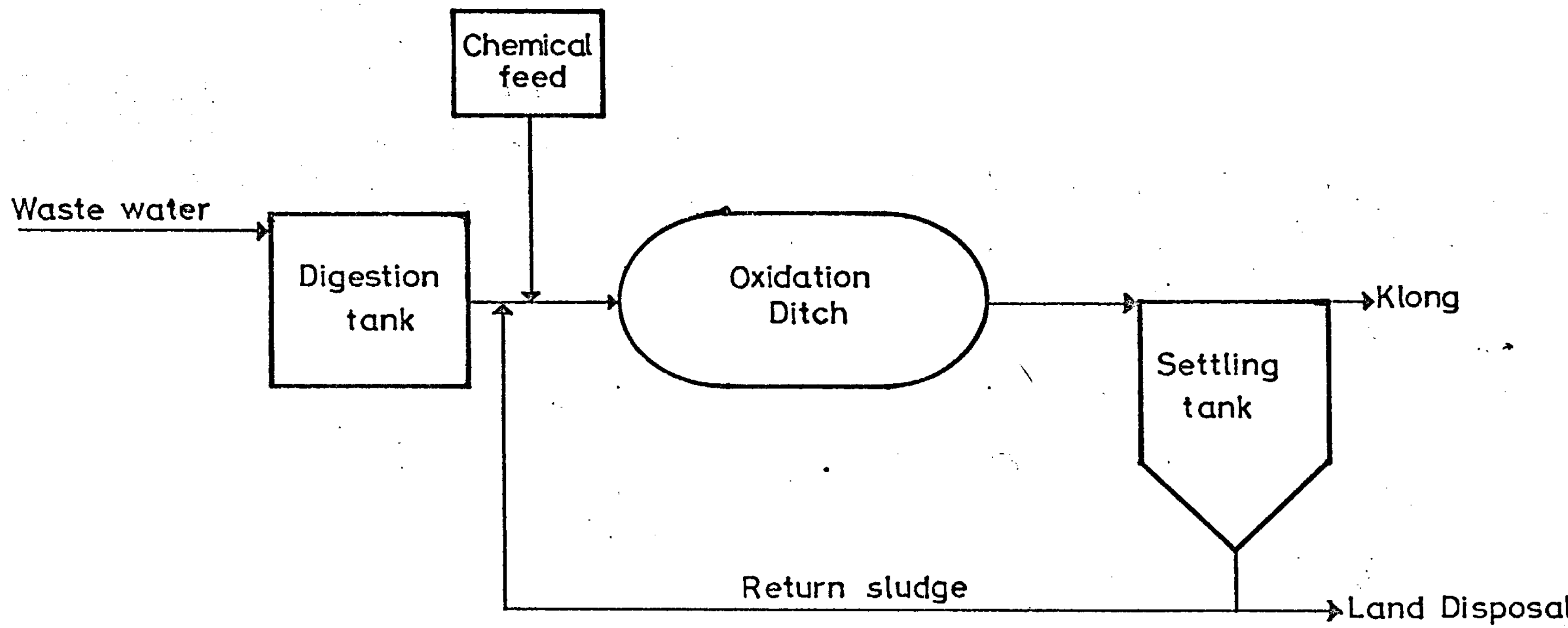
TYPICAL MANUFACTURING PROCESS OF LEATHER



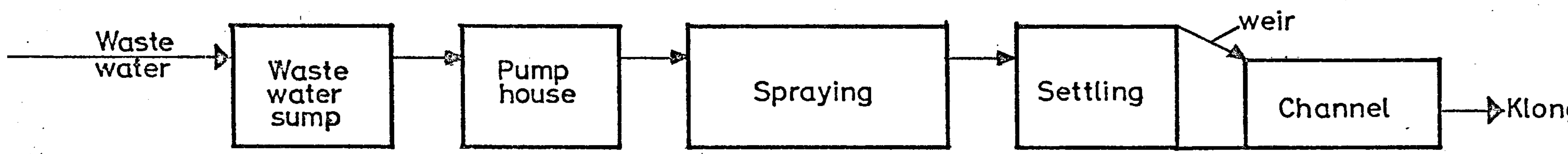
TYPICAL MANUFACTURING PROCESS OF CEMENT ASBESTOS PIPES



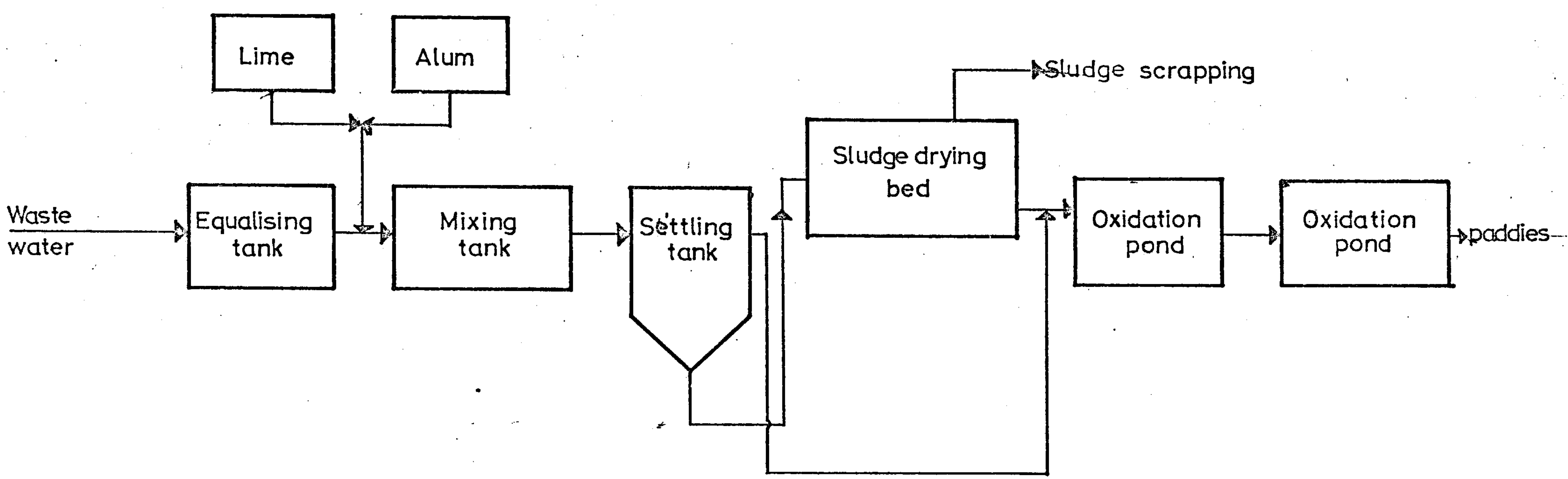
Typical flow chart of treatmen of soft drink factory wastewater
(COCA COLA, PEPSI COLA, GREEN SPOT)



Aypical Flow Chart of Treatment of milk wastes
(THAI MILK, 7 UP)



Flow chart of treatment of foremost factory's waste water



Flow chart of treatment of Thai filament co's waste water

Appendix B

Tablulation of Results

Table B-1 Production data on various Factories visited.

Name of Factory	Location	Total Investment million ฿	Production capacity cases/day	Production Labour	Years of Operation	Total Waste-water, Flow m^3	Pollution Capacity BOD-Kg/day	Method of Disposal
Soft drinks								
Pepsi Cola	Super Highway	35	30,000	200	6	640	960	Klong
7 - up	Nonburi	30	9,000	300	4	45	68	"
Green Spot	Hua Mark	30	2,500	120	5	700	420	"
Coca Cola	Hua Mark	55	45,000	180	10	1,370	822	"
Bireley's	Nonburi	10	6,000	55	5	80	176	"
Union Soda	Lan Laung	15	3,000	200	5	150	60	"
Breweries								
Boon Rawd	Saem Saen	900	17,000 (beer) 1 million bottles (soda)	970	39	1,100	2,750	Klong (Chao Phya) River
Thai Amarit	-do-	200	200	150	8	450	450	Chao Phya River
Milk and Ice Cream								
Foremost	Rangsit	40	12,000 gallons	83	4	152	200	Klong
Thai Milk	Minburi	12	3,000	150	4	14	14	"
Pop Ice Cream	Hua Mark	3	1,300 gallons	40	5	45	244	"

Table B-1 (Continued)

Name of Factory	Location	Total Investment million ฿	Production capacity cases/day	Production Labour	Years of Operation	Total Waste-water Flow m^3	Pollution Capacity BOD-Kg/day	Method of Disposal
Abbatoir								
Union Live Stock	Klong Toey	60	Cattle-200 Hog - 3,000 Beef-200 Poultary-30,000 per day	800	10	4,000	4,000	Klong
Bang Khay	Bang Khay	1-2	60-100	8-12	4	25-40	24	Klong
Distillery								
Bang yee Khan	Thonburi	400	Mekong * (750 cc) 15 million bottles Kwangthon spirit, wine 21* mil. bottles	2,000	60	Distt. waste 700 cooling water 2,400	157,000	Chao Phya River
Textile								
Thai Toray	Minburi	460	500 Tons/Yr.	600	5	2,400	720	Klong
Thai Filament	R gsit	400	240 Tons/Yr.	800	4	2,000	200	paddies
Soap								
Rubia Industries	Klong Toey	15	8 Tons/month	80-100	-	6-10	43	Klong
Lever Brothers	Chareon Krung Road	100	1,200	450	60	50	300	Klong
Tannery								
Thai Tannery	Klong Toey	50	200,000 Sq.ft. of Sole and soft leather each	200	10	520	936	Klong
Cement								
Siam Fibre	Nonburi	100	Abs. cement 30,000 Tons/Yr. PVC 2,000 Tons/yr.	240	7	15	.075	Klong
Ice								
Nonburi Ice	Nonburi	12	168 Tons/yr.	62	8	250	4	Klong

* For a period of six months

Table B-2 Characteristics of Wastewater From Various Factories Visited.

Name of Factory	COD mg/l	BOD mg/l	S.S. mg/l	NH_3-N mg/l	D.O. mg/l	pH	Temp. C^o
<u>Soft Drinks</u>							
Pepsi Cola	2,080	1,500	170	0	4.5	10.3	37
7 - up	2,000	1,500	145	0	6.5	6.8	37.5
Green Spot	1,040	600	90	0	4.0	8.1	37
Coca Cola	1,496	600	60	0	5.2	9.7	36
Bireley	320	220	130	0	5.6	7.9	34
Union Soda *	600	400	-	0	-	-	-
<u>Brewerics</u>							
Boon Rawd	5,000	2,500	130	0.10	13.0	7.1	18
Thai Amarit	2,300	1,000	56	0.10	3.1	7.2	31
<u>Milk and Ice Crem</u>							
Foremost	2,704	1,320	200	0.88	0	7.5	36
Thai Milk	1,500	1,000	130	1.8	0	6.5	38
Pop Ice Cream	7,100	5,435	860	0	0	8.0	36
<u>Abbatoir</u>							
Union Live Stock	1,742	1,060	600	1.2	3.7	7.6	31
Bang Khay	800	600	80	1.36	0.0	6.9	30
<u>Distillery</u>							
Bang Yee Khan	Dist. 230,000	225,000	14,910	1.28	0	3.7	50
	Cooling 96	20	62	0	5.4	6.5	36
<u>Textile</u>							
Thai Filament	330	100	10	0	2.0	8.4	37
Toray Nylon	1,232	300	10	0	0.5	7.5	37

* No cooperation was received, data presented here were taken from Camp Dresser and Mckee's report.

Table B-2 (Continued)

Name of Factory	COD mg/1	BOD mg/1	S.S. mg/1	NH_3-N mg/1	D.O. mg/1	pH	Temp. C°
<u>Soap</u>							
Rubia Indust.	-	-	-	-	-	-	-
Lever Brothers	80,000	60,000	2,000	1.96	0	11.5	34
<u>Tannery</u>							
Thai Tanning	2,200	1,800	970	0.16	4.2	8.7	32
<u>Cement</u>							
Siam Fibre	340	5	200	0	4.2	4	32
<u>Ice</u>							
Nonburi Ice	80	16	20	0	6.9	7.1	50

Table B-3 Characteristics of Treated and Stream waters of various Factories Visited.

Name of factory	COD mg/l		BOD mg/l		S.S. mg/l		NH_3-N mg/l		D.O. mg/l		pH		Temp. °C	
	Treat.	Str.	Treat.	Str.	Treat.	Str.	Treat.	Str.	Treat.	Str.	Treat.	Str.	Treat.	Str.
Soft drink														
Pepsi Cola	28	50	20	30	20	100	nil	-	2.5	5.0	8.3	7.7	33	33
7-up	40	160	20	80	10	50	-	-	7.8	3.8	8.3	8.0	30	32
Green Spot	76	-	40	-	20	-	-	-	9.2	-	9.0	-	33	-
Coco Cola	160	180	140	100	34	68	-	-	0	3.9	8.0	7.9	35	33
Bireley	132	320	60	140	40	40	-	-	4.1	3.1	7.9	7.6	32	32
Breweries														
Chaophya River	-	464	-	40	-	54	-	-	-	5.2	-	7.4	-	32
Klong (Boon Rawd)	-	560	-	140	-	80	-	-	-	0	-	7.4	-	32
Milk and Ice Cream														
Foremost	704	184	150	180	270	80	-	-	1.5	1.0	7.3	7.3	35	36
Thai milk	172	164	25	44	20	50	-	-	10	7.3	7.7	7.7	36	36
Abbatoir														
Union Live Stock	1342	183	600	50	1040	50	0.8	2	0	0	7.3	7.5	30	28
Bang Khay	96	256	60	210	80	22	.64	1	0	3.8	7.3	7.4	34	32
Distillery														
Bang Yee Khan	-	496	-	60	-	70	-	.08	-	6.0	-	6.8	-	32
Textile														
Thai Filament	190	-	18	-	-	-	-	-	6.0	-	8.0	-	33	-
Toray Nylon	288	30	96	24	10	20	-	-	0	4.7	7.3	7.1	32	31
Soap														
Lever Brothers	-	600	-	400	-	107	-	0.29	-	1.0	-	9.4	-	34
Tannery														
Thai Tanning	-	185	-	80	-	60	-	2	-	0	-	7.5	-	30
Cement														
Siam Fibre	144	96	0	16	30	24	0	1.2	9.2	6.9	7.8	8.4	32	32
Ice														
Nonburi Ice	208	-	26	-	45	-	0.8	-	5.1	-	2.4	-	31	-

Table B-4 Data on Treatment Plants of Various Factories Visited

Name of Factory	Cost of Treatment as % of Total Investment	Operation Cost of Treatment Plant	Type of Treatment	Years of Operation	% Efficiency
<u>Soft Drink</u>					
Pepsi Cola	18	46,000 ฿/month	Activated Sludge	2	99
7-up	1	7,000 "	Oxidation Ditch	1 month	99
Green Spot	5	21,000 "	Activated Sludge	3 years	93
Coca Cola	3.5	40,000 "	"	5 "	76
Bireley	8	16,000 "	"	4 "	76
<u>Milk and Ice Cream</u>					
Foremost	1	30,000 ฿/month	Sprinkular Acration	4	89
Thai milk	.83	6,880 "	Oxidation Ditch	4	98
<u>Abbatoir</u>					
Union Live Stock	-	-	Septic tank	10	43.5
Bang Khay	1.5	600 ฿/month	Anacrobic Oxidation Pond	3	92
<u>Textile</u>					
Thai Filament	0.67	60,000 ฿/month	Chemical Biological	4	82
Toray Nylon	0.03	2,000 "	Sprinkular Acration	5	75
<u>Cement</u>					
Siam Fibre	0.2	2,000 "	Brine Treatment & Filteration	2 months	98