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Environmental Assessment
of
Société Anonyme Monastirienne
Monastir, Tunisia

by

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The technical advice and the services provided to Société Anonyme Monastirienne (SAM) in Monastir, Tunisia, during the period of June 1992, by an expert working under the sponsorship of the World Environment Center (WEC) of New York, New York, U.S.A., was and is to be furnished on a free-of-charge basis. As a result, the World Environment Center, the expert provided by it, and the United States Agency for International Development (USAID), hereby disclaim any legal responsibility and liability, whether under the laws of Tunisia, the United States, or any other jurisdiction, vis-a-vis Tunisia, the Government of Tunisia, its agents, and its residents for the advice and services provided by such expert (which advice includes explicit and implicit suggestions and the omission of suggestions.)

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I. EXECUTIVE SUMMARY

An assessment of environmental controls at the Société Anonyme Monastirienne was conducted under the sponsorship of the World Environment Center (WEC) and the United States Agency for International Development (USAID) in June 1992. The project supported USAID's Project in Development and the Environment (PRIDE).

The assessment was performed by Mr. Gerald N. McDermott, a licensed Professional Engineer, with over forty years of experience in the detergent industry and working with governmental agencies.

Monastirienne produces edible oil and bar soap. The edible oil is produced by refining crude oil to a quality suitable for consumers. Fatty acid soap is produced by chemically modifying the fatty acid part of vegetable oil.

Monastirienne's wastewater is estimated at 45 to 62 cubic meters per day. The major possibilities for in-process wastewater reduction are in the recovery of glycerine and lecithin. US organizations having information on recovery systems for these materials are identified in this report.

Monastirienne has no treatment facilities for its wastewater. The wastewater is presently carried, via pipes or trenches, to the rear of the plant's property where it is spread on low lying areas. Although groundwater degradation is not a significant risk, it is recommended to replace this disposal method with one which eliminates the unsightliness and hazards associated with having a caustic pond (caused by the plant's wastewater) in the plant's vicinity.

Engineers at Monastirienne are very interested in wastewater treatment alternatives in order to comply with the limits of the public sewer system. The pretreatment processes of neutralization and biological treatment are suggested for investigation.

Land treatment is also a possible method for treating Monastirienne's wastewater. This method involves spraying the wastewaters on soil (at low rates) and allowing the bacteria in the soil to degrade the organics. A few hectares of land are probably sufficient for land treatment of Monastirienne's wastewater. Before land treatment is implemented, it should be assured that no degradation of groundwater used for drinking purposes will result.

The most economic and reliable system for addressing Monastirienne's wastewater would be treatment at a joint community facility which serves residential, commercial and industrial users.

A formal safety program is recommended to handle hazardous materials being used at the plant. At this time, Monastirienne uses the following hazardous materials: sodium hydroxide (caustic), hexane and fuel oil. Secondary spill containment measures are recommended for these materials.

II. INTRODUCTION

The World Environment Center (WEC) contributes to sustainable development by strengthening industrial and urban environmental, health and safety policy and practices. In June 1992, WEC furnished the services of Mr. Gerald N. McDermott, an environmental engineer, to assess the environmental control program of Société Anonyme Monastirienne in Monastir, Tunisia.

This assessment gives an account of Société Anonyme Monastirienne's manufacturing activities and facilities pertinent to environmental control. The account includes manufacturing process descriptions with emphasis on wastewater, gas emissions, and discarded material sources. Some assessment of the hazards to workers' health and to the environs of the plant is included. The information was gathered by the author during site visits.

The author is experienced in dealing with environmental problems at one of the world's largest producers of soap, detergents and food oils.

In general, plants that refine edible oil and manufacture soap treat their wastewater in community treatment facilities. The wastewaters are accepted in community systems without regard to the concentration of compatible constituents. In the United States, only one plant

of approximately one hundred provides sufficient treatment for discharge of its wastewaters directly to a stream or lake. A different system of environmental control is being established in Tunisia.

Tunisian environmental regulations limit industrial wastewater characteristics to the concentrations found in residential sewage. Such an approach requires complicated pretreatment processes. This assessment judges the appropriateness of those pretreatment processes, in-service or being planned, and suggests any possible improvements.

This report is a useful document for the future and should be updated periodically. It will be of assistance in a number of applications including:

- reviewing manufacturing and environmental programs by management;
- training supervisory and operating personnel;
- promoting understanding of the program by the community and neighbors; and
- reviewing environmental matters with environmental regulating agencies

The cooperation of Société Anonyme Monastirienne was flawless and the assistance of the manager and engineers was enthusiastic and complete.

III. FINDINGS

A. Manufacturing Processes; Wastewater and Emission Sources

1. Edible Oil Plant

a. Materials

Soy bean oil
Phosphoric acid
Sodium hydroxide (caustic)
Bleaching earth (clay)

b. Equipment

Storage tanks
Mixing tanks
Centrifuges
Pumps
Deodorizing column
Plate and frame filters

c. Products and Production Rates

Edible oil - 20,000 metric tons per year

d. Employees

Total plant (edible oil and soap units) - 150 employees

e. Process Description; Wastewater and Emission Sources

Unrefined soy bean oil is received by truck and transferred to storage tanks on the plant site.

The initial process is the contacting of the soy bean oil with water which has been made slightly acidic with phosphoric acid. This initial step, to alter the composition of the raw oil to make it suitable for cooking and shortening, is called degumming.

Undesirable natural constituents in the food oil are removed by degumming. Lecithin is the principle material removed. The extraction of these materials is more effective under acidic conditions, hence the use of phosphoric acid with the water. Lecithin and other organics dissolve in the acidic water and are then separated from the oil by centrifugation. The water extract from the degumming process is added to other extracts, described subsequently, and pumped to the soap plant.

Lecithin is not recovered in the soap plant but becomes a component of the wastewaters from the soap making process. Fatty acids or oil may be present in the initial water extract particularly if the centrifuge malfunctions, so its processing in the soap making operation may be considered a means of reducing the pollutant load.

Lecithin is not recovered at many refining plants in the United States because it is not economical to do so, since and the market for lecithin is limited. Lecithin recovery lessens the wasteload of biodegradable organics in the wastewaters. The possible recovery and marketing of lecithin from refining plants in Tunisia is discussed in the Conclusions and Recommendations section of this report.

The degumming step is followed by a second extraction of the oil by a strong caustic solution. The sodium in the caustic replaces the hydrogen ions on the fatty acids. Fatty acids are natural breakdown products of the oil which occur during its pressing and shipment. The fatty acid content of oils may run up to 3 or more percent under the normal conditions of pressing and shipment. The sodium soaps created by the reaction with caustic in this extraction process are soluble and dissolve in the water present in the dilute caustic. The oil (i.e. triglycerides) is not soluble in water to any extent. The water containing sodium salts of the fatty acids is separated from the oil by centrifugation. This water stream is called "soap stock" in the trade.

Traces of the soap stock and caustic remain in the oil since the centrifugation separation is not 100 percent effective. In order to rinse these traces from the oil, water is added to the extracted oil and the oil is centrifuged again. This centrifugation separates the water, caustic and fatty acid remnants from the oil. The product of rinsing is referred to as "soapy water" in US industry. In the United States, a number of practices are employed to handle the soap stock and soapy water. At Monastirenne, these extracts are routed to the soap plant to recover their content of fatty acids and oil. This routing minimizes the organic material discarded with the wastewaters. The ultimate sewering of the water is described in the section on soap making.

The oil stream from the alkaline extraction contain traces of odorous compounds and other compounds which impart color to the oil. These odor and color producing materials must be removed to create the bland oil needed for shortening and frying purposes.

The color imparting compounds are removed by a process referred to in the trade as "bleaching". Bleaching is accomplished by adsorption of the color producing compounds on a particular clay. The clay, called bleaching earth, is a natural material that has been found to be effective in adsorbing color. Natural clay deposits with this property are common and available commercially. The clay supply for Monastirenne is obtained from Germany.

Clay is mixed with the oil in a contacting tank, which is merely a stirred tank. Clay is fed to the tank and oil is added continuously. The slurry of clay and oil is pumped to plate and frame filters to separate the clay and adsorbed color compounds from the oil and, thus, renders the oil clear. The oil is heated before the adsorption process to make it more fluid and improve the removal. The filters are fabric and are supported on hollow cores.

When filtration is started, the suspension is recirculated and a layer of clay will build up on the surface of the filter until the stream is clear. Filtration is then continued with straight-through flow which produces a clear oil. When the pressure of filtration builds up to a selected level, or the filter is full of clay, the slurry feed is stopped.

The oil remaining in the piping and spaces, after filtration is stopped, is forced on by a flow of process steam. In this way, the residual of oil in the color-laden clay is minimized. In spite of this effort, a filter cake of approximately 30 to 40 percent oil is produced. Clay is removed from the filter by opening it and allowing the clay cake to drop off.

At Monastirenne, used clay is hauled to an area of the plant and spread as a layer on the ground. Occasionally, the clay is loaded in trucks and hauled to a landfill. There seems to be no problem with this practice which is surprising since, under certain conditions, oil-laden clay will ignite spontaneously. Particularly, when the oil is exposed to air and sunshine, it oxidizes and heat can build up in the pile causing a fire. Evidently, spreading the clay in a layer sufficiently prevents this heat build-up. As a further safety measure, Monastirienne has located the clay pile away from other flammable materials.

In the final process of purifying the oil, odorous compounds are removed by steam stripping under vacuum in a deodorizer. The deodorizer achieves movement of the oil and steam countercurrently, by means of a series of trays which hold the oil for a short residence time as it falls, tray by tray, counter to a flow of steam. The steam flows from the top of the deodorizer into a chamber where a spray of cold water is directed. The water condenses the steam and, thus, a vacuum for volatilization of the odorous compounds is produced. Noncondensable gases in the deodorizer condensing system are removed by a vacuum pump.

The vacuum pumps consist of a rotor tightly fitted to a chamber. The rotor and chamber are fitted so that as the rotor turns, it catches a certain volume of the contents of the chamber to be evacuated, pulls it into the pump chamber and then pushes it to atmosphere. The pump is constructed so that a seal of water has to be maintained between the rotor and the chamber in which it is operated, so that the captured material is held in place momentarily. The water comprising the seal passes out with the discharge to some extent and, consequently, has to be continuously renewed. At a flow of 2 liters a minute, a quantity of about 3 cubic meters per day will be discharged. This water is not polluted to a significant extent.

The oil, now odor and color free, passes out from the bottom of the deodorizer to storage tanks. It is shipped to other plants for bottling and marketing.

The condensing water used in the deodorizing operation is pumped to a cooling tower and directed upon media in the tower. A strong draft of air is pulled over the water as it cascades over the wetted surfaces. Evaporation cools the water to approximately air temperature. The materials which are volatilized from the oil in the deodorizer are chiefly fatty acids and these are condensed with the steam. Some droplets of oil may also be present as carryover in the steam. These organics are largely insoluble in water and will accumulate in the recirculated condensing water. They appear as emulsions of fine particles in the water giving it a white, milk-like, appearance. Some particles large enough to float to the surface are formed in a more or less crystalline form. This material is referred to in the industry as "clabber".

Some of the congealed matter will build up on the surfaces of the cooling tower. Much will accumulate on the pool of water beneath the cooling tower and in the basin in which it is collected before recirculation. At Monastirenne, it is expected that this material is skimmed manually, and added to the soap stock. This is good for pollution reduction since otherwise it might be discharged as waste. The specific practice employed at Monastirienne was not recorded in the author's notes.

Some discharge is made from the recirculated cooling water system. The soluble and emulsified material builds up to high concentrations in the cooling water, as it is recirculated, and the rate of water discharge from the system determines the concentration of material which will accumulate in the recirculated water. A balance is established between water added and withdrawn from the system. A high concentration can be tolerated and, thus, a low discharge rate of the water is usually practiced. At Monastirienne, this white water is discharged to sewers and trenches which lead to an area on the plant property.

The air stream leaving the water cooling tower will contain some of the more volatile odorous materials removed from the oil in the deodorization process. In addition, the organic material circulating in the cooling water will be degraded by bacteria and the breakdown products may be volatile odorous compounds. The quantity of organics involved is not so much that this emission is considered a serious source of volatile organics in most air sheds in the United States. For the most part, odor is not considered a health problem and is regulated as a local matter by local governments.

The significance of odor will depend primarily on the proximity to the plant of residences and the attitude prevailing in the neighborhood. In industrial neighborhoods, odor is tolerated with little, if any, complaints. In neighborhoods of more expensive housing, there have been cases where the edible oil industry has been forced by the public to control the odors. The industrial district near Monastirienne is a few kilometers from a resort area, so the process and equipment changes necessary to control odor are not considered a priority and are not discussed in this report.

A second source of odorous compounds are odorous gases which are not condensed by the water in the deodorizer condenser. Certain gases which do not condense in the system will be present in the vapor space of the condenser. The predominant gas is innocuous nitrogen which has entered with the water supply but there will also be some other odorous compounds. As stated earlier, noncondensables are removed by a vacuum pump and discharged to atmosphere.

The environmental aspects of the edible oil manufacturing operations at Monastirienne are summarized as follows:

Wastewater from the edible oil refining process are largely discharged via wastewater from the soap plant. This is because the edible oil wastewater streams are pumped to the-soap plant where fatty acids are recovered. Edible oil wastewaters include:

- degumming wastewater from water washing of the oil for removal of lecithin and other nonoil constituents;

- soap stock from caustic extraction; and

- soapy water from rinsing the oil.

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Two other wastewater sources at the oil plant are:

- the wastewater stream that is discharged from the condensing water recirculation system; and

- the vacuum pump seal water from the deodorizer process.

No analytical or flow data are available on these separate wastewater streams, but data on the total plant wastewaters are presented later.

Air emissions include:

- the exhaust air from the cooling tower; and

- the noncondensables from the deodorizer condenser.

The solid waste material is the spent bleaching earth.

2. Soap Plant

a. Materials

Olive Oil from extraction at Monastirienne
Sodium hydroxide (caustic)
Sodium chloride
Soap stock and soapy water from Monastirenne

edible oil plant

b. Equipment

Reactor tanks, four, 15 cubic meters each
Soap blending machine
Vacuum soap drier
Soap extruder
Bar cutting machine
Bar soap drier
Packing line conveyor

c. Products and Production Rate
Laundry soap bars - 3000 metric tons/year

d. Employees

Total plant (edible oil and soap units) - 150 employees

e. Process Description; Wastewater and Emission Sources

The main source of material for soap making is a special olive oil referred to at Monastirienne as "fatty oil" which is extracted from seeds in a process described in a subsequent section. The other source of material from oil is the streams of fatty-acid-bearing water from the edible oil refining process.

Fatty oil is pumped from the extraction plant to one of four reactors, called ketties, in the soap plant. A solution of caustic is next pumped into the reactor. Steam is added continuously to the tank through ports in a coil at the bottom of the kettle. The live steam heats the contents and keeps them mixed. The soap making process at this plant is a batch process.

Under these conditions, the oil molecules are broken into their components of fatty acids and glycerine. This reaction is called hydrolysis or oil-splitting and consists of separating the three-carbon backbone of the triglyceride (oil molecule) from the three fatty acids attached to it. This results in the production of a glycerine molecule and three fatty acids. The fatty acids react with the sodium ions from the caustic to produce fatty acid soaps. Under these conditions, the soaps have limited solubility in the dilute caustic.

The oil splitting reaction is promoted by high temperatures so the batch is heated. The reaction takes time, so the kettles are kept heated and mixed for several hours. A quantity of sodium chloride, salt, is also added to the reactor. Sodium chloride helps to prevent the formation of emulsions of oil or fatty acid in the dilute caustic. The salt also increases the concentration of sodium ions so that the formation of sodium soaps is enhanced and the residual of unreacted caustic is reduced. The solubility of the soaps in the dilute caustic is also reduced by the addition of salt.

In addition to the fatty oil, other raw materials for soap making are contained in the aqueous streams of material extracted in the edible oil plant. These include the soapy stock, soapy water and the degumming streams. The major component in these streams is fatty acid which has split off naturally during storing and shipment of the oil. These fatty acids are converted to soap in the kettles.

After a period of heating and agitation, steam addition is halted and the reactor is allowed to stand quiescent for several hours. The contents of the reactor separate into an upper layer of soap and a lower layer of water which contains the remaining caustic and chlorides. Sufficient caustic is used so that a high concentration remains after the reaction. The caustic solution is pumped from the bottom of the kettle into another kettle.

Traces of caustic will remain in the soap layer. Such traces are undesirable in the soap product as they would make the soap harsh on the skin. The remnants of caustic are reduced by spraying the surface of the soap layer with water. This water is allowed to settle through the soap layer and accumulates on the bottom. The caustic dissolves in the water droplets and settles to the lower layer. This water is drawn to the sewer. The washing may be repeated as much as three times. Sodium chloride may be added to this wash water to improve washing effectiveness.

The caustic solution, first withdrawn to a second kettle, is reacted with fresh raw oil in the second kettle. Here the caustic solution settles from the oil and is discharged to the sewer. This wastewater is referred to as "nigre" in the trade. The contents of organic and mineral matter in nigre is typically very high. Organic impurities amount to as much as one or two percent of the raw oil. The glycerine produced in the oil splitting is one of the main constituents of the nigre. The mineral content is largely sodium chloride. There may also be a significant percent of fatty acids and oil in nigre.

In typical operations at other plants, the settled material from the kettle soap process usually contained three layers; a top layer of soap, a caustic layer on the bottom, and a third layer at the interface of the soap and caustic. The third layer was composed of soap and oil emulsions in water. Engineers at Monastirienne have not experienced the creation of a significant emulsion layer in the kettles. This is an unusual benefit for the control of wastewaters.

At US plants, the emulsion layer was significant enough that it was accumulated in a separate kettle and then sulfuric acid was added to break the emulsion and free the oil and fatty acids. A very acidic waste was thus created in the bottom layer. Another mode of operation to minimize the volume of emulsion, was to keep the emulsion in the reactors, batch after batch, until ultimately the emulsion was broken or the accumulation was so great that it had to be withdrawn and treated separately. At Monastirienne, the bottom layer after two uses is discharged as wastewater.

The soap kettles are covered and a large vent is provided which projects through the roof of the building. A certain amount of vapor will be produced while the kettle is being heated and stirred. If the temperature used is near boiling, large volumes of vapors will pass out of the vent. At Monastirenne, it is understood that the temperature of the kettles should be maintained at much less than boiling and, thus, the vapors are not great in volume.

The washed soap is pumped from the kettles to a drier. The purpose of the drier is to remove water traces from the soap so that it will form a harder soap bar when cooled. The soap is made into streams creating a large surface area in the body of the drier and a vacuum is created in the drying chamber. This causes the water to vaporize rapidly. The vacuum is created by a steam ejector and vacuum pump. The steam from the ejector is discharged to a condensing chamber where it meets a water spray sufficient to condense all the steam. The water is recirculated to a cooling tower. The vapors entering this water are negligible. At Monastirienne, the condensing water spray is supplied from the one recirculation system. This system is also used for the deodorizer of the edible oil plant and the wastewater created, as described in that section.

The drier vacuum-producing system has a vacuum pump for evacuating the noncondensables from the system and for contributing to create the vacuum. The vacuum pump is the same type as that used in the deodorizer of the edible oil plant (described previously). The flow of the seal water, which discharges to waste, was estimated at 3 liters per minute or 4 cubic meters per day. This water would not be polluted to any significant extent.

The soap from the drier passes to a machine which works the heavy paste to an amorphous rather than a crystalline, state. The machine extrudes the paste as a stream of square cross-section onto a conveyor. The conveyor moves the ribbon onto a table where the ribbon is

mechanically cut into squares. The bars are moved through a hooded section through which a stream of air is drawn by a blower. This dries the cake surfaces so that they do not adhere. The air is vented into the building.

In summary, the following are sources of discharge from the soap plant:

The wastewater sources are:

- the bottom layer of water separated in the soap and discharged to waste, called nigre;
- the condensing water associated with soap drying (the cooling tower system is shared with the edible oil plant deodorizer and, thus, the condensing water discharge is listed with the oil refining plant); and
- seal water from the vacuum pump.

The air emissions are:

- the vapors vented from the soap kettles; and
- the air from the bar soap driers.

The author saw no solid waste discharge at this plant.

3. Fatty Oil Plant

a. Materials

Olive seeds which have been ground and pressed for oil removal at other plants
Hexane
Steam
Water

b. Equipment

Extraction columns
Pumps
Boiler
Cooling tower for recirculated water

c. Products and Production Rates

2000 metric tons per year of fatty oil

d. Employees

Total plant (edible oil and soap units) - 150 employees

e. Process Description; Wastewater and Emission Sources

At Monastirienne, fatty oils are recovered from olive seeds that have previously been ground and mechanically extracted at other locations. The seed particles contain a significant amount of oil. The ground seeds are shipped in bulk to the Monastirienne plant and the residual oil is separated from the seeds by solvent extraction. The process is described in detail in the following paragraphs. The oil is the principal raw material supply for soap making at this plant.

The reason for referring to the oil as fatty oil instead of olive oil is that it has a high content of fatty acids. During the exposure between mechanical pressing and oil extraction, the conditions are such that a considerable amount of the oil in the seed particles will be oxidized and/or will be hydrolyzed by the action of bacteria so that the oil is separated into its components of glycerine and fatty acids. The recovered material is an olive oil which is unusually high in fatty acid content, hence the name fatty oil.

The seed particles are conveyed to one of several extraction vessels which are cylindrical columns. The extractors are connected to a manifold of pipes such that the extracting liquid, hexane, can be pumped through the series of contactors with any one of the contactors capable of receiving fresh extractant.

The entering fresh hexane can be pumped into any one extractor. The system is operated such that an extractor which has been under extraction the longest can be taken off line and the fresh hexane entrance can be moved to the next in the series. Thus, in effect the hexane is caused to flow opposite the movement of the seeds even though the seeds are not moved. The contactor which has been most thoroughly extracted is isolated from the system after the hexane in this contactor is pumped from the bed of seeds onto the next extractor.

Residual hexane is stripped from the seeds by the passage of steam through the bed to volatilize the hexane. The hexane-laden steam is directed into a spray of condensing water. The steam and hexane are condensed and flow with the condensing water to a separation tank. In the separation tank, the flow is quiescent so that the hexane, which has a low water solubility, will separate out by gravity as a layer on top of the water. The upper layer flows by gravity automatically, as it accumulates, to the hexane supply system. The water passes from the bottom over an overflow point to a sump from which it is pumped to a cooling tower. In the cooling tower, the flow is distributed over media which provide a high-surface area for evaporation. A large volume of air is pulled through the media by a fan which discharges to the air space. The evaporation of the water cools it to near ambient

temperatures. The waste is then pumped to the spray condensers again in a continuous recycle.

Notes by the author on the plant indicate that there is only one cooling tower at Monastirienne for all the condensing and cooling water needs of the three plants. The contribution of the extraction and hexane recovery processes to the cooling water is expected to be negligible. Hexane is slightly soluble in water, but is expected to volatilize from the water in the cooling tower. It is assumed, therefore, that the cooling tower wastewater, described in the section on oil refining, does not incur a significant increase in pollutant quantity resulting from the condensing operations of the above extraction and hexane recovery process.

Extracted olive seeds are dumped from the reactor as a batch. Engineers state that the hexane content of the extracted seeds is negligible. The material is piled in the yard and shipped to market as a fuel. The oil and hexane solution from the extraction column is pumped to a hexane recovery unit. The recovery unit is a vertical tube evaporator in which the liquid flows down the walls of tubes which are surrounded by steam. The steam is contained in a cylindrical tank surrounding the tubes, referred to as a steam chest. The volatiles from the oil and the hexane vapors flow upward to a duct system which conveys them to a surface (indirect) condenser. The water supply for the indirect condenser is pumped from a cooling water recirculating system through the tubes of the condenser. The cooling water is the same as that used for direct condensing and other cooling in the plant.

The condensed hexane is pumped to the hexane supply system. The oil is pumped from the bottom of the evaporator to a storage tank in the soap making department.

In summary, the sources of environmental significance from the fatty oil plant are:

The wastewater sources are related to the cooling water recirculation system. The wastewater from this system is listed in the wastewater summary of the edible oil plant.

The air emissions are:

- exhaust air from the condensing water cooling tower which would be expected to contain any hexane dissolved in the condensate from the stripping steam

- any hexane residual that is present in the extracted and stripped seeds which volatilizes in storage before shipment for fuel use.

The author saw no solid waste discharge at this plant.

B. Wastewater Sources Other Than Process Wastewaters

1. Laboratory Wastewaters

The laboratory where the quality of raw materials and products are checked and process control tests are made will generate a small amount of wastewater. This wastewater originates from the washing of glassware and sample bottles, spent chemical solutions from certain analytical procedures, solvents used in analytical separations, samples of product and raw materials, and cooling and condensing water for such laboratory equipment. The following recommendations are good practices for minimal discharge of pollutants:

1) placing of spent solvents in a separate container for disposal as waste material rather than discharge to the sewer;

2) no use of mercury containing compounds in the analyses;

3) thorough cleanup of any spilled mercury such as from broken thermometers; and

4) no disposal in the sinks of reagents containing toxic materials or toxic organics.

2. Rainfall Runoff and Spill Protection

Environmental concerns of stormwater runoff are (1) that stormwater is not allowed to be discharged to a process sewer or sanitary sewer, and (2) that there is the possibility that stormwater would be significantly polluted from materials lost on the surfaces of the plant particularly if there were a major spill of materials such as a tank overflow.

There appears to be no potential of discharge of stormwater to an inappropriate sewer. The plant has little impervious area (paving) with the exception of the roofs and no stormwater conveyance system is evident, such as pipes or channels. The stormwater apparently drains toward the lower elevation end of the plant to the west and north. Much of the rainfall would be expected to percolate into the ground on the plant site.

Secondary containment for stored liquids are not provided for storage tanks or unloading areas. A casual inspection indicates any spilled material would spread on the plant grounds and be subject to flowing off as the stormwater does. Materials which would be classified as hazardous and would require spill protection under US regulations are hexane, sodium hydroxide, and fuel oil.

3. Sanitary Wastewaters

The toilets and showers of the plants are conveyed to a public sewer in the street in front of the plant. It is understood that no process wastewaters are allowed to be discharged into this sewer system. The daily volume of sanitary wastewaters is estimated to be about 3.2 cubic meters per day.

4. Housekeeping Wastes

A limited amount of finished operating floors and packing area floors exist in this plant. Housekeeping wastes are apparently negligible.

5. Water Treatment Wastewaters

The water used to generate steam in the boiler is treated to remove scale-forming minerals before such use. The scale forming minerals are chiefly calcium and magnesium. These elements are captured on ion exchange material in the physical form of grains. The bed of ion exchange material is contained in a tank and the water is passed through it. The ion exchange material gives up sodium ions as it takes up the calcium and magnesium ions. The sodium ions do not contribute to scale formation.

The exchange capacity of the ion exchange material is limited so that it becomes ineffective after capturing a certain quantity of calcium, etc. It has to be regenerated periodically. Usually this is done on a daily basis. In regeneration, the tank is filled with sodium chloride brine. The brine is recirculated for a period. The brine is then drained to the wastewater

system. Water is passed through the system to flush out the brine and this flushing water is also drained to the wastewater system. The tank is then placed back in service.

The volume of regeneration wastewater and rinse water is estimated at 2 cubic meters per day. The wastewater will contain high concentrations of the minerals involved (i.e. sodium, calcium and magnesium) to which a high concentration of chloride ions are associated.

C. Existing Wastewater System

The plant has a very limited amount of pipes or trenches for process wastewaters. What there is carries the wastewaters to the rear of the property where the wastewaters appear to spread on the low lying areas. During the visit, I did not gain a good understanding of the ultimate disposal of the wastewaters. Evidently they evaporate, infiltrate the ground or possibly are carried away with stormwater when rain causes the low area to overflow to natural drainage channels. At least, there appeared to be no discharge to a public or private sewer away from the property. There are no treatment facilities.

Monastirienne engineers were highly interested in wastewater treatment alternatives. Their objective is to comply with the limits of the public sewer system. Many of these limits cannot be met, economically, by any technology. The rationale of discharging the wastewaters (with characteristics compatible for transport and treatment) with other residential and commercial community wastewaters in a community system, was stressed when responding to requests for information on treatment. Economically, this is the only

feasible method in my opinion. A more complete discussion of this alternative is found in Conclusions and Recommendations.

Monastirienne management has had the process wastewaters of the plant analyzed by a local commercial laboratory. It was understood that the samples were composites taken over an operating day for one day per week for several weeks.

The volume of the wastewaters has not been measured. The best estimate appears to be based on the estimate of the volume of water purchased from the utility less that which is evaporated and used for sanitary purposes. The volume evaporated is, at least, equal to that supplied to the boiler and will be more since the cooling tower has to evaporate all of this plus the equivalent of other heat additions to the cooling water.

The estimated volumes are:

Water supplied per day 66 to 83 cubic meters

Water evaporated per day 18 cubic meters

Sanitary wastewaters per day 3 cubic meters

Estimated wastewaters per day 45 to 62 cubic meters

These estimates were about twice the volume that the engineers had previously estimated. The figure is about 33 percent higher than the sum of the individual estimates of wastewater volumes from the individual operations. The discharge from the cooling tower is the source

that cannot be estimated with any confidence. This flow could account for much of the discrepancy. A better estimate will have to await further work in this area.

The characteristics of the process wastewaters, as reported in the sampling and analytical program above, are tabulated below:

Process Wastewater Characteristics

Sample	pH	NaOH g/l	MES (suspended solids) mg/l	NaCl g/l	BOD (Biochemical Oxygen Demand)
Sous lessive		14	30	2000	
1 lavage	14	15	1500	55	30,000
2 lavage	14	10	800	32	15,000
3 lavage	14	6	600	25	10,000

C. Air Emission Control Practiced

The air emissions in terms of particulate matter, carbon monoxide and reduced sulfur compounds or nitrogen compounds from this plant are of no significance in terms of possible violations of ambient air quality standards. There just is not enough of them and no situation of stagnant air.

Possibly there will be some loss of the hexane solvent used: hexane from the extracted and stripped seed piles and from the cooling tower where the water that contacts hexane is

cooled. The quantity could easily be checked by totaling the purchases of hexane over a prolonged period.

The personnel did not express concerns about odor that might be objectionable to the neighborhood. The immediate area is of an industrial and commercial character and the residential and hotel developments are a kilometer or so away. Thus, there is presently no odor problem.

The plant has not put in place measures for air emission or odor reduction and such measures are not called for at the present time.

IV. CONCLUSIONS AND RECOMMENDATIONS

The following recommendations are made to Monastirienne and discussed more fully in the section on Findings or in the subsequent pages:

1. To minimize pollutant discharge in laboratory wastewaters, institute these practices if not already followed:

   - place solvents in a separate container for disposal as waste material;
   - do not use mercury containing compounds in the analyses;
   - clean up thoroughly any spilled mercury such as from broken thermometers;
   - do not dispose into sinks reagents containing toxic metals or toxic organics.

2. Investigate the possibilities for recovering lecithin and glycerine, materials that are currently discharged in the wastewaters.

3. Replace the present method for disposing of Monastirienne's wastewaters with one which eliminates the unsightliness and hazards associated with having a caustic pond in the plant vicinity.

4. For pretreatment of Monastirienne's wastewater, consider the possibilities for neutralization and biological treatment.

5. Consider land treatment as a possible method for wastewater treatment if it is assured that no impact results on groundwater used for drinking.

6. Institute a formal safety program to include:

   - labels on tanks containing hazardous materials;
   - exhibition of safety data sheets on the tanks or in the immediate area;
   - records of employee training including dates and types;
   - elimination of any overhead piping of hazardous materials where possible; and

- provision of secondary spill containment for storage tanks and unloading areas for hazardous materials.

7. Install, in areas where caustic is handled, special eye wash stations to reduce the risk of eye damage caused by exposure to caustic.

8. Assure that established boiler safety practices are followed.

9. Promote the use of a more economic joint treatment system where industry wastewaters would be treated at a community facility serving residential and commercial customers, as well.

A. In-process Measures to Reduce Wastewater Flow or Pollutant Quantities

The major possibilities of in-process wastewater reduction are in the recovery of materials currently discharged in the wastewaters. The two materials are glycerine and lecithin. Glycerine is a product that is common in commerce throughout the world. Almost all soap or fatty acid plants in the United States recover glycerine. Monasterienne managers stated that there was a plant recovering glycerine some 16 kilometers from their plant. There are apparently a dozen or more soap plants in Tunisia that do not recovery glycerine. Lecithin, on the other hand, although marketed in large amounts is not recovered by a large number of US plants. However, there should be a market in North Africa and Europe for lecithin where oil supplies are not as large and a surplus of lecithin not likely.

The recovery of lecithin from the water extraction of oil is standard technology that is described in reference books on oil refining. Describing the technology is not appropriate to this assessment. Probably, the Tunisia oil refining industry could approach the recovery of this material best by contacting companies in the United States which are recovering lecithin.

A joint or cooperative effort could possibly be developed. It is suggested that this matter be pursued by contacting the following organizations:

Mr. Roger Sisram, Technical Director
Lucas Meyer, Inc.
765 East Pythian Avenue
Decatur, Illinois, USA 62526

Mr. Robert M. Reeves, President
Institute of Shortening and Edible Oils, Inc.
1750 New York Avenue, N.W.
Washington, D.C., USA 20006

The Lucas Meyer firm is solely in the business of lecithin recovery and purification. The trade association likely could direct Monastirienne to oil refiners who recovery lecithin.

The recovery of glycerine is accomplished by distillation of the glycerine from the water in which it is found. The separation is generally accomplished in the United States by a two-stage process. The glycerine-containing-stream is fed to a distillation column and the overhead vapors are condensed. The distillation is done under low pressure. The first distillation achieves a glycerine condensate with a water content of about 80 percent. A second distillation yields glycerine with a low water content. The glycerine is generally contacted with an adsorptive agent such as granular activated carbon before marketing. Medicinal grade glycerine commands a good price.

Glycerine distillation is described in the texts on the industry such as Bailey's. Probably there are no kettle soap plants in the United States, such as this plant, using the nigre (wastewater) for glycerine recovery. However, it was done in earlier years. When glycerine

is recovered, the waste picture changes markedly as the bulk of the organics are either recovered or produced as a water free still bottom. The latter is handled in the manner of waste material not a wastewater.

The best help to the Tunisian industry in glycerine recovery could probably be obtained from a company recovering glycerine in the United States. The best contact should be the trade association:

Mr. Richard I. Sedlak, Jr., Technical Director
The Soap and Detergent Association
475 Park Avenue South
New York, New York, USA 10016

A central operation serving several plants for refined glycerine production might be the best system. The nigre would be shipped to the central location for distillation. An alternative would be for the crude distillation product to be shipped to the central location for final distillation.

The glycerine and lecithin are estimated to constitute between 25 and 50 percent of the organics in Monastirienne wastewaters.

B. Pretreatment

The engineers at this plant were extremely interested in treatment methods and facilities that could be used by them to meet the concentration limits for discharge to the public system. One pretreatment process that was discussed was neutralization, that is the lowering of the pH of the wastewater to near neutral. The pH is very high because of the presence of a

large amount of sodium hydroxide. A discussion of neutralization of an alkaline waste is included in Appendix D of this report. Neutralization would be a requirement of any system for these wastewaters.

The pretreatment process that could possibly accomplish a major reduction in the concentration of organics in these strong wastewaters would be biological treatment. The effectiveness of such treatment is best described in terms of percent of pollutant removal rather than removal to a certain level. To reach the BOD concentration normally found in domestic sewage would be difficult. In biological treatment, effluent concentration is, to a certain extent, related to the concentration in the untreated wastewaters.

The biological treatment system that would be best for these wastewaters would be a newer system called sequential batch reactors, an aerobic biological treatment system. This system accommodates great irregularity in wastewater production: slug loads can be tolerated because the wastewaters are handled in batches. In total, four systems of biological treatment were outlined to engineers while at the plant. These included the batch reactor system mentioned above, aerated stabilization basin treatment, standard activated sludge treatment, and anaerobic treatment. An estimate of the size of the basins and equipment for each of these was reviewed with the plant engineer.

C. Groundwater Quality Protection

The geographical features of the city of Monastir and the Monastirienne plant probably make

the consideration of groundwater quality in the city and specifically in the vicinity of the plant of less importance than in other situations. The peninsula that constitutes most of Monastir appears to be a limestone or sandstone ridge. The plant sits a few hundred yards from a steep rock bluff forming the Mediterranean shore. The underground formations are likely limestone with a few permeable beds and fissured limestone spaces.

Ordinarily, groundwater pollution is a major concern when a plant's wastewaters are discharged on the ground near the plant. In the case of the Monastirienne plant site, though, I doubt that there is much harvestable groundwater. Any groundwater that may be present is likely to be brackish due to the close vicinity of the sea. It is also likely to be located in fissures and channels in the rock.

The wastewaters of Monastir which permeate the ground likely reach these channels and underground rock and move to the ocean. The high pH could possibly persist through the soil and become a hazard in a small part of the beach. Water at the pH reported for the weekly samples, will harm the skin. Blisters can form with a minimum of contact and skin can be severely damaged with long exposure. The high pH, caused by the caustic in the wastewaters, makes it unlikely that bacterial degradation takes place to any extent in the shallow basin or in the soil. In time, carbon dioxide in the air could neutralize some or much of the caustic.

The impact of the plant's wastewater on sea water quality may be minimal. The mineral content of the wastes will not be significant compared to normal sea water variations. The ocean's bacteria would soon degrade the organics and, likely, the oxygen resources would be ample since the oxygen level is kept high due to the wave action along the beach.

Although groundwater degradation may not have significance, certainly the unplanned wastewater bog in the plant's vicinity is aesthetically objectionable. The caustic nature of these wastewaters would prevent any growth of bacteria or other organism in the pond. Likely, this pond constitutes a hazard as any one wandering on the property and stepping in the water could sustain severe skin or eye damage from the caustic. So regardless of groundwater considerations, this disposal method should be replaced.

D. Land treatment

Land treatment refers to a wastewater treatment method consisting of spraying the wastewaters on the surface of a permeable soil and allowing the bacteria which develop in the soil to degrade the organics as the water passes through the water table. Wastewater should be applied at rate that accounts for the soil's permeability. The amount of organics applied per day must also be limited to what the organisms developing in the soil can handle.

Land treatment under many circumstances is the most economic biological treatment method. Vegetable processors, fruit canneries, and orange juice extraction and concentration plants

made wide use of the method in the United States. The availability and use of land near a plant is a big factor in choosing this method; although one juice processor pumps the process wastewaters 10 miles to a site of cheap land and another pumps food wastewaters four and a half miles through a 16-inch pipe to a spray field.

The area required for land treatment is not easily estimated but, for Monastirienne wastewaters, probably a few hectares would be sufficient. The groundwater situation must be appropriate. If the groundwater is used for a drinking water, the method would not be recommended. Likewise, land treatment would not be recommended if the high mineral content of the wastewater was a problem. If the groundwater in the area merely passed through the soil to the sea, there would be no problem.

E. Safety Considerations

Occupational safety is not the author's expertise.

There is one material being handled and stored at Monastirienne that warrants safety considerations for worker protection, namely sodium hydroxide (caustic). Plant management is aware of the hazards in the use of caustic however, the tanks in which caustic is stored or used did not contain any warning signs nor were the usual emergency eye rinse fountain or body spray noticed in the areas.

A more formal safety program is recommended to include:

- labels on tanks containing the hazardous materials;
- exhibition of safety data sheets on the tanks or in the immediate area;
- records of employee training provided, dates and type;
- elimination of any overhead piping of these materials where possible; and
- provision of secondary spill containment for storage tanks and unloading areas for these materials.

Some of these measures are aimed at reducing the risk of eye damage caused by caustic. For this reason, standard practice wherever industrial quantities are used, is to provide work areas with special eye wash fountains. These are constructed so that they can be actuated with a foot and the person can position his face between two sprays of water, one into each eye position. Also for incidents of body contact, an emergency spray is provided so that a person can run to it, pull a chain, and receive a drenching quantity of water.

The material, hexane, used for seed extraction is highly explosive and so presents a marked risk of fire or explosion. Monastirenne is aware of this hazard. My notes do not mention any air space monitors for detecting any leaks or losses.

Boiler safety is an ancient practice. One boiler for steam generation is operated at this plant. Mechanical engineers who deal with boiler design and maintenance generally have knowledge of the safety measures. The art has progressed to the extent that these are test book matters. Safety valves for over-pressures, temperature controls and fuel explosion protection are some of the requirements. Inspection of steam pipes in the boiler, etc. for impending fractures is a

periodic safety measure typically taken. No attempt was made to review the practices at the Monastirenne plant regarding boiler safety. It suffices to call attention to the need as Tunisian engineers are undoubtedly expert in this area.

F. Treatment of Monastirienne Wastewaters with Community Wastewaters

The present direction of water pollution control in Tunisia does not provide the best chance for economic growth and promises only limited environmental improvement over other less costly and less disruptive programs. The author feels that the strongest contribution possible to Tunisia's effort, is to call attention to the fact that requiring pretreatment of wastewaters for the removal of pollutants that can be satisfactorily handled in a community system, is ineffective for both environmental control and cost saving. An approach which has predominantly been found to be of maximum societal benefit, is to provide wastewater services for all members of the community: residential, commercial, and industrial in a single system. Of course, the community systems would accept only industrial wastewater with constituents and characteristics compatible with transport and treatment in their systems.

The present regulations for industries in Tunisia do not permit this approach, since they put strict limits on pollutants which can be adequately treated by the same processes that are used for residential wastewaters. For toxic pollutants, on the other hand, the limitations in present Tunisian regulations are commensurate with the treatment of combined wastewaters of the community and much like those imposed by agencies accepting all compatible constituents. The effort to serve all customers is called joint treatment--indicating all users join in the

effort. Industrial users properly consider the joint facilities as an extension of the manufacturing facilities and can be involved in the effective and economic operation to a degree, not dissimilar, to their concern in making a quality product.

Joint treatment is practiced by most all local agencies in the United States. Each wastewater agency has appropriate sewer use regulations. The local regulations incorporate requirements imposed by the United States Environmental Protection Agency. Such regulations do not require the reduction in concentrations of compatible pollutants by pretreatment.

In the edible oil and soap industry, manufacturing products for household use, the industrial wastewaters contain the same materials as household wastes. Therefore, the materials are necessarily compatible with the treatment of residential wastewaters in community facilities.

The quantity of pollutants in industrial wastewaters generally is a small percent of the quantity normally found in the total community wastewaters. The concentration discharged from any one source is not significant, in itself, but only as it contributes to the concentration at the treatment plant in conjunction with the other wastewaters. The total mass of materials from all users determines the concentration at the treatment plant. Thus, the contribution of a small volume of concentrated wastewaters will make an incremental addition of little consequence of the compatible materials.

In joint treatment, permits are issued to each industrial user where the total quantity of each important material is registered. Thus, the treatment capacity provisions which must be included for each industry are known. To control facility use on a concentration basis would not make sense in many cases. An industry may have high concentrations in its wastewaters but this is not necessarily a bad or undesirable fact, in itself. The important practice of conserving water, for example, will increase the concentration of constituents in an industry's wastewaters.

An approach which requires industry to install and operate costly and unrewarding pretreatment facilities, will require extensive policing of industry. The pretreatment equipment may be installed and demonstrated but not operated regularly When pretreatment is very difficult and costly, industry may choose to haul the wastewaters to a place of disposal. To save costs, the hauler may dump materials illegally.

The cost of treatment by individual plants will be much higher than costs of treatment in a community system. The costs of a community system can be shared equitably among the users. The industry must provide its system with a means for measuring its wastewater volume and enough monitoring must be done to confirm wastewater concentrations so that a fair charge for using the community system can be made. The local agency would be expected to participate in checks on wastewater volume and strength. All costs of serving and policing industrial users would be borne by industry via service charges. The residential users need bear none of the industry generated costs. In fact, because the treatment plant for

all the community members will be larger than one for the residential class alone, the scale factor will result in lower costs for all users including residential.

V. APPENDICES

APPENDIX A

Itinerary for Gerald N McDermott

June 29, 30 and July 1: Conferred and observed Société Anonyme Monastirienne

APPENDIX B

Persons and Organizations Visited

Société Anonyme Monastirienne

Hellara Amor, Directeur Général Adjoint

Felhi Mongi, Genieur Genie Alimentaire

Rahim Chokri, Ingénieur

APPENDIX C

Business Cards of Persons Contacted

SAM SOCIETE ANONYME MONASTIRIENNE

HELLARA AMOR
Directeur Général Adjoint

SAVONNERIE & RAFFINERIE

Route du Port
B.P. N° 6 - 5018 MONASTIR

☎ : 03 - 61 379
03 - 60 657
FAX : 03 - 63 989

SOCIÉTÉ ANONYME MONASTIRIENNE
Extraction d'Huile de Grignons Savon l'Ancre
et la Louve Raffinerie des Huiles

SAM

FELHI MONGI
INGENIEUR GENIE ALIMENTAIRE

ROUTE DU PORT B P N° 6
MONASTIR - TUNISIE

FAX 63989 ☎ 0361.379
0368657

SOCIÉTÉ ANONYME MONASTIRIENNE
Extraction d'Huile de Grignons Savon l'Ancre
et la Louve Raffinerie des Huiles

SAM

RAHIM CHOKRI

ROUTE DU PORT B P N° 6
MONASTIR - TUNISIE

FAX : 03 63989 ☎ 0361.379
0368657

APPENDIX D

Neutralization

The wastewaters according to the analysis previously reported are highly alkaline, pH 14. This is due to the use of caustic. The wastewaters would never be expected to be acidic as the use of acids is minimal. Therefore, the neutralization process need only be designed to lower the pH from some value near 14 to the neutral range, below 9 or possibly 8 according to the sewer use regulations. The pH has to be lowered for biological treatment or other treatments to function.

A number of acids could be used such as the mineral acids, sulfuric or hydrochloric, to neutralize the caustic. However, the use of another compound, namely carbon dioxide, has many advantages over use of a mineral acid.

The following are disadvantages of using mineral acids:

1) Mineral acids would pose an environmental and safety hazard. If mineral acids are used, the following precautions should be made:

   secondary containment for tanks and equipment should be provided; and

   emergency wash stations for employees should be available.

2) Control of the dosage is critical. An excess of acid can corrode equipment and destroy concrete sewers and structures.

3) Control of the dosage must be made automatic unless batch neutralization is adopted. Dosage control is maintained by pH sensing equipment and automatic control of acid pumps or feeders. This equipment requires a lot of maintenance.

4) The cost of using mineral acids is significant.

On the other hand, the use of carbon dioxide gas has unique advantages and availability.

1) The dosage does not have to be carefully controlled. Dosage management must only assure that an excess is provided. It is virtually impossible to use too much. At atmospheric pressures, it is virtually impossible to get enough carbon dioxide to dissolve to produce a pH as low as 6.5.

2) Carbon dioxide gas is inexpensive. It can usually be purchased in pressurized cylinders from local suppliers. It is nontoxic and nonhazardous. In fact, for neutralization purposes, the gases from combustion such as from the stack of a boiler or the like can be used. These gases contain as much as 14 percent carbon dioxide.

3) The use of carbon dioxide avoids any further mineralization of the water as opposed to the high concentration of sulphate ions added were sulfuric acid to be used for neutralization.

The use of carbon dioxide does have some disadvantages:

1) It must be distributed in the wastewater and conditions must be provided so that the gas dissolves and reacts with the caustic. This requires a large basin so that the residence time is sufficient and there is space for a large number of gas diffusers.

2) If flue gases are used, there will be some stripping of volatile and odorous compounds from the wastewaters into the off gases. If serious, the off gases would have to be passed through an absorption tower.

The neutralization takes place due to the properties of carbon dioxide to dissolve in water and to form carbonic acid:

$$CO_2 + H_20 \text{ ---> } H_2CO_3$$

Carbonic acid will ionize to produce hydrogen ions:

$$H_2CO_3 \text{ ---> } H+ + HCO_3-$$

$$HCO_3 \text{ ---> } H+ + CO_3 =$$

When the pH is near neutral, the concentration of carbon dioxide will increase. The carbon dioxide will dissolve in the water until saturation and any excess will pass to the atmosphere.

Carbon dioxide manufacturers usually provide information and design assistance to companies installing a neutralization system. No instrumentation is usually necessary beyond that required to monitor the pH of the effluent.

APPENDIX E

Excerpts from *Bailey's Industrial Oil and Fat Products*, Section on Wastewater Control and Treatment Methods, Gravity Settling. Edited by Daniel Swern, John Wiley and Sons.

Gravity Settling. The art and science of design of sedimentation and flotation facilities is found largely in engineering disciplines involving municipal wastewater and water supply treatment. A technical principle for design of sedimentation and flotation tanks has been in existence for decades. Chemical engineers have utilized sedimentation processes for liquid streams in chemical processes. The volume of such process material streams compared to water and wastewater treatment streams makes for great differences in sophistication of design. In chemical processing, many systems of feeding the inflow to a tank and taking out an effluent with settleable matter removed have been employed satisfactorily. However, more thought to scientific principles should be helpful in large flow rate situations.

The objectives of a gravity sedimentation or flotation facility is obviously to achieve a slow, smooth, tranquil, and uniform passage of the liquid stream horizontally from the inlet end to the effluent end. To achieve this ideally, the inflow would have to be distributed evenly over a cross section of the tank at the inlet and collected evenly across a cross section of the tank at the outlet. During the period when the water is moving through the tank, the oil particles that rise at sufficient velocity and are near enough the surface to reach it will be removed. Thus it appears that a shallow tank would be advantageous because an oil particle in a shallower tank would, on the average, have less distance to rise to the surface than in a deeper tank. On the other hand, for the same surface area, the deeper the tank, the longer the water would reside in the tank and hence the time available for a particle to reach the surface would be longer. A mathematical analysis shows that the theoretical removal should be independent of depth and be proportional to the surface area divided by the inflow rate. This criterion used in design is referred to as the *surface overflow rate* and is usually expressed as gallons per day per square foot. This parameter can also be expressed as a rise rate or settling rate such as feet per day. This parameter conforms to the theory that removal should be independent of depth. A shallow tank will thus have economic advantage. However, there is the obvious limit of keeping the velocity compatible with nonturbulent flow and low enough not to drag floating oil back into the current. Also depth is needed for oil accumulations at the surface and sludge on the bottom.

The concept of separation of an oil particle in a gravity-settling system may be applied to a test program to determine the time necessary for the oil particles to rise to the water surface. In the absence of reasons for expecting otherwise, the oil particles dispersed in water should be distributed uniformly from large particles that reach the surface rapidly,

down to very small particles that are subject to other actions and will not rise at appreciable rates. Theoretically, assuming a uniform distribution of particle sizes by weight and that the particles remain discrete, the removal per unit of time would be maximum at first and would drop off with time such that the removal per unit of time would soon be low. A removal time plot would theoretically be a curve of parabolic form. In laboratory tests, such removal phenomena data often fail to follow the theoretical curve closely. Tests to obtain such data are called column settling tests. The test is performed by first placing fresh oil-bearing wastewater samples in a column of about the depth to be used in the full scale settling system. Samples are collected from ports at several points in the column at selected intervals of time. The samples are analyzed for oil and a plot made of oil concentration versus time. From such a plot, a designer can theoretically choose a residence time for a wastewater flow in a settling tank that will achieve removal of the preponderance of floatable oil or some chosen portion so as to achieve all removal possible that it is cost-effective to remove.

As previously mentioned, work experience with wastewaters from edible-oil refining and soapmaking have generally not followed the theoretical prediction. The data typically show a rapid initial removal and very little additional removal after 15–30 min. A number of factors could contribute to the accuracy of the sampling and measurement as to make it difficult to predict plant performance accurately. These wastewaters are typically hot and inevitably there will arise strong convection currents in the test column. These will flow vertically down at the walls and up in the center and keep oil in suspension that otherwise might gravitate to the surface. Measures can be taken to avoid such convection currents, but in a practical sense they are unavoidable.

The employment of such a column test has been advocated for wastewater and water treatment plant design for several decades. In practice, useful data similar to the theoretical are seldom obtained. The test is more an exercise in the training of technicians and engineers than one of design utility. Thus use of such a sophisticated test to design a flotation system is not considered a worthwhile activity. To satisfy a logical need for evidence that a sedimentation system will remove a significant amount of floatable oil a simple bench top test using a beaker or graduated cylinder suffices. Accurate prediction of how much oil will be removed is difficult because if there is a layer or globs of free oil floating on the surface in the sewer, it is impossible to obtain a representative sample.

Thus in the absence of a technical basis for sizing a gravity settling facility, an alternative is to rely on past practices. An EPA-sponsored

survey of wastewaters of the edible-oil-refining industry reported that the design loads advocated by industry technicians were as follows:

Surface overflow rate	600 gal/(day · ft^2)
Residence time	60 min
Minimum liquid depth	5 ft

Such a system meets in a practical degree an objective of an effective size of facility; a slightly larger facility would cost more than the additional removal would be worth. Nevertheless, some plants employ gravity separation tanks with residence times of 6 or 12 hours. The incremental additional removal accomplished by the larger facilities are relatively small; therefore, costs per unit are high.

The details of the design of oil separation facilities are theoretically important. However, tests for floatable oil remaining in the effluents of a variety of odd and incongruous designs seldom have revealed a significant concentration of oil escaping. This is attributed to the fact that a liberal theoretical residence time was present in the systems tested. With liberal residence time involved, poor performance has been rare.

Ideal design achieves distribution of the flow coming in, which is typically in a pipe of 12-in diameter or less, evenly over a cross section of a tank typically 50 ft^2 or more. (Here the discussion involves a rectangular sedimentation tank; circular tanks are discussed subsequently.) Traditionally in large settling tanks of municipal sewage systems a number of ports or slots and a baffle ahead of the ports or slots is the practice for distributing the inflow. Such an adoption to a small tank may consist of a small baffle immediately in front of the inlet pipe. With floating oil in the system, it is important that the inlet pipe does not enter below the water surface because oil will accumulate in the pipe upstream wherever the free surface is and may congeal in the sewer and plug it. Also, the pipe should not come in above the water surface because the plunging water plume will cause currents in the tank.

Complex devices to achieve the distribution have been used. A circular baffle with a curved surface just ahead of the inlet directing the inlet velocity back against the wall is on the market. The American Petroleum Institute recommends a design of vertical slots spaced across the tank width. This design is difficult to adopt to the smaller tanks for the smaller flows of the edible-oil refinery and other industries involved. The most definitive work on inlet devices was reported by Mau (1). His laboratory investigations showed that to achieve even distribution across a tank section, the slots in a distribution device must be sufficiently narrow to

cause a significant difference in the water surface level upstream and downstream of the slots. However, with such design he found that the velocity of water through the slots was such that the jets extended well into the downstream tank and caused undesirable mixing.

This jet problem was overcome by placing target baffles a few inches downstream of the slots. Also, with the use of the target baffles a lesser velocity in the slots did not sacrifice much in the distribution pattern. Larger openings corresponding to lower velocities are better because of lessened potential for plugging.

Designers have also used a distribution device consisting of a wall across the entire tank, just downstream of the entrance, in which many small holes, say, 1-in diameter, are spaced. Slots are much easier to clean in place than holes. The placing of target baffles opposite each hole such as with the slots discussed previously would be possible but would entail an expensive design.

At the downstream end of the tank there is a need to collect the flow uniformly over the cross section. The usual arrangement is a baffle extending below the water surface to hold the oil layer and following this, an overflow weir. Flow is under the baffle and up over the weir. This flow pattern leaves opportunity for some stagnant areas of the tank. Mau (1) found these in his observations and suggested the use of a wall with slots spaced in it to achieve the full cross-sectional distribution at the outlet as is achieved at the inlet. This eliminates the need of an underflow baffle and overflow weir if a submerged pipe outlet is used. Theoretically, such a design would enable a smaller tank to do the job.

Circular sedimentation tanks are the most popular form for sewage treatment because they are more economical to construct. The most common flow pattern is from a distribution chamber, located in the center, radially to an overflow weir around the periphery of the tank. Floating scum is captured behind a baffle slightly interior of the weir. Many designs of circular tanks with different flow patterns exist, including peripheral feed and central weir, peripheral feed at low depth with a peripheral weir also, and spiral flow from wall to center. The technical considerations are basically the same as described for a rectangular tank. Some circular tanks are in use in the industries involved in this discussion. Commercial units of circular form and of rectangular form are available.

An important adjunct to the system is a means of removing the oil layer accumulating on the surface. The most sophisticated system is a continuous mechanical collector. For a rectangular tank, such a commercial device uses shallow moving collecting baffles extending a couple of inches or so below the water surface. These are mounted on endless chains and are moved slowly along the tank. At the end of the tank the baffle enters

a wide trough with the floor sloping upward and ending a few inches above the high water surface. The oil trapped in this trough behind a collecting baffle is pushed up the trough as the baffle moves through it and the oil falls into a sump. This system operates satisfactorily in some applications. If the oil is very thin (nonviscous), there is difficulty in the seal between the moving baffle and the trough. These devices are also expensive, in the order of $25,000 installed. Such a device for a circular tank consists of a moving baffle at the end of a rotating arm pivoted at the center. The collecting baffle extends from the peripheral baffle inward just a few feet.

An alternative to the continuous mechanical skimmer is a stationary collector. The more sophisticated form is a cylinder about 12 in. in diameter and positioned across the water surface and mounted at the ends in slip bearings. The pipe has a slot cut in it lengthwise. The pipe is equipped with a means of rotating it so that the slot may be positioned at any elevation desired. The slot is left at the top normally. When it is desired to skim oil, the pipe is turned until the slot is below the oil surface. The oil flows into the pipe and to a sump at the end. This device enables taking a thin layer the full length of the slot so that the trap can be skimmed quickly.

The simplest skimmer is a pipe system with swing connections. It may be fitted with a funnel inlet. The end of the pipe is raised or lowered by a hand-cranked ratcheted axle and cable or chain.

Within the last 10 years skimming devices have come on the market that make use of the property of some plastic surfaces for having an affinity for oil in preference to water. A belt or a hose of such material is drawn through the oil layer on the basin. The adhering oil is wiped off at a point above and flows to collectors. One advantage is that the oil removed is relatively free of water. Some such devices have experienced plugging problems from pieces of plastic trash floating in the water. The device is not operable when not kept at temperatures that prevent congealing. Stationary baffles in tanks and use of multiple tanks in series add to the skimming work because of the need to skim at several points.

The collection of the oil is not possible unless it remains fluid. In severe climates the oil will congeal on the surface. This may happen only following plant shutdowns as on weekends. Discharge of live steam directly in the tank to liquefy the congealed material will disturb the flow and cause loss of oil. To overcome this, a system of heating pipes placed just below the surface can be used. Steam or hot water in the pipes will keep the oil liquid. The convection currents from such practices are limited because the high-temperature material tends to stay where it is created,

that is, on top. Heating has also been practiced by providing a cover for the tank and admitting steam to the air space.

The accumulations at the surface in a gravity flotation tank will commonly consist of an oil layer or an oil-and-fatty-acid layer and a second layer of water-in-oil emulsion—typically about 10–30% oil. The emulsion layer may be skimmed with the oil or the emulsion layer may be left for a suitable time to break the emulsion and release the oil.

Usually some water is drawn with the oil or oil-and-emulsion skimmings. The mix of skimmings is pumped to an accumulation tank, where the emulsions are broken by the use of heat. The operation and decanting steps may be automatic or by hand. The pumping of the skimmings must be with pumps that do not create emulsions.

In gravity flotation system design and operation, thought has to be given to any problems from settleable matter accumulating in the tank. A representative plant has a minimum of such materials in the wastewaters. Such matter is usually limited to a little decolorizing clay and perhaps some bean fragments in the raw oil. Of course, the settling tank can be equipped with mechanical devices for continuous or frequent removal of the contaminant. In plants of the industries involved here this is rarely needed. The material that settles out is suitable for transport and treatment in municipal systems. Thus contaminated material can be drawn from the tank to the downstream sewer periodically if the quantity involved does not cause a slug load at the municipal plant. If the economics favor disposal in the manner of a solid waste, this may be the method of choice. Of importance is that the sludge not be allowed to accumulate to such extent that it occupies so much of the volume of the tank as to cause poor efficiency of the system in removing oil. There is a human tendency to allow a layer of oil, emulsion and sludge to accumulate so that the system is not as effective as it could be.

The effectiveness of gravity-settling systems is significantly improved in typical cases if the wastewaters are highly acidified. A pH of about 2 is most effective. The acid conditions break emulsions and also convert fatty acid soaps to free fatty acids that are insoluble and will float. Such acid conditions can be maintained in some plants if wastes from the acidulation process are continuously discharged to the sewers without neutralization. The acid has to be neutralized, of course, downstream from the settling tank before discharge.

This leads to a caution about materials of construction of gravity-settling tanks and sewers leading to them. Typically, the wastewaters of the plants involved contain sufficient concentrations of fatty acids that they cause disintegration of common concrete in time. Disintegration of the concrete

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is not corrosion because of acidity, but a property of fatty acids. Therefore, unprotected concrete tanks, concrete sewers, and manholes are not recommended. This is particularly true if the acidic conditions recommended in the previous paragraph are utilized. Tanks of stainless steel and of reinforced fiberglass have been employed. Also, concrete tanks have been provided with troweled-on liners.

Logic would indicate that pumping wastewaters to such a settling system can lower removal effectiveness by emulsifying oil as a result of the shearing action of the pump. For this reason, construction of the tank in the ground so that flow to it is by gravity is recommended. If economics dictate pumping, pumps can be selected with low peripheral speeds so as to minimize emulsification.

In some circumstances there may be an advantage in improved flotation effectiveness if continuous or frequent removal of the oil as it accumulates is practiced. If there are periodic losses of highly alkaline wastes or wastes containing emulsifiers, an accumulated oil layer can be emulsified and pass out in the effluent. In the absence of such events, the accumulation of a depth of oil and its automatic collection by an overflow set at a selected elevation are possible.

Before leaving the subject of gravity flotation, it is of interest to mention European design of such systems. European practice and even recent European literature describes practices in which three circular tanks are used in series. Inlets are baffled and outlets are from below the surface via elbows or tees. Such a design would be similar to a rectangular basin which was compartmentalized by baffles. Such baffles add to dead (unused) space in the tank and, hence, are not recommended.

Treatment with Community Wastewaters. At least 90% of the industrial establishments that process animal or vegetable oil discharge their wastewaters to public sewers for treatment with residential sewage and other industrial wastewaters of the community. This practice has economic advantages for wastewaters compatible with such joint treatment. The lower costs per unit capacity of larger treatment works is shared among residential, commercial, and industrial users. For many urban industries, this means of treatment is the only practical way because of limited space for industry to take care of its wastewaters itself. Unfortunately, municipalities have traditionally placed limitations on concentrations of oil in wastewaters that are accepted in the public sewers. At one time most municipalities had a limitation of 100 mg/liter of total oil in the wastewaters. Many of these ordinances had provisions for variances so that industries with high concentrations of dispersed animal–vegetable oil were able to continue to discharge their wastewaters with concentrations of dispersed oil of 500 mg/liter or more. Some municipalities have

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formal variance provisions, but few actually enforce the limit on a case-by-case basis when they realize it does not serve a useful purpose. At present, only a few communities are known to enforce a 100-mg/liter limitation on wastewaters from animal–vegetable oil processors.

With ever-increasing interest in environmental control and with stepped-up emphasis of the EPA on pretreatment, renewed and rigorous defense of this practical way of treatment of dispersed animal–vegetable oil is required on the part of industry. This is best done by determining the reality of problems alleged to occur from higher concentrations of oil, examining the reasons for these problems, and, finally, comparing the economics of removing the oil before discharge.

The problems encountered in community wastewater systems in transporting and treating oil-bearing wastewaters, although rather numerous, have solutions that allow continuation of this practice. With a modest degree of control, the evidence is that treatment of *certain kinds* of oil in the physical form referred to as the *dispersed* state, and at the concentrations encountered in normal industrial practice, is a practical and advantageous means of water pollution control.

One of the problems in municipal systems is caused by the congealing of animal–vegetable oil in the sewers and the subsequent obstruction of sewers and control mechanisms. This problem is largely avoided if oil, which is of a droplet size sufficient to float to the surface in the sewers and pump stations, is removed at the plant before discharge. The removal of free-floating oil by gravity settling is rather easy and has previously been described in this section. Municipal system managers have reported that obstructions in small sewers serving restaurants and foodservice establishments have been a problem. These have been largely solved by traps or settling tanks in the drains for removing free-floating oil.

One major municipality has reported the most frequent sewer blockages occur in small sewers serving apartment buildings equipped with garbage grinders. The blockages are composed of fibrous material, garbage pieces, and congealed fat. It is not surprising that congealed oil or fat is found. Residential wastewaters contain appreciable amounts of oil and fat. In fact, the normal 30–50 mg/liter in strictly domestic sewage makes up to 15% or more of all the organic matter present. Furthermore, these household wastewaters receive no pretreatment, so part of this oil is in floatable form. Gravity settling of domestic sewage will remove appreciable oil; about 30–40% is a representative figure.

There can be problems with the handling of oil-containing skimmings from the treatment of the sewage as it will congeal and coat surfaces. Pipes can become completely plugged. Even pumps can plug and systems can be ruptured by the pressures such obstructions cause. But satisfactory

systems for removal and transport of such skimmings are a necessity for a good design. Any design that does not make this possible is faulty and should be laid to inadequate knowledge of sewage because all household sewage has oil and grease. Designers have learned to use larger pipe sizes, to use pipe with very smooth surfaces, to avoid elbows of short radius, to provide steam or other methods of heating the lines, to include cleanout plugs at appropriate locations, and to provide adequate access to cleanout locations. Thus systems have been created that work without intolerable problems.

In about half the municipal plants in the country the skimmings (with their content of oil) and other residues (sludges) are processed by anaerobic digestion. In this process the sludge is held in large tanks for prolonged periods, 15–30 days or more. Anaerobic bacteria convert some organic matter in the skimmings to methane. The remaining residue is less offensive and more easily disposed of. Prior to about 1950, these digesters were not heated nor were the contents mixed or stirred regularly to a significant extent. Consequently, oil entering the digester would rise to the surface and accumulate there. Layers of congealed oil and other floating material would solidify to depths of several feet. Periodically the digester would have to be emptied and this material laboriously removed. The scum layers were real problems, and cleaning was a disagreeable task.

In designs of the last 30 years or so digesters have been provided with means for keeping them mixed and heated to speed up the process. The scum-layer-forming tendency in such digesters is much reduced and is manageable. Coincident with this practice came the knowledge that some of the oil when kept fairly dispersed was converted to methane in the digester. Triglycerides and fatty acids, if kept dispersed in the digester, are degraded to methane by bacterial action. In fact, these materials are converted at a greater rate and to a greater extent than are other classes of organics, such as carbohydrates. In dispersed form these materials are valuable sources of methane. Petroleum oils (hydrocarbons), on the other hand, are not degraded in the anaerobic digesters. The undegraded liquid oil remains in the liquid separated from the stabilized solid matter. At the plant where this liquid material is recycled to the incoming sewage, the oil is recycled through the system over and over again.

Another supposed problem with oil in sewage treatment plants concerned the fate of the oil that passed through the initial settling process and was present, therefore, in dispersed form in the main wastewater flow going to subsequent treatment processes. The subsequent treatment process is, practically speaking, almost always biological. Fundamentally, biological treatment consists of maintaining a great mass of bacteria in

a system and bringing the wastewaters into close contact with the bacteria. The bacteria oxidize and thus degrade organic matter in the sewage. The masses of bacteria are subsequently separated from the wastewater, and the treated wastewaters flow on to the river or other water course. The most common system maintains the bacteria in a suspended particle state with the particles large enough to be separated by settling from the treated wastewater. This is known as the *activated sludge process*. In other forms of biological treatment the bacteria are maintained attached to the surface of some media such as small rock. One such system is referred to as a *trickling filter*. Early in sewage treatment the belief prevailed that oil was not degraded in these bacteriologic processes. Again this case against oil in wastewaters was brought about through failure to recognize differences in the properties of the different kinds of oil. Evidence slowly built up beginning more than two decades ago that triglycerides and fatty acids of animal and vegetable oils were biodegraded in these processes without any problem. Some evidence was developed that petroleum oil (of the crankcase variety) was not degraded at like rates and that too much would cause agglomerates of oil and bacteria that would not settle from the wastewater. Consequently, these particles would be present in the treated effluent.

Very recently information has been published showing data from 55 publicly owned treatment works (2). Recently the U.S. EPA has made data available on two municipal plants whose treatment effectiveness was evaluated in a research study (3). The data from these 57 plants is on total oil, that is, as measured by the common analytical method for wastewater analysis. The data show that more than 90% of these 57 plants achieved a greater percent removal of oil than their percent removal of biodegradable organic matter as measured by the BOD test. The concentrations of total oil in the wastewaters entering the treatment plants ranged up to an average of over 100 mg/liter. Since domestic sewage typically contains only 30–50 mg/liter of oil, the contribution from industrial wastewaters was much in excess of 100 mg/liter. The average oil content of the effluents was in the range of 3–8 mg/liter for those plants that were in compliance with the national BOD limitations for biological treatment. These effluent concentrations were for total oil; there were no data available on these plants on the kinds of oil present. These removals were obviously achieved without limitations on the concentration of oil in the discharges of industrial users.

Evidently, municipal treatment can be effective in removing some petroleum-type oil even though the degradation rate is slow. This could be accomplished in two ways. The oil could become agglomerated with the clumps of bacteria and be removed as part of the excess bacterial sludge

as it is separated from the system. Or, if the oil were held long enough in the presence of the bacteria, it could be degraded even though the rate would be slower than for other materials. The average period for bacterial clumps to be kept in the system is 5–10 days, sufficient time for even a slowly degraded material to be degraded to an appreciable extent.

Thus it appears that there is no reason to limit concentrations on dispersed animal–vegetable oil on the basis of their not being biodegraded in the system. These materials are degraded at about the same rate and to about the same extent as is the broad spectrum of biodegradable organic compounds found in domestic sewage.

Animal–vegetable oil in municipal effluents can logically be controlled as components of the organics that are measured in the test used for biodegradable organic matter, namely, the BOD test. Animal–vegetable oils in well-treated effluents of biological treatment systems do not exhibit any surface film problems. Animal–vegetable oil is not toxic, does not impair the flavor of fish flesh, does not cause taste and odors in the water, and does not persist long in the natural waters because it is biodegradable at a nominal rate. Therefore, no effluent limitation or water quality criteria for animal–vegetable oil is needed.

Treatment for Direct Discharge. The first step in treatment of wastewaters from this industry is the removal of floatable oil by gravity settling. This process is, of course, applied to wastes that have been minimized by in-plant control as previously discussed. The oil remaining after gravity settling is in a dispersed state or in solution. The removal of the dispersed oil and other biodegradable organics can be accomplished by either of two treatment systems: (*a*) biological treatment or (*b*) chemically enhanced air floatation followed by biological treatment. The choice is an economic one between chemically enhanced air flotation and the additional biological treatment capacity. Practically all the plants in the industry have chosen to use chemically enhanced air flotation followed by biological treatment. Some managers have utilized air flotation because it offered a backup process to gravity settling when a slug or an emulsifying agent loss would cause abnormal passthrough of oil through gravity settlers. Troublesome massive overloads of biological treatment with oil are thus avoided.

The dissolved air flotation process consists of creating minute air bubbles in the wastewater introduced to a settling tank; these air bubbles tend to become attached to surfaces such as the surfaces of oil particles in the wastewater (see Figure 8.1). A few air bubbles on a particle of oil will rapidly buoy it to the surface. The air bubbles seldom become attached in sufficient numbers to smaller oil particles to permit their re-

Professional Resume

GERALD N.
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Principal
Environmental Engineer

Years Experience: 40+

Education:

Massachusetts Institute of Technology, Sanitary Engineer
Harvard University, S.M., Sanitary Engineering
University of Wyoming, B.S., Civil Engineering

Experience:

- Mr. McDermott was a member of the Commissioned Corps of the United States Public Health Service and has assigned his entire public career to the Water Pollution Control Research division in Cincinnati, Ohio. He was instrumental in industrial waste studies that developed guides to water pollution control for several major industrial categories. He participated in several field studies of water quality including the Ohio, the Pearl, the South Platte, the Yellowstone, and other rivers.

  During this work, he was the first to measure and report the quantity and characteristics of municipal landfill drainage; the first to employ bioassays in industrial waste source surveys for identification of toxic streams; and the first to investigate the use of clays for the removal of trace levels of oil and other organics. He supervised an exhaustive investigation of the tolerance level of heavy metals in biological treatment.

  He served as Chief of Process Development, Advanced Waste Treatment Program for the Public Health Service. He supervised field application of activated carbon adsorption, integrated biological chemical treatment, foam separation, reverse osmosis, algae harvesting, powdered activated carbon treatment of wastewaters, and supervised research on use of the Total Organic Carbon measurement and the dissolved oxygen monitoring for control of an activated sludge plant.

- During his employment with Procter & Gamble Company, he first served as group leader and then as Wastewater Technology Leader. He provided design and engineering service in the treatment of wastewaters for direct discharge. These facilities included activated sludge treatment, aerated lagoon treatment in the largest such facility in the world, the largest land application system in the citrus industry, reverse osmosis treatment of food oil refining wastewaters, and granular activated carbon treatment of sulfation wastewaters of a chemical plant.

  As a technology leader, his assignment included keeping abreast of all developments in wastewater treatment technology. He did this by studying the current literature, by site visits to new process installations, and attending technical sessions of various organizations.

  He also supervised research conducted by consultants and university researchers for P&G and was acquainted with most of the leaders in such work. He was particularly active in maintaining relationships with the municipalities which received P&G wastewaters and was called upon to help solve technical and financial problems of the plants and agencies.

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Professional Affiliations:

American Academy of Environmental Engineers
Water Pollution Control Federation
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Registrations:

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Additional Accreditations:

Former Task Group Chairman for BOD and Oil Analytical Methods, Standard Methods

Represented P&G in Industrial Associations:

Edible Oil, Soap, and Detergent
Chemical Manufacturers Association
National Food Processors Association
Associated Municipal Sewerage Agencies
Oil Chemists Society