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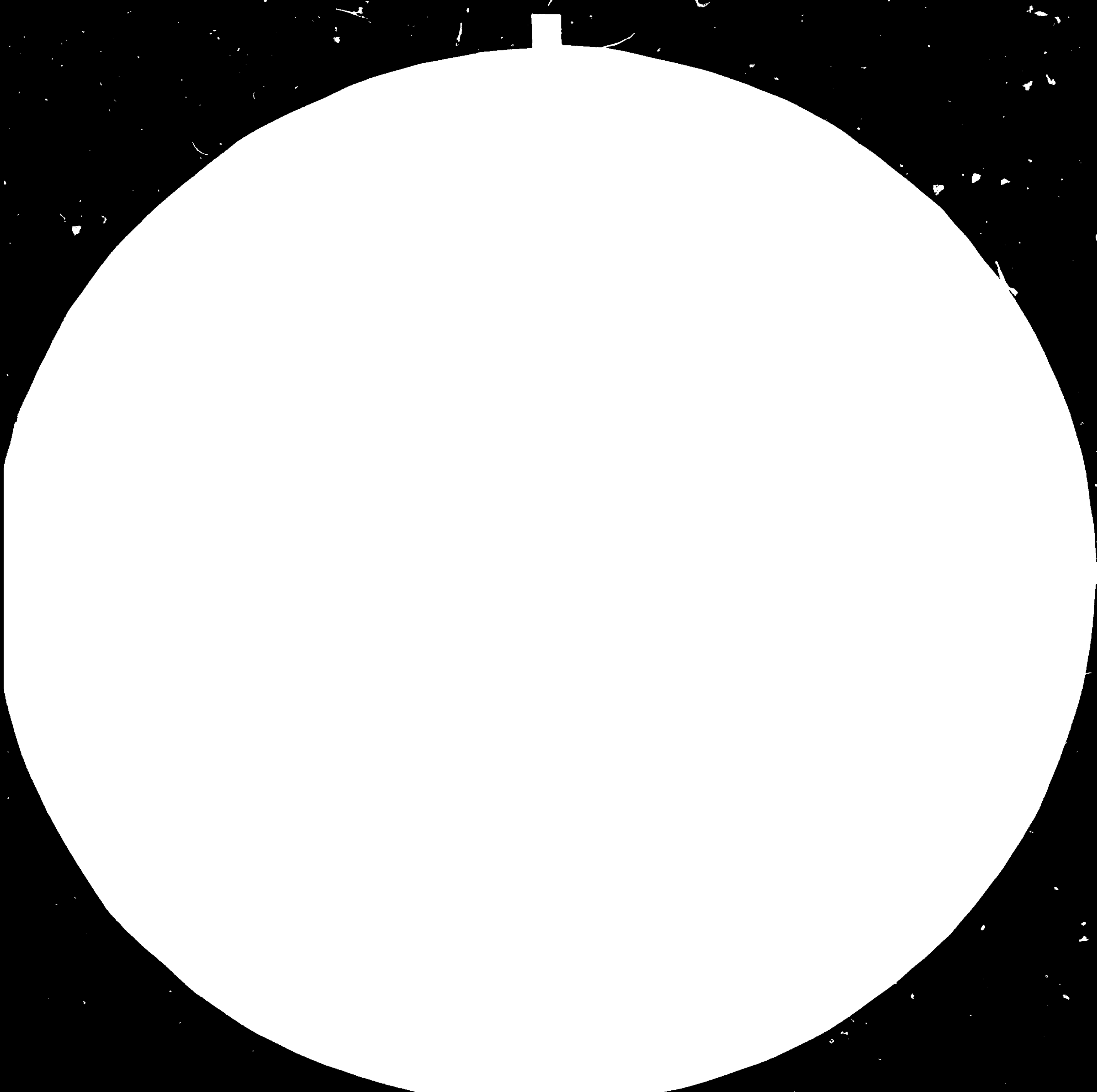

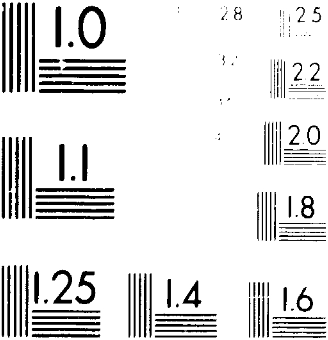

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Egypt.

Improvement of ENPPI'S engineering capacity in the treatment of industrial effluents.

DP/EGY/81/016/11-C2/32.I.H

Technical report

Prepared for the Government of the Arab Republic of Egypt by the United Nations Industrial Development Organization

Based on the work of ALFREDO MARGOLA,
expert on waste water pollution control.

1984

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INTRODUCTION

The development of new petroleum, petrochemical and chemical industries follows a favourable trend in Egypt because of the availability of crude oil and natural gas, whose production has steadily increased in recent years.
This justified the establishment, in 1978, of a national engineering firm - Engineering for Petroleum and Process Industries, from here on referred as ENPPI - to serve the growing industrial demand for engineering services.
Well aware of the increasing importance of environmental protection, and conscious that industrialization should be without detriment to the quality of life, ENPPI has established an effluent treatment activity to study all environmental aspects and to design the necessary effluent treatment facilities for the new industries, as well as for the existing ones.
A special group of engineers was therefore dedicated to this task.
In order to develop the capitalities of this newly established group, ENPPI has requested the assistance of UNIDO through the Ministery of Industry.
This project - DP/EGY/81/016/11-02/32.I.H- to be considered in the frame of the above purposes, is specifically aimed at improving the engineering capacity of ENPPI in the treatment of industrial effluents, through man power development of ENPPI's group of engineers.
The mission started on april 5-1984, and was concluded after two months, on june 4-1984.
Although engineering capacity and experience development are

medium term achievements, to be obtained step by step, the writer believes that the mission activity, which included advising on the general organization of the environmental group, reviewing its technical outputs, establishing general systems and procedures for the study and development of projects, providing system manuals for sizing and design, training of ENPPI's engineers to apply the same on the job, added much to the existing base level of this particular ENPPI's section.

I. MAIN DUTIES AND OBJECTIVES OF THE PROJECT

Soon after the arrival, the writer was acquainted with the procedures and work organization currently followed by ENPPI's environmental group.
A list of projects, and the relative technical documentation already produced, were submitted for examination.
It was then agreed, together with the environmental group leader and with ENPPI's training coordinator, that the main duties and objectives of the assignment should cover the following points:

A-Guidance/Seminars/Training

1)- Provide guidance for developing and expansion of ENPPI's environmental group in all environmental control aspects.
2)- Preparing two days seminar to give in Alexandria, c/o the Center for Engineering Development (CED) on management of Refinery wastes.
3)- Preparing two lectures to give in Cairo, c/o ENPPI's head=quarters; one to cover refinery liquid wastes management and control; the second to cover air pollution control, and solid wastes/sludges handling and disposal.
4)- Review ENPPI's existing references and recommend any additional environmental literature.

B-Assiut Refinery Project

1)- Review the effluent water treatment basic design.
2)- Review Piping and Instrumentation and chemical engineering

drawings related to the effluent treatment system.

3. Review and comment the general specification developed for the project.
4. Give recommendations on final destination of the effluent exit stream (River Nile, or irrigation purposes).
5. Give recommendations on sludge waste disposal handling.

C. Suez Refinery Expansion

1. Review the effluent water treatment basic design.
2. Review Piping and Instrumentation and chemical engineering drawings related to the effluent treatment system.
3. Review and comment the general specification developed for the project.
4. Provide comments on ballast water treatment facilities.

II. TECHNICAL ACTIVITY

The various technical activities developed during the two months assignment covered the following principal points:

- Understanding the system organization of the environmental group (leadership, work organization and distribution, fields of interest, eventual facilities at disposal -e.g. laboratory-) and studying the possible measures to improve it.

- Preparing a two days course on management of refinery wastes, given c/o the Alexandria branch of ENPPI, on may 7th and 8th.
  The course was atteined by technicians from:
  Alexandria Petroleum Company
  NASR Petroleum Company
  Petrochemical Company
  Outlines for each of the subjects treated (waste water pollution management and control, air pollution control, sludges and solid wastes management and disposal, were delivered to the participants.

- Preparing two lectures, on the main subjects of water, air, solid waste management and disposal in the petroleum industry, given c/o the Cairo headquarters of ENPPI, on may 28th and 29th.
  Participants were from the following ENPPI's sections:
  Environmental
  Project management
  Chemical engineering department

Piping engineering department

Civil engineering department

Outlines, as in the above point, were delivered to the participants.

- Reviewing Assiut refinery project waste water treatment piping and instrumentation and units specification.
  Observations and comments on this subject, as well as recommendations on final destiny of the effluent exit stream, were submitted to the counterpart. (See Annexe N. 2)

- Reviewing Assiut refinery project waste water treatment basic design.
  Observations and comments on this subject, as well as recommendations on sludge handling and disposal, were submitted to the counterpart. (See Annexe N. 3)

- Reviewing Suez refinery expansion waste water treatment piping and instrumentation drawing and units specification.
  Observations and comments on this subject were given to the counterpart. (See Annexe N. 4)

- Reviewing Suez refinery expansion waste water treatment basic design.
  Observations and comments on this subject, as well as comments on ballast water treatment facilities, were given to the counterpart. (See Annexe N. 5).

- Frequent talkings on various technical subjects were also a usual part in day time schedule. Specially examined were legislation problems, technical data and sizing procedures for biological treatment plants.

- An example of basic design manual for biological plants was prepared and handed to the counterpart; the manual included also some new references and recommended literature on the subject.

- Examined were also environmental technical problems of industrial sectors different from the petroleum and petrochemical ones. A case study for the treatment of sugar industry effluents was in particular developed and handed to the counterpart. Specific literature on various industrial sectors effluent treatment was also recommended.

III. FINDINGS

Interest in environmental design and engineering is a relatively recent development in ENPPI's activities: a special group of engineers was established in 1981 and devoted to this field.
The environmental group is still a small one, consisting of 5 people: the group leader, a senior environmental engineer, and 3 engineers (one of which joined the group just at the end of my assignment).
The group leader and the senior engineer have spent, during the mission, only part of their time with the environmental group, having previously being assigned to different projects in other company's departments.
This is cause of some lack of coordination within the group.
The writer has experienced the good level of technical knowledge already attained by this recently established environmental group.
From the theoretical point of view, ENPPI's engineers seem to be able to handle all problems in basic process design regarding the petroleum and petrochemical industries. Sufficient references and literature are also at disposal of the group.
Generally, however, the engineers are lacking in practical on-site training and detailed sizing experience.
No laboratory exists for analyses or testing water purification processes. Therefore all the basic process design for water treatment facilities is developed on the basis of references, literature, and, in some cases, of specific experience of individuals.
The group has been interested, up to now, in two major projects: new Assiut refinery and Suez refinery expansion.
The projects have been carried out, as far as basic process

design, with much understanding and on a general sound basis. Equipment or plant specification, as from the documents already produced, was instead to be considered, in some cases, too general, thus showing a lack of practical experienced knowledge in this field.

IV. UTILIZATION OF THE RESULTS OF THE ACTIVITY

The writer (see Annexes 2 to 5) gave several indications and suggestions about the two main projects (Assiut refinery, and Suez refinery expansion) currently undertaken.
Many of them, and namely;

a. For Assiut refinery:

1. to install a final polishing system (tertiary treatment) after the biological plant, in order to meet the very strict effluent standards required by the Egyptian legislation;
2. to discharge the effluent stream back to the river Nile, unless relaxation of underground standards shall be obtained;
3. to treat the refinery domestic sewage in the refinery general biological treatment plant, rather than in a specific small plant;
4. to stabilize the flow to the D.A.F. (Dissolved Air Flotation) unit, through a surge basin, and to use manually adjustable feed pumps rather than automatically proportioning ones.

b. For Suez refinery expansion:

- to install a biological, rather than a D.A.F. unit to treat the final effluent;
- to stabilize the flow to the D.A.F., as in point a.4);

have received a great interest and should be the basis for the reviewing of the related documents.

The writer also prepared the basics of sizing and design manuals for biological treatment plants, that shall be used in reviewing the too general specification already prepared for biological treatment units, in the Assiut refinery project.

V. CONCLUSIONS

The activity at ENPPI's headquarters, within the environmental group, acquainted the writer with the engineering capacity of this recently established group in ENPPI.
In particular, reviewing some documentary outputs, and commenting various environmental items were helpful to focus the main capabilities and skills, and the main contraints of the group.
The first ones can be summarized in a good general background and theoretical knowledge of environmental problems, and sufficient capacity in basic process design.
The second ones are mainly related to a lack of experienced detailed engineering work for sizing and for the specification of equipment and plants.
Group organization and leadership, too, need to be better established.

VI. RECOMMENDATIONS

It is opinion of the writer, after having carried out the two months'assignment within ENPPI's environmental group, that the following recommendations are suitable for establishing a more sound basis for the development of this newly formed group:

- The organization of all environmental activities in one indipendent section, within the chemical department, is highly recommended.
  This would certainly help the developing and the expansion of this section, and the establishing of the image of the company's environmental design philosophy.

- The group, at the moment, has no full time leader. The need of a full time section leader is greatly felt in order to provide continuous guidance and coordination to the work of the various engineers.

- If/when an independent section is established, it will be advisable to specialize the activities in two subsections:
  a. one for water pollution problems, with two engineers, minimum.
  b. one for air pollution problems, with one engineers, minimum.

- ENPPI engineers should spend some time in the field for practical on-job training on waste treatment plants, to gain operational experience, that shall be helpful in the design and specification work.

-A laboratory activity, for testing water purification processes, for waste characterization studies and for chemical analytical purposes would certainly greatly help ENPPI's engineers in selecting the best treatment methods, and in finding solutions to improve the efficiency of existing treatment plants.

Untill ENPPI is prepared to set up its own laboratory, agreements should be established with some well equipped research institutions, or with industrial laboratories ad-hoc equipped, which could perform such tasks in close cooperation and under guidance provided by ENPPI's engineers.

ANNEXE N. 1

Senior counterpart staff

- SAAD KAMEL , Chemical Engineer - Environmental group leader
- AMIN ALAREF, Chemical Engineer - Senior environmental engineer

ANNEXE N. 2

ASSIUT REFINERY - OBSERVATIONS AND COMMENTS ON WASTE TREATMENT PIPING AND INSTRUMENTATION DRAWINGS AND UNITS SPECIFICATION.

A)-Effluent collection and treatment system-spec.9268-100-100-60

-Point 3.2 should be amended with the following addition: "A tertiary finishing oxidation, stabilization pond shall be provided for final settling and removal of stable organics and nutrients from the biological treatment unit effluent".
It's most improbable, in fact, that the effluent from the biological treatment will fully satisfy the standards of the national law 48/1982.

-Alternatives for final destination of the treated effluent (irrigation or discharge into the river Nile, main stream) and considerations of its pollutant contents are issues of primary importance and are related to each other.
Due to the very strict requirements of the Egyptian legislation and to the technical difficulties in meeting some of them (namely COD and TDS) we should consider the destination of clarified water which will allow less strict standards.
Although irrigation could save the cost of a 9 km long pipeline, and would obviously appear as the most logical and practical use of the treated effluent, the writer

believes that this alternative should be selected only if a relaxation of the most strict underground water standards is officially agreed with the responsible authority.

To support this request of relaxation, it may be pointed out that some special irrigation practices do not necessarly interfere with public underground waters, or drainage canals.

If, on the contrary, a relaxation of underground water standards are not accepted, we recommend that the treated effluent should be sent back to the river Nile.
In this case the less strict river Nile, main stream, standards shall be selected.

Since also the latter standards are strict and somehow difficult to meet, it should be stressed that the main object of the law 48/1982, is, after all, to protect all water courses from the adverse effects of pollution, and that the industrial water pollution control practices should be aimed at this purpose.

Consequently, the respect of sweet water quality standards in the river Nile, as stated in the law 48/1982, and not the strict respect of effluent standards, is to be considered as the ultimate goal of water protection.

Sampling procedures (24 h composite samples) and analysis determining the average 24 h concentration of pollutants,

instead of grab samples and instantaneous concentrations, can practically help in obtaining, de facto, a relaxation of some effluent standards.
These procedures, although not specifically previewed by the law, are not excluded either.

B)- A.P.I. Separator accessories-Spec.9268-120-166-1

The specification is thoroughly detailed and there are no observations.

C)- D.A.F. Package - Spec. 9268-120-166-2

- There are no influent water specifications, nor effluent water requirements for pH, COD, BOD_5.
  Since the DAF effluent is the influent to the biological treatment, the same characteristics requested for the influent to the biological treatment (9268-120-166-3, page 22) should be requested for the D.A.F. effluent.
  In practice, we could estimate the characteristics of the influent to the DAF as follows: pH = 6-9; COD = 600 mg/l; BOD_5 = 300 mg/l, and require that the DAF should be designed for a 60% removal of COD and BOD_5 at its maximum flow rate, thus producing an effluent of COD = 240 mg/l; BOD_5 = 120 mg/l max.

- A control valve is foreseen on the discharge line of the API separator treated water pumps, to increase or decrease the discharge flow, proportionally to the oily drain flow

rate.
This requires that the DAF package should be provided with automatically proportioning chemical feed pumps.
We could achieve better results in stabilizing the flow rate by providing an adequate surge basin for the API's effluent water pumps, and in fixing the discharge flow rate through a manual valve. The constant flow rate should be a little more than the $\frac{\text{total daily flow}}{24}$. The second pump should than be used as stand-by.
This new design would save the investment for the automatic valve and its by-pass on the discharge line, and the extra cost of the proportioning pumps in the DAF package and require only the investment for an additional surge basin. From the operation and maintenance point of view, this system would be more reliable and easy to control, since continuously varying feed pumps, and the ancillary equipment, are to be considered very delicate ones.

- The type of chemicals, and their dosing rates, should be a specific request for the documentation to be supplied by tenders.

D)- Biological treatment plant.-Spec.9268-120-166-3

- This specification is very general, thus leaving the vendors the responsibility on all the basis for design (sizing, retention time in the oxidation and settling basins, aerators total installed power, raising velocity in the settler, etc...).
In order to receive more comparable proposals from vendors

and to be sure that the basics of plant sizing are in accordance with the company's minimum requirements, the basics of the design data should favourably be included in the specification.

ANNEXE N. 3

ASSIUT REFINERY - OBSERVATIONS AND SUGGESTIONS ABOUT THE BLOCK FLOW DIAGRAM-DWG. 9268-100-KD-7

Final polishing of treated water

To reach the required effluent standards for COD, the system proposed (API separator, DAF biological treatment), is likely to be insufficient. A tertiary treatment station should therefore be considered. The use of activated carbon is not recommended at this about, because of the difficulties and the cost of regeneration.

Stabilization ponds and aquatic plants, instead , are a possible solution, worth being studied in detail, provided that the climate in Assiut is favorable to this approach.

Domestic sewage treatment

Domestic sewage of the refinery should be sent to the refinery biological treatment plant. In fact:

a. Domestic sewage nutrients will favor the development of a good quality activated sludge in the station.

b. It will make unnecessary the construction of another specific treatment station. (Saving further investment and maintenance costs).

c. There will be only one final discharge point, instead of two, to sample and analyse for routine and official controls.

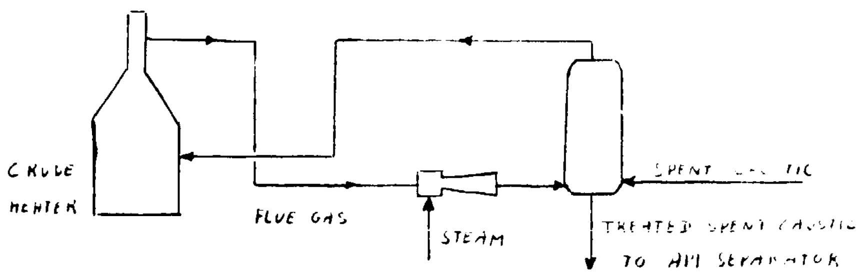
Collection and disposal of spent caustic treatment unit vent gas

The vent gas from the spent caustic oxidation unit should be sent to the flare or, even better, if possible, to the crude heater; not to a local stack.

Spent caustic treatment

Spent caustic treatment could be achieved, as an alternative to the oxidation process, also through the use of flue gas. Flue gas will neutralize the free soda, and convert Na_2S and R-SNa into H_2S and R-SH, which are stripped and sent to the crude heater for oxidation.

The treatment unit scheme, and the reactions involved are as follows:



$$2\ NaOH + H_2CO_3 \rightleftharpoons Na_2CO_3 + 2H_2O$$

$$Na_2S + H_2CO_3 \rightleftharpoons H_2S + Na_2CO_3$$

$$2R\text{-}SNa + H_2CO_3 \rightleftharpoons 2R\text{-}SH + Na_2CO_3$$

Sewerage system

If difficult to be connected to the separate oil-free sewer, the oil-free rain water could be connected to the oily water drain - This will not cause problems to the API separator, because rain in Assiut is very rare.

Sludge disposal

a. The dump area for the dry solids from the oil-free water sewer should be clearly specificated, and positioned on the p ot plan.

b. Sludges from API separator and DAF unit should be collected separately from those produced by the biological unit. These ones, if not contaminated by oil, could then be used as land fill.

c. The dump area for the API separator and DAF dry sludges should be clearly specificated, an positioned on the plot plan.

Evaporation lagoon sizing

The volume of the demineralizer regeneration effluent should be carefully checked, to control that the sizing of the evaporation lagoon is adequate.

The observations and suggestions hereabove are based on prelimi nary and theoretical approach, intended to maximize the results of the environmental policy for waste waters and sludges.

Some of them, however, could require too high investment costs, if compared to the benefits, and shall, therefore, be avoided when developing the detailed enginnering and construction phases.

ANNEXE N. 4

SUEZ REFINERY EXPANSION - OBSERVATIONS AND COMMENTS ON WASTE TREATMENT PIPING AND INSTRUMENTATION DRAWINGS AND UNITS SPECIFICATION

A. Effluent collection and treatment system Spec.9283 - 200 - 100 - 60

It is suggested the rewriting of the following paragraph "The exit water is expected to meet the Egyptian Standards regarding Oil content. As for other standards (e.g. BOD_5, COD, TSS) no effort will be made to change them".
Through the treatment facilities designed (gravity separator, D.A.F., skim basin) we shall in fact be able to control also these parameters in order that they meet the specific Egyptian Standards for effluent rejected to sea waters, that is:

COD : 100 mg/l
BOD_5 : 60 mg/l
TSS : 60 mg/l

These limits should therefore be added in Table 1, column 9, of the specification.

B. D.A.F. Package - Spec. 9268-230-166-01

- There are no influent water specifications, nor effluent water requirements for pH, COD, BOD_5.

  Influent characteristics for these items could be specificated,

as an estimation, as follows: pH, 6-9; COD, 600 mg/l; BOD_5 300 mg/l max.
Specifications should then be given for the D.A.F. unit to be designed for a 60% removal of COD and BOD_5 at max. flow rate, thus producing an effluent of COD 240 mg/l, BOD_5 120 mg/l max.

- No control valve (see P. & I. drawing 9283-230-KE-01) is foreseen on the discharge line from the API separator to the D.A.F. unit.
  To stabilize the flow rate, the API effluent pump basin, whose volume shall be carefully checked, will act as a surge basin.
  It will not be needed, therefore, to vary the dosing of chemical feeds, since the flow rate to the D.A.F. unit is steady. Simpler and less troublesome manually-adjustable chemicals feed pumps could therefore be specificated, instead of the automatically proportioning ones.

- Documentation supplied by tenders should specifically include the type of chemicals to be used and their dosing rates, indicate their cost and whether they are available in Egypt.

ANNEXE N. 5

SUEZ REFINERY EXPANSION - OBSERVATIONS AND COMMENTS ON WASTE TREATMENT BASIC DESIGN SYSTEM.

General block flow diagram

The treating system of the general oily drain, as shown in the block flow diagram (DWG 9283-230-KD-013) includes: a API gravity separator, a DAF unit and a final skim basin.

We understand that the choice of a DAF unit, instead of a biological treatment one, is mainly due to a lack of space at the refinery site. According to this, we agree that the system selected can be considered as the most suitable one.

We remind, however, that a DAF unit is somehow more complex and difficult to operate than a biological one, (more mechanical maintenance, periodical handling and preparation of chemicals, chemical sludge disposal) and that, should the necessary space be found, a biological treatment plant would be more advisable than the DAF one.

Ballast water

It is remarkable, as positive, that facilities for the collection and treatment of ballast water have been provided, in order to minimize pollution from tankers traversing Mediterranean and Red Sea.

The facilities include storage tanks for ballast water, equipped with skimming devices for separated floating oil; ballast water then is gradually released from storage tanks and sent to the general oily drain. Then it undergoes all final treatments, together with the refinery process wastes. This system can be considered very accurate for the treatment of ballast waters.

Sludge disposal

Dried solids in the lagoon shall be periodically excavated and disposed of in a proper dump or incinerated, but not used as land fill.

Dried solids can, in fact, retain chemicals ond oily residuals, and precautions should be taken regarding the final disposal dump area.

ANNEXE N. 6

OUTLINES OF LECTURES GIVEN AT THE CENTER FOR ENGINEERING DEVELOPMENT (CED), c/o ENPPI OFFICE IN ALEXANDRIA (may 7-8 1984) AND AT ENPPI HEADQUARTERS IN CAIRO ON WATER, AIR, SOLID WASTE MANAGEMENT AND DISPOSAL IN THE PETROLEUM INDUSTRY.

A. Waste water pollution management and control

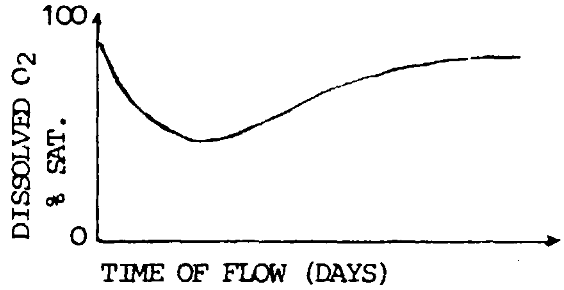
Introduction

- General sources of water pollution:
  a. domestic
  b. industrial
  c. agricultural

- Type of sources:
  a. point sources (industrial outfalls, domestic sewage outfalls);
  b. non point sources(run-off, domestic wastes without sewage, motor boats, tankers).

- Effects:
  a. non persistent (biodegradable matters)
  b. persistent (heavy metals, non biodegradable matters)
  c. eutrophication (excessive growth of algae, flowers in rivers, channels, lakes).

- Natural defenses from pollution:
  Self purification capacity as regards organic matters, P - N compounds, etc.



Sampling procedures for waste waters

All sampling should be accomplished by skilled staff.

Continuous sampling

Grab samples

Composite samples - e.g. 24 hour composite sample - equal aliquots collected at 1 hour intervals during a 24 hour period - or 6 samples every 4 hour in 24 hour.

Type of material of the sampling bottle: glass - plastics.

Sampling bottle preconditioning (don't wash the bottle with the same water to be sampled; some pollutants- e.g. oil- could stick on the inner walls).

Position of sampling: against the flow, not at the surface, nor at the bottom only.

Sample preservation. Samples should be kept during the transportation and stored at the laboratory at 4°C. Laboratory analyses should start as soon as possible, but anyway within 24 hours from sampling.

Brief review of laboratory methods of analyses

Analytical methods should be reliable, precise and accurate, and have a widespread usage among water laboratories. Selection and sensitivity of instruments, reagents, glassware cleaning, as well as the analytical methods must conform to the equipment, skills, and analytical time limitations established by the national regulations, or stated in some selected manuals (e.g.: Standard Methods for the esamination of water and waste water).

Here below are listed some of the most common analyses on waste water:

- pH : electrometric
- Settleable solids: Imhoff cone
- T.S.S. : glass fiber filtration - gravimetric
- BOD5 : Biochemical Oxigen Demand. The 5 day 20°C BOD_5 test is used to determine the oxygen consumed by living organisms to oxidize the biochemically oxidizable organic and inorganic matter of the waste sample to non putrescible end products.
- COD : Chemical Oxygen Demand. The COD measures the quality of oxygen required to oxidize organic and inorganic matter of the waste sample under severe chemical and physical conditions. (K_2CrO_4, 2 hours COD test).
- Oil and grease : liquid- liquid hexane extraction (hexane gravimetric procedure);

liquid-liquid trichlorotrifluoroethane extraction (Freon extractibles).

- Specific hydrocarburs: gas chromatography.
- Heavy metals : flameless atomic absorption

Interferences in analytical methods - Interlaboratory and intralaboratory deviation.

Philosophy of waste water management and regulations

The aim of waste water pollution control policy should be:

TO PROMOTE, RESTORE AND MAINTAIN THE CHEMICAL, PHYSICAL AND BIOLOGICAL INTEGRITY OF THE NATIONAL BODIES OF WATER.

Integrity means that water bodies should be maintained in accettable conditions; means that they should not be impaired and that they should be preserved in order to be used for all the possible purposes to which they are destinated (drinking - bathing - irrigation - fishing - industrial usage - navigation etc.).

The word polluted should therefore be related to the receiving water, not to the waste water as such.

An effluent stream, may be polluting the receiving water , but only when it compromises its natural characteristics, which should instead be preserved.

We can't say that an effluent as such, causes pollution to a water body when we take into consoderation only the concentration of pollutants in the effluent. Other factors must be considered as well, such as:

- the volume of the waste discharged
- the flow rate of the receiving stream (or the diluition rate

with the receiving water)

- the self purification capacity of the receiving water body
- the use to which the receiving water is destinated, and the consequent water quality classification of the receiving water body.

There are different philosophies and different approaches for the establishing of water pollution control policies:

1. <u>Tolerance limits for the effluents (Effluent limitations)</u>
   Only tolerance limits for the effluent are established.
   Tolerance limits can be:
   a. fixed on a nationwide base
   b. related to the classification of water bodies
   c. specifically established for each main outfall.
   Nationwide limits are usually established according to the Best Pollution Control Technology Available - BPCTA.

2. <u>Surface water quality standards (s.w.q.s.) for every significat body of water.</u>
   The National, or a regional authority, fixes s.w.q.s. which represent the goals pollution control policies are meant to secure.
   As a next step, effluent limitations are fixed, to establish the amount and kinds of pollutants wich can be discharged in order to respect the established s.w.q.s.
   Effluent limitations should therefore be different, according to local conditions, and be issued case by case in discharge permits. Sometimes, however, they are issued in a rigid

and general way. This doesn't take into account the volume of the discharge, the flow rate of the receiving stream, etc. which are also important factors, in determining the effects of the waste waters on the receiving body.

3. Total pollution load

Limits are not established for pollutant concentrations in the effluent, but for the total quantity of the daily pollutants discharged.

This prevents from using dilution as a possible mean to reach the effluent limitations.

4. Charges system

In principle, neither tolerance limits nor total pollution load are fixed. But money charges are applied to the waste waters, proportional to the amount of pollution discharged.

This kind of taxation, practically, induces a great limitation to the discharge of pollutants.

5. Combination of: s.w.q.s. - Effluent limitations- Charges system.

Surface water quality standards are first set.

As a next step,two lists of tolerance limits for the effluents are established by the responsible authority, case by case;

the stricter list (guideline) is based on the best pollution control technology available, the second one (maximum acceptable concentration -m.a.c.) is to be considered the maximum acceptable pollutant concentration that do not impair the established quality standards of the receiving waters.

Wastes that do not respect the guidelines limits, but only the m.a.c. should pay a money charge, according to the following formula:

$$C = \sum_{1}^{n} {}_{i} \quad r \; c \; y_n \; \frac{(a_{ix} - a_{il})}{a_{il}} \; Q_i$$

where:

C = total money charge/year

r = reduction factor (e.g.: 0.10 for the first year

0.30	"	"	second	"
0.65	"	"	third	"
1.00	"	"	fourth	"

c = money charge/m^3

y_n = factor related to the class of the pollutant

(e.g. y_n = 2 for heavy metals, etc.

y_n = 1 for BOD5, COD, S^-, CN^-, etc.

y_n = 0.5 for Cl^-, $SO_4^=$, etc.)

a_{il} = guideline tolerance limit for the "i" pollutant

a_{ix} = average concentration of the "i" pollutant in the effluent.

Q_i = volume of the waste (m^3/year) containing the "i" pollutant.

Comments on Egyption legislation on water pollution control

The major items of legislation on water pollution control in Egypt are:

Law N. 93 of 1962	
Order N. 56 of 1962	(dealing with measures to protect harbours and territorial waters)
Decree N. 649 of 1967	(regulations for the implementation of law N. 93)
Law N. 48 of 1982	(issued by the Ministry of irrigation) concerning "Protection of River Nile and water courses from pollution".

While the previous laws provided regulations concerning only the effluent concentrations, the new Law n. 48 of 1982 provides both surface water quality standards and effluent standards for 3 different classes of waters:

- Nile branches, canals, etc. and underground water.
- River Nile (main branch, from southern border to Delta barrage)
- Salty waters.

Brief review of foreign regulations

a. U.S.A.

All environmental activities are coordinated by EPA, a federal agency established on December 2, 1970.

Main item of legislation: Clean Water Act of 1972, as amended in 1977 and 1981.

-The act requires each State to set water quality standards for every significant body of surface water.

-States, with the guidance of EPA, will set effluent limitations on the amount and kinds of pollutants that can be discharged into waterways, and issue:

-Discharge permits to parties; EPA and State environmental agencies, through a vigorous enforcement programm, will ensure that the industries meet the requirements set out in their discharge permits.

EPA, as such, can not establish w.q.s. or effluent limitations; this agency can only provide "guidance" to the States on this subject.

b. Italy

The main item of legislation on water pollution control is Law N. 319 of may 10, 1976.

The law sets nationwide tolerance limits for the effluents. Minor differences are foreseen only for chlorides and sulfates : no limits for these pollutants are fixed for wastes discharged into the sea.

Main sources and characterization of refinery liquid wastes

The extension of processing, complexity of oil refining will have a parallel impact on the character and quantity of contaminants entering a given refinery waste water system.

The main sources which are likely to exist in most refineries are the following:

- desalter
- tankage farm
- pumps seal leakage
- exchangers or towers drain
- water cooling of pressure pumps
- chemical laboratory
- ballast water (for refineries located close to oil terminals)
- spent caustic
- sour water
- oily rain water
- boiler blow down
- cooling tower blow down
- raw water clarifier sludge
- water filter back wash
- demineralizer regeneration effluent

Since wastes from different refineries can be different, there is not a general basic design applicable to all refineries liquid effluents.

Characterization studies should therefore be carried out in every case.

a. characterization of specific unit process streams (catalitic cracking, spent caustic, sour water, etc.); this study is specially useful for selecting specific pretreatment plants.

b. characterization of the combined oily sewage.

A gravity separator should be, in any case, the basic treatment unit for oily wastes, acting, also, as a trap for accidental spills which might occur in any area of the refinery.
The expected characteristics of the gravity separator effluent are, generally, as follows:

			Avg.
Oil and grease	mg/l	: 10 - 300	30
BOD_5	"	: 30 - 300	100
COD	"	: 100 - 600	250

<u>Review of the principal conventional methods for the treatment of refinery liquid wastes</u>.

A. Specific treatment

1. For spent caustic:
   a. oxidation
   b. flue gas stripping and neutralization

2. For sour water : steam stripping
3. For ballast water : settling in storage tanks
4. For waste water from the demineralization unit: neutralization.

B. General treatment for oily wastes

1. gravity separators :
   a. API separators
   b. CPI separators

2. chemical treatment:
   a. D.A.F.
   b. flocculation
   c. neutralization

3. biological treatment:
   a. activated sludge process
   b. trickling filter
   c. aerated lagoon
   d. oxidation - stabilization pond.

   The activated sludge process is usually recognized as the best level of treatment currently used by the refining industry for the control of BOD_5 and COD parameters. To some extent, it can remove also inorganic pollutants ($S^=$, NO_2, NH_4, SO_3, etc.) as well as heavy metals; the last ones are partially absorbed by sludges, and discharged with the surplus sludge.

<u>The operation of liquid waste treatment facilities - Problems and controls.</u>

A. Activated sludge plants

All efforts should be made to obtain the maximum treatment efficiency from the plant and to prevent the bulking.

a. Specific studies should be carried out to identify:
   1. the major organics treatable by the activated sludge process.

2. the major organics refractory to the activated sludge process.
3. the major causes of sludge poisoning.

b. Operation practices should include:
   1. the control of the best pH range
   2. the control of the best temperature range
   3. the control of the dissolved oxygen concentration in the aeration basin.
   4. the control of the concentration of activated sludge in the oxidation basin (MLSS).
   5. the control of the activated sludge recycle rate
   6. the control of the proper balance ratio of nutrients (e.q.: $BOD_5/N/P = 100/5/1$)
   7. all actions aimed at minimizing shocks or sudden variations of the influent's
      - flow rate
      - physical properties
      - chemical properties.

Training and qualification of the operating personnel of the treatment unit are essential.

B. D.A.F. units.

Operating practices should include:
- renewal of chemicals in chemical storage tanks
- frequent mechanical controls and maintenance on the most delicate equipments (chemical feed pumps, pH control sensor

and transmitting devices, etc.).

- removal and disposal of the chemical sludge.

Final (tertiary) treatment of waste water

a. Multimedia sand filtration (for final removal of TSS)

b. Activated carbon.

Pilot-scale screening studies should be first conducted to determine applicability and effectiveness of activated carbon in further reducing concentrations of priority and classical pollutants.

- Granular Activated Carbon (GAC)
- Powdered Activated Carbon (PAC)

c. Aerated lagoons

Surface, floating aerators, or revolving brushes can be used to dissolve oxygen to complete the degradation of organic resistent compounds.

d. Natural stabilization - oxidation ponds.

In large, swallow basins, planktonic algae population or aquatic plants can complete the degradation of organic resistent compound, and the removal of specific nutrients (P,N) from the wastes.

e. Chemical oxidation

The addition of chemicals (O_3, Cl_2, Cl_2O_2, NaOCl) can perform the final oxidation of stable organic compounds, as well as the water sterilization.

B. Air pollution control

Introduction

- Sources of air pollution:
  a. stationary (factories, power plants, house heating, etc.)
  b. mobile sources (automobiles, trucks, etc.)

- Effects of air pollution:
  a. on human health (human health may be endangered by high concentration of air pollutants).
  b. on plants, or animals (grape leaves are effected by SO_2, Fluorine, etc.).
  c. on materials (preservation of monuments from corrosion, from acid rains, etc.).

- Sampling equipment:
  a. manually operated
  b. automatic sampling and monitoring stations.

Air pollution control standards and regulations

The fundamental objective of air pollution control programmes and regulations is the protection of human health, plants, animals, materials and welfare from harmful effects of air pollution.

This requires the setting of air quality standards, i.e., the maximum acceptable levels of pollutants for the outdoor air, as measured at ground level, above which:

a. human health can be endangered,

b. plants, animals and materials can be endangered

c. welfare is reduced.

This can be achieved through the establishing of:

- National ambient air (or outdoor air) quality standards (a.a.q.s.); or
- Specific ambient air quality standards: different and more restrictive in order to:
  a. prevent air quality degradation in such places as national parks or wilderness areas where air quality is exceptionally good and should be preserved like it is.
  b. protect specific plants, animals or materials (artistic monuments).
  c. improve the air quality in some particolar inhabitated areas (residential areas, amusement areas, hospital areas, etc.).

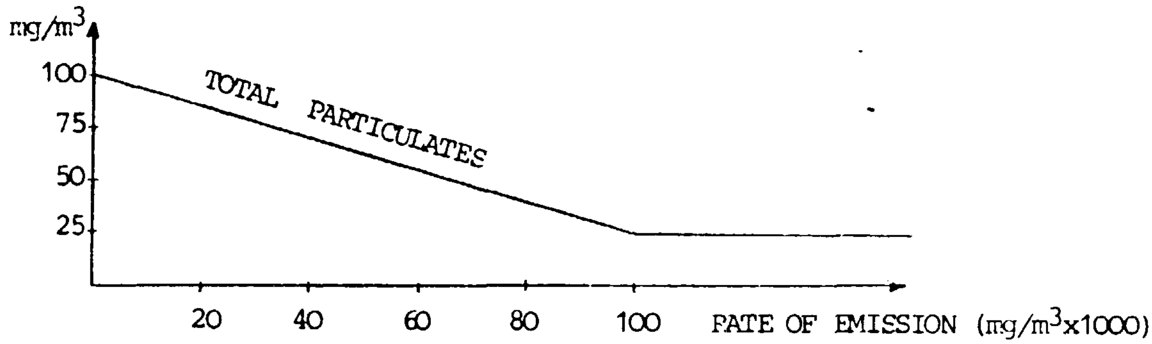
In order to achieve the a.a.q.s. set by the national law, emission limitations are issued, case by case, by the responsible authority (generally a local authority).
Emission limitations should therefore be based upon the "ground level concentration resulting from the emission".
They should take into account:

- air quality standard implemented in a specific area
- height of the stack, velocity and temperature of the air emission.

- the background level concentration existing in the area for every particular pollutant.
- the volume of the air effluent
- the weather conditions (prevailing wind directions, etc.).

Emission limitations are often issued, instead, on the ground that the industry should install anyway the "best pollution control technology available".

Sometimes emission limitation are established proportionally to the volume of air emission, as shown in the following chart:



<u>Main sources of refinery air pollutants (SO_2 - CO - Particulates - Unburned HC)</u>

- All heaters
- Power station
- Flare
- Cone roof tanks
- Safety valves (unless connected to the flare header).
- Specific maintenance works (degasification of tanks, etc.).

Atmospheric dispersion theories

Evaluation of ground level concentration: many formulas have been presented by Sutton, Bosanquet, Pearson, etc.

One of the most used is the following:

$$\chi_{max} = \frac{2Q}{e \pi \mu H^2} \frac{\sigma_z}{\sigma_y}$$ where:

χ_{max} = concentration, at ground level

Q = uniform rate of emission (grams/sec.)

σ_y = standard deviation of plume diffusion in the horizontal

σ_z = standard deviation of plume diffusion in the vertical

μ = wind velocity, in meters per second

e = the base of natural logarithm

H = effective stack height (physical stack height + plum rise).

Methods of abating air emissions

- High stacks (they do not reduce emissions as such, but are helpful in meeting or reducing the ground concentration of pollutants).

- Optimize the combustion: this will descrease the concentration of CO, unburned HC, particulates.

- Use low sulfure fuel such as: natural gas, low sulfure heavy oil, desulfurized gas-oil.

- Do not send any main stream containing pollutants directly to a stack, but connect all of them to the flare.

- If possible, send to the crude heater, not to the flare, the air streams containing relevant concentrations of hydrocarbons. In the crude heater, in fact, the combustion is more complete than in the flare.

- Install a sulfur recovery unit. Refineries can be major producers of pure Sulfur (otherwise the same S is discharged as SO_2 or H_2S).

- Install devices for smokeless flaring; they are based on the principle of increasing the burning rate by the injection of steam into the flame.

C. Sludges and solid wastes handling and disposal

Introduction

Sources:

-Domestic solid waste (organic matter, paper, textiles, wood, metals, rubber and plastics, glass, etc.).

-Industrial wastes:

a. from treatment facilities. Treatment of liquid waste waters can be accomplished through the removal of pollutants as semiliquid sludge. Once the pollutants are removed from the waste waters, the disposal of the sludge becomes a major problem.

b. from manufacturing process. These wastes can be: solids, semiliquid sludges, or low volume highly concentrated liquids.

Disposing of domestic and industrial waste is a serious and costly business, requiring measures to protect the environment.

Classification of industrial wastes:

a. inerts (e.g. remains from the manufacturing of stones, granites, demolition of buildings or civil works, etc.)
b. similar to domestic wastes (textiles, paper, glass, etc.)
c. non toxic (special wastes)
d. toxic and hazardous wastes

Toxic and hazardous wastes should be properly defined.

Environmental risks connected to a poor final waste disposal

Treatment of liquid wastes is producing an increasing quantity of semiliquid sludges.

Unfortunately environmental engineers generally spend more time removing the pollutants from the waste water then finally disposing them.

Quite aften, then, a poor solids-disposal programme will reduce the overall efficiency of an otherwise properly designed and operated w.w.t.p.

Uncontrolled waste sites present environmental risks, requiring action to prevent degradation of:

- water; the waste could move through the soil and reach water courses or the underground acquifers. (water table).

- soil ; a disposal on agricultural land of some sludges (heavy metals, toxic materials, etc.) can have harmful effects on the productivity of the soil, or could endanger agricultural products (absorption of toxic compounds in the agricultural products).

- air ; bad smelling, or dangerous to health gases could evolve from concentrated liquid wastes or toxic substances improperly disposed of on the ground.

-public; health and general welfare; uncontrolled waste sites for domestic or other organic wastes (food industries, etc.) can be the cause of wild animal growth (mices, mosquitos, etc.) and/or cause the degradation of some selected areas.

Regulations on waste disposal

Wastes should be classified first.

Then the basic characteristics of the disposal sites, should be established, according to the class of waste to dispose.

Regulations should also be issued for:

- temporary storage
- transportation
- treatment before disposal.

Conditioning of sludges before final disposal

a. Physical/mechanical methods for dewatering of sludges:
   - sludge gravity thickner
   - sludge drying beds
   - filter pressing (plate filters)
   - belt filters
   - vacuum filters
   - centrifuges

Chemical conditioners are sometimes added to facilitate dewatering. Dewatering is however only a mean to reduce the volume of sludges for ultimate disposal, and to improve the handleability of the sludge itself.

But it does not improve the chemical stability of the sludge.

b. Chemical methods for treatment of sludges and special wastes:

- sludge digestion
- thermal method
- incineration
- wet combustion
- chemical fixing (the solidified sludge should fulfill standard tests showing its capability not to release heavy metals or toxic constituents if exposed to rain water).

Methods for ultimate disposal of conditioned sludges

- Composting
- Land filling, land ploughing
- Lagooning
- Sludge barging
- Reuse
- Dumping in an authorized dump
- Land reclamation.

ANNEXE N. 7

GUIDE TO AEROBIC BIOLOGICAL TREATMENT PLANT DESIGN (ACTIVATED SLUDGE PROCESS)

A. Scope

This guide covers basic requirements for the design, sizing and controlling veriables of activated sludge biological treatment units.

B. References

The following guides and pubblications are referred to herein:

- API (American Petroleum Institute). Publications Manual on Disposal of Refinery wastes, volume on liquid wastes, 1979; Chapter 13, biological treatment.

- Hydrocarbon Processing - Gulf Publishing Company 1968: Waste Treatment and flare stack design handbook.

- R.L. Bolton - L. Klein (Butterworths, London): Sewage treatment - Basic principles and trends

C. System description

Aerobic biological treatment is used to abate the content of biochemically oxidizable organic and inorganic components of the waste.

The various steps of the activated sludge process can be summarized as follows:

- The raw stream entering the aeration tank is mixed with sufficient return activated sludge to give an appropriate suspended solids concentration in the aeration tank.
  The optimum concentration af activated sludge must be determined experimentally for each plant.

- The resulting mixed liquor is aerated, through a mechanical aeration device, (surface aerator) for a suitable period in the aeration tank, where an appropriate concentration of dissolved oxygen is kept and controlled.

- At the outlet end of the aeration tank, the mixed liquor is allowed to settle in a final settling tank.
  The supernatant liquid, constituting the purified effluent, is discharged into a watercourse (or sent to a final polishing treatment system).

- Part of the activated sludge is then returned to the aeration tank inlet and mixed with the raw stream.

- The surplus activated sludge from the clarifier is disposed of in various ways (disposal on land, composting, anaerobic sludge digestion, etc.).

D. Procedure for sizing

Aeration tank

A. Volume

-The detention time "t" in the aeration tank depends upon the strength and character of the waste.
It can range from 6 h for weak waste to about 12 h or more for strong waste.
A minimum detention time of 8 h is recommended.

-Expressed in terms of applied BOD_5 of raw waste, the space loading "r" should be 0,3 - 4 Kg BOD_5/day per m^3 of aeration tank capacity, the lower values being used for weak wastes (BOD_5, 100 mg/l approx), the higher for strong ones (BOD_5 5000 mg/l, or more).
The volume of the aeration tank shall be calculated from the above values and the following formulas:

$$V_A = Q \cdot t \quad \text{, or}$$

$$V_A = \frac{\text{Kg } BOD_5}{r \cdot \text{day}} \quad \text{, where}$$

V_A = volume of the aeration tank (m^3)
Q = waste water fed to the tank (m^3/h)
t = detention time (h)
r = space loading; the BOD_5 charge (Kg) which is allotted to 1 m^3 aeration volume daily $\left(\frac{\text{Kg } BOD_5}{m^3 \cdot \text{day}}\right)$

B. Power consumption (referred to surface fixed aerators)
There are many methods of oxygen trasfer to the mixture of waste water and activated sludge (e.g.: coarse bubble aeration with low-pressure air produced by fans; diffused air system, with low-pressure or comparatively high-pressure air produced, respectively by fans or compressors, depending upon the immersion depths of the diffuser system; brush system; mamoth rotor; submersed aerators; fixed or floating surface aerators, etc.).

The use of surface aerators has however come to the fore in recent years, for the semplicity of the system and the relatively low energy required.
Power consumption is here reffered to this type of mechanical aeration system.

-The water absorbs only a portion of the oxygen from the air which is dissolved into the aeration space. The amount of oxygen absorbed dipends on the dimensions of the aeration tank, the air intake device, and the oxygen concentration maintained in the aeration tank.

With consideration of the above mentioned factors, an oxygen quantity of approx. 2,2 Kg O_2/kg removed BOD_5 is worked out using "standard" commercially available equipments.

-The rate of oxygen transfer of various surface aerator devices is affected by the nature of the aerator, depth

of submergence, temperature, turbulence in the tank, depth of the tank and chemical character of the waste.
We can say, however, that commercially available surface aerators, under average conditions, have an oxygenation capacity of 2 $\frac{Kg\ O_2}{Kwh}$ approx.

The surface aerator power consumption can therefore be estimated as:

$$\text{Aerator power consumption} = 1.1\ \frac{Kwh}{Kg\ \text{removed}\ BOD_5}$$

C. Depth of the aeration tank

In order to easy the suspention of activated sludge, the aeration tank should be 2,4 - 3,5 m deep (plus the dead space).

D. Return sludge ratio

The activated sludge that has settled in the clarification tank must be recirculated into the aeration tank, so that the sludge concentration that is needed for the decomposition can be maintained.
The ratio between return sludge flow and waste flow is colled return sludge radio (RS).
The required ratio depends very strongly on the settleability of the sludge in the clarifier. With easly settling sludge the return sludge ratio can be proportionately lowered.

On normal conditions, the RS varies from

RS : 50 - 150 percent.

The return sludge pump should be accordingly sized.

Settling tank

Settling tanks for large-scale plants are usually circular in plan and the sewage enters at the centre, into a vertical cylindrical drum, form where it passes via ports into the body of the tank. It then flows towards the perimeter of the tank, round the whole of which there are an outlet weir and a channel into which the settled waste overflows.

A. Upward flow velocity.

The surface area of the tank is the main factor in determining the rate of upward flow.

The following formula is considered:

$$U.V. = \frac{Q}{S} \frac{(m^3/h)}{(m^2)} = m/h,$$ where

U.V. = upward velocity (m/h)

Q = waste water maximum flow to the settling tank (m^3/h)

S = surface area of the settling tank (m^2)

Upward velocity of 0,5 - 1 m/h are usually considered as the suitable for the sedimentation of activated sludge.

The surface area can be accordingly calculated.

B. Detention time

Detention time in settling tanks varies form 3 to 4 hours. The volume of the tank can be accordingly calculated.

E. Controlling variables

- MLSS - Mixed Liquor Suspended Solids

  Is the amount of activated sludge suspended in the mixed li quor.

  Normal values of MLSS are usually: from 2000 to 5000 mg/l.

- Sludge Volume

  Is the percentage by volume of sludge in the aeration tank, as measured after 1 h settlement in a graduated litre cylinder.

  Normal values of Sludge Volume are usually: from 10 to 30 per cent.

- BOD_5/Solids Loading

  It indicates the BOD_5 load (Kg) that is allotted daily to 1 Kg solids (MLSS). For large-scale units, loading values are usually between: 0,3 - 0,7 Kg BOD_5/Kg MLSS day.

- Oxygen Concentration

  Is the oxygen concentration to be kept in the aeration tank in order to assure optimal life conditions to the bacteria of the activated sludge and minimize dispersion of oxygen blown into the aeration space.

Normal values of Oxygen concentration are between 1-3 mg/l.

- Sludge Volume Index - S.V.I.

  Is the volume (in ml) occupied by 1 g of sludge after settl ing the mixed liquor for 30 min. in a litre graduated cylinder. S.V.I. increases as the sludge tends to settle badly or "bulk", and generally varies from around 50 ml/g for a good sludge to about 100 ml/g or more for a poor sludge.

- Nutrient Requirements

  Appropriate ratio of $BOD_5/N/P$ in waste water undergoing purification is necessary for the biodegradation of organic substances.

  Ratio of $BOD_5/N/P$ = 100/5/1 is usually considered to be the most suitable. Adequate addition of nutrients should be provided when the wanted nutrient ratio is not found in the raw stream.

- Sludge Growth Index - S.G.I.

  Is defined as the weight of activated sludge formed per unit weight of BOD_5 applied.

  S.G.I. varies between 0,45-0,9 $\frac{\text{Kg MLSS}}{\text{Kg BOD}_5\text{ applied}}$

- Excess sludge

  According to the S.G.I., a parallel quantity of excess sludge shall be removed from the plant, at normal operating conditions.

ANNEXE N. 8

SUGAR INDUSTRY

TREATMENT OF WASTE EFFLUENT FROM FERMENTATION/DISTILLATION PLANT

A. Basic data

-Waste water stream	: 20 m^3/h x 24 h/d
-Destination	: river Nile (main stream)
-Color	: brown
-Odor	: very light fermented liquor
-Temperature	: 85-90 °C
-pH	: 4,5 - 5,5

The waste contains:

- sugar
- organic acids
- organic solvents (acetone, butylalcohol)
- dissolved salts (ammonium sulphate)
- suspended solids:
  - inorganic: calcium salts
  - organic : rice bran + wheat bran
- some remainder of bacteria (eventually)

B. Development of the research study for the treatment of the waste

Characterization of the waste

a. Collect a representative sample of the different wastes:

-bottom of distillation column (steady flow)

-discontinuous discharges from fermentation tank, etc.

b. Make laboratory analyses of the different samples.
The most important analyses required are:
-color, odor.
-pH
-TSS
-BOD_5
-COD
-TDS

c. Should the discontinuous discharges have characteristics significatly different from the steady flow wastes, prepare at the laboratory an "average sample", mixing in due propor tion the different wastes (steady and discontinuous).

d. Repeat the required analyses on the average sample.

<u>Laboratory test of water purification processes</u>

a. Make laboratory jar tests on various aliquots of the combined sample.
It should be experienced: the different flocculants, their dosing rate, the best pH range for flocculation, the most suitable polyelectrolite and its dosing rate, the quantity of sludge produced.

b. Following the jar tests, the required analyses should be repeated on different samples of treated water, in order to check the most effective method, among the many tested, in abating TSS, COD and BOD_5.

c. It is expected:
   - an almost complete removal of TSS
   - a BOD_5 and COD reduction of 50-70%
   - a neutralization of the waste to 8-8,5 pH values
   - a reduction of color and odor.

   No abatement of TDS will, on the contrary, be obtained.
   Further abatement of BOD_5 and COD can be obtained through a biological treatment unit.
   The characteristics of the chemically treated waste are the basis for the sizing of the aerobic biological treatment plant.

P.S.: Since no practical test has been developed, no sure results can be anticipated about the effectiveness of the flocculation method in abating the main pollutants concentration. The developing of the following point c. is therefore based on experience and theoretical estimations. The system described is not to be taken as the treatment method selected, unless practical laboratory tests and analyses confirm its effectiveness.
In particular, anaerobic treatment could also be taken into consideration especially if the concentration of BOD_5 and COD in the raw waste, as from the analyses, results particularly high (COD of the order of 100.000 mg/l).

Selection of treatment facilities (see the drawing attached, scheme N. 1).

The treatment facilities should consist of:

- a surge basin, to equalize the flow rate and the chemical characteristics of the effluent to be treated.
  The basin should be provided with adequate stirring, to prevent sedimentation of suspended matter.

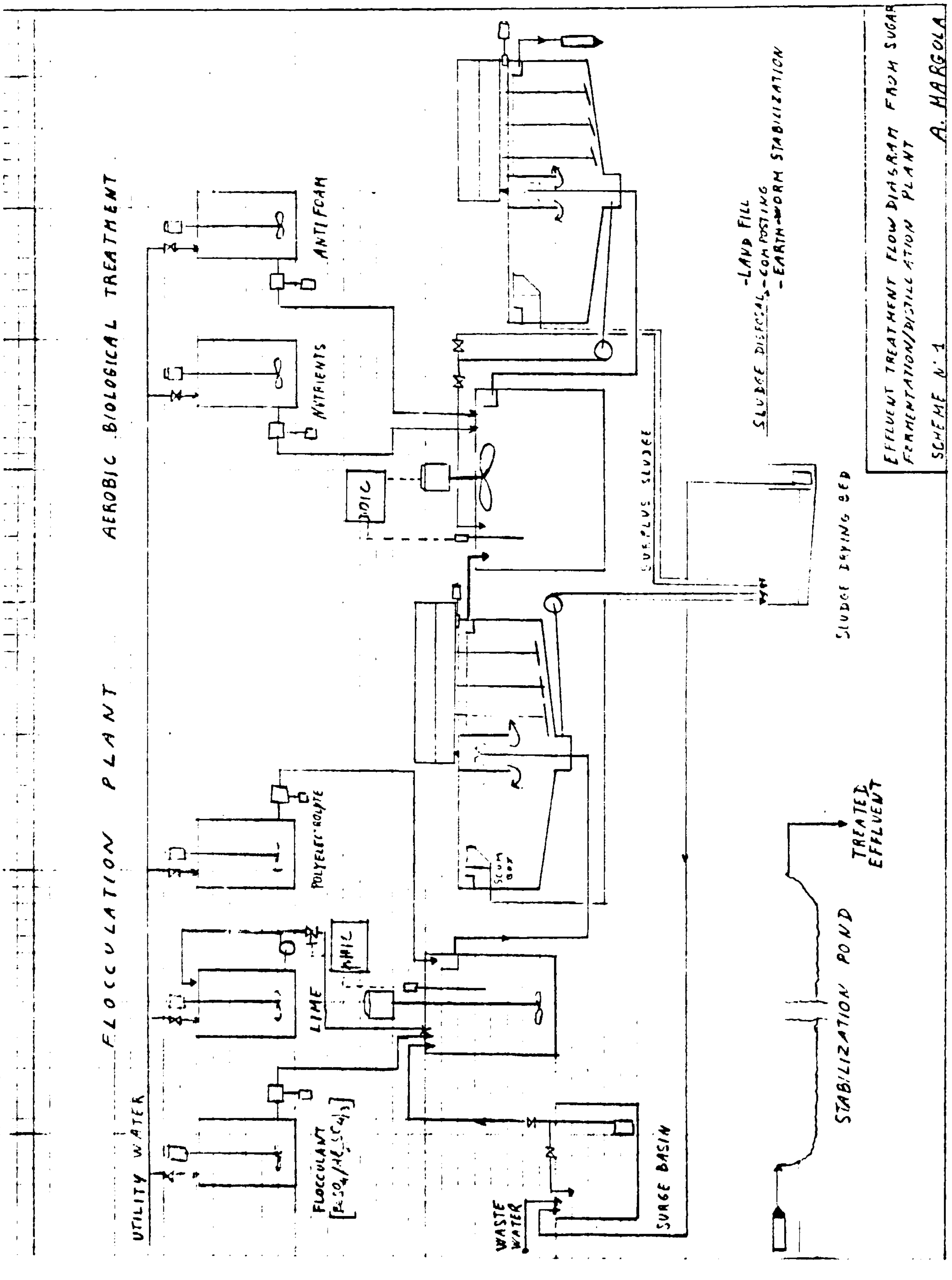
- a flocculation unit, consisting of a station of chemical storage tanks and feed pumps; a reaction basin; a settling tank for the separation and removal of chemical sludge.

- an aerobic biological treatment unit, consisting of an oxidation basin and a settling tank for the separation of activated sludge, part of which is then returned to the aeration basin inlet, part discharged as surplus sludge. Chemicals storage and feed equipment are also to be provided.

- a large shallow polishing pond, where final stabilization and removal of organic matter and nutrients can be achieved under the influence of oxygen, bacteria, sunlight, algae and, eventually, of aquatic plants.
  Fishes may be put in the basin to control algae growth; they can also be regarded as a source of animal protein.

- sludge drying beds, for dewatering of sludges from the flocculation and biological plants.

  Land filling, or treating through bio-stabilizers (e.g. earth-worms, which produce humus directly utilizable as fertilizer) can be regarded as interesting alternatives for the sludge final disposal.


EFFLUENT TREATMENT FLOW DIAGRAM FROM SUGAR FERMENTATION/DISTILLATION PLANT
SCHEME N° 1
A. MARGOLA
AEROBIC BIOLOGICAL TREATMENT
FLOCCULATION PLANT
UTILITY WATER
FLOCCULANT
LIME
POLYELECTROLYTE
NUTRIENTS
ANTIFOAM
WASTE WATER
SURGE BASIN
SCUM BOX
SURPLUS SLUDGE
SLUDGE DRYING BED
SLUDGE DISPOSAL
-LAND FILL
-COMPOSTING
-EARTH-WORM STABILIZATION
STABILIZATION POND
TREATED EFFLUENT