Waste Water Disposal From a Highly Diversified Fat and Fatty Acid Plant[1]

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Abstract

A case history of waste water disposal at the Drew Chemical, Boonton, New Jersey plant is presented together with details of various treatments that have been studied. These include biological, chemical and physical treatment methods. Treatment of concentrated wastes having a soluble biochemical oxygen demand of approximately 10,000 mg/liter is emphasized.

This paper discusses some of the waste water problems that have been encountered at the Boonton, New Jersey plant of the Drew Chemical Corporation.

No pat answers for the treatment of waste waters from a highly diversified fat and fatty acid chemical plant are offered, but we are glad to share what we have found over the years on treatment of concentrated waste waters in the hope that it may be of some value as you evaluate your own problems.

The Boonton plant is the largest and most diversified production facility of Drew Chemical. It operates 24 hr a day and 7 days a week. The principal production activties are the refining of vegetable oils to produce margarine, shortening and specialty fat products and the production of distilled fatty acids, synthetic oils, esters and ethoxylates for industrial use. There are many other organic and inorganic specialties for edible and industrial needs. Examples of these are nickel catalyst, defoamers, corrosion inhibitors, etc. The plant has been expanded regularly in the past and such expansion is expected to continue well into the future.

Waste water disposal has received considerable attention for many years particularly because of the plant's location on the upper Passaic River water shed and its close proximity to the Jersey City water reservoir. The local sewage treatment plant which is operated by Jersey City to protect its own water shed will not accept industrial waste into the system. Therefore, it has been necessary to handle our waste independent of the local treatment plant. Drew has shipped concentrated waste waters by railroad tank car 25 miles for treatment in a large municipal treatment plant. This is not a very economical or flexible approach.

Although there are many criteria for measuring level of contamination, the waste waters described here are best defined by the term biochemical oxygen demand (BOD) to indicate the quantity of dissolved oxygen (mg/liter) required during stabilization of the decomposable organic matter by aerobic biochemical action in sewage effluents, polluted water or industrial wastes. Thus, if there were glycerin present, the oxidation would be glycerin plus oxygen to form CO_2 plus water; 100 parts of glycerine in 1,000,000 parts of water would give 122 mg/liter of BOD.

The principal characteristics of the concentrated wastes as generated in the plant are low pH, a high dissolved organic level, substantial oil content, and a high sulfate content. The organic portion is primarily made up of water soluble materials such as glycerine, alcohols, glycols, surfactants, etc. These wastes originate throughout the plant and are collected in a mixing chamber after which they pass through two sets of three oil traps each where oil is decanted and recovered. The waste flow is then neutralized in air agitated tanks to a pH of 6.5 to 7.5 by the addition of 50° Be sodium hydroxide. These treated wastes make up the material shipped via rail to a sewage treatment plant. A typical analysis is as follows: pH, 7.0; BOD, 10,000 mg/liter; suspended solids, 300 mg/liter; fat content, 100 mg/liter. The volume is approximately 150,000 gal/day. (The BOD content is approximately 40 times higher than conventional sanitary waste.) In order for industrial waste waters to be discharged into local streams they have to be treated to give a 90% BOD reduction and a maximum of 25 mg/liter BOD.

One of the major factors in the overall waste water program has been the conservation and reuse of water so that the total volume of water for disposal can be kept to a minimum. Some of the steps that have been taken are the following:

1. Extensive use of cooling towers combined with separation of clean and dirty waters.
2. Reuse of cooling tower waters by centrifugal separation of insolubles so that the water can be used for rinsing and sequential washing.
3. Return of condensate water and hot heat exchanger water for boiler water makeup.
4. Waters used in processing edible oils were used for acidulation of soapstock.
5. Utilization of a meter program to control excessive use of water; where individual meters prove impractical, effluent metering by simple weirs has proven satisfactory for area control.
6. The closing off of old lines that allowed indiscriminate use.
7. During the winter months fans were turned off on the cooling tower to cut down losses from evaporation; while this is not directly related to minimizing waste it does cut down new water use and saves considerable power.
8. Careful separation of clean and dirty waters to minimize amount of concentrated waste.
9. The amount of storm and surface waters entering the concentrated waste waters was minimized.
10. Clean waters were reused.

Through the above steps and with constant policing of in-plant water regulations, the volume of concentrated waste water has remained constant, the past fifteen years, while the plant water requirements almost doubled.

More can be done in analyzing processes to reduce the use of water. We currently have a major study underway which hopefully will result in improvements. Areas of interest are more efficient product washing and continuous processes.

For the past 20 years biological treatment of the concentrated wastes has been the subject of extensive laboratory scale and pilot plant studies. For example, a combined trickling filter activated sludge pilot plant was operated for a period of two years. Waste water treatment is highly complex and the conclusions reached only relate to waters under specific testing conditions. The following is a summary of the findings on various biological treatment processes.

Biological Treatment Processes of Waste Water

Trickling Filter

This technique was assessed as part of a combined activated sludge aeration digestion followed by a recirculating trickling filter made up of plastic plates set in towers that served as a medium for the growth of the digesting bacteria. In addition, the perforated plates allowed uniform distribution of the circulating water. BOD reductions in excess of 98% were obtained, but required

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high recirculation ratios and dilution rates even after pretreatment by activated sludge. Only a small portion of the total BOD removal occurred in the trickling filters. The bulk of the reduction occurred in the aeration tanks. It was found, however, that once the biota was established it could withstand shock treatment from variations in the feed without materially affecting the final effluent.

Day to day variations that occur in wastes are generally taken care of in pretreatment and aeration tanks that precede trickling filters. The inflow liquid ranges from 5000 to 15,000 in BOD and the chemical composition varies depending on the product mix being produced in the plant. It is essential that toxic materials and excess free oil be kept to a minimum. The varying flow rate is controlled by pumping from the aeration tanks so that the load on the system can be adjusted slowly. Although offering considerable promise this method is not necessarily the most economical way to remove the high level of soluble organics from waste water.

Sand Filter

Slow sand filtration removed less than 25% of the BOD when compared with the trickling filter pilot plant. The soluble BOD remaining after the trickling filters was difficult to screen out. Also, the high land requirement caused us to rule it out as a feasible method of reducing BOD.

Anaerobic Digestion

Laboratory experimentation with Anaerobic Digestion after chemical precipitation produced less efficient BOD removal than those obtained by the activated sludge process. This was probably caused by hydrogen sulfide toxicity. A solution to this toxicity problem could probably be found, but potential odor problems do not justify further work at this time.

Activated Sludge

An activated sludge aerobic digestion pilot plant without the use of trickling filters gave very good results. BOD reductions from 95% to more than 98% were obtained with retention times of 7 to 20 days. As with the trickling filter process the activated sludge system was able to handle variations in the BOD and chemical composition of the starting material.

Physical and Chemical Treatments

In addition to the above biological systems, physical and chemical treatments have been studied. Some observations on these are as follows:

Oxidation

Wet combustion under high temperature and pressure provides a high degree of oxidation of organic material. The process is feasible when the organic concentration is high enough to maintain combustion without added fuel; this generally requires 10% organics. The use of this process was ruled out because our wastes only have an organic concentration of approximately 1%. Catalytic oxidation where the organic materials are oxidized in the presence of a metallic catalyst was also considered. The high sulfate concentration, however, shortens the life of the metallic catalyst. Neither of these oxidation processes offered an economical solution. Concentration of wastes by partial evaporation followed by wet combustion might provide a solution, although the high sulfate content could still offer a problem.

Coagulation

Chemical coagulation reduced the BOD approximately 25%. Unfortunately, the bulk of our material is soluble and coagulation of the major portion was not effected. However, we would expect to use high molecular weight polymeric coagulants as both prime coagulants and coagulant aids in pretreatment facilities and in the activated sludge process to aid in the following ways: improved solids separation at the initial neutralization step to put less of a load on the biological treatment; increased solids content of cake in the sludge removal to reduce solids removal; increased plant production; and reduced maintenance cost of cleaning filter mediums.

Filtration

Ultra filtration or reverse osmosis through the use of microporous filters was studied, but we did not find it feasible for the removal of the soluble low molecular weight organic and inorganic compounds that are present in our waste. A nonionic membrane with a molecular weight cut-off of 1000 reduced the BOD approximately 20% from a starting material based on neutralized waste water having a BOD of approximately 8,000. An anionic membrane with a molecular cut-off of 350 to 500 reduced the BOD 40%, but the rate of flow was cut in half. Prefiltering concentrated waste waters neutralized with lime followed by membrane ultrafiltration improved the BOD reductions an additional 25% while improving the flow rates approximately 30%. These reductions, although interesting, were assessed to be inadequate for our purposes because the effluent would require still further treatment. The use of electrodialysis is similarly not advised, based on a literature survey. Large amounts of organic material not only caused a rapid deterioration of most membranes, but also caused fouling of the membranes and decreased flow rates. High costs of equipment and operation ruled this out for the present. In addition, disposal of concentrated brine remains a problem. These techniques offer considerable promise and might well be an excellent method of treatment at some point in the future.

Evaporation & Extraction

A limited amount of work was undertaken to concentrate the waste by evaporation followed by a series of solvent and physical extractions to remove the individual fractions for reuse or resale. Theoretically, through this technique crude fat, glycerin, sodium sulfate and other by-products could be recovered. It does not seem, at this time, however, that the recovery of these by-products would justify the complexity and cost of such a process when compared to a biological system. Evaporation alone was assessed to be uneconomical. Also, water from evaporation would require condensing in order to minimize odors. In addition, the condensed waters had BODs of approximately 500. This would require additional treatment.

Absorption

Absorption on activated carbon was tried as a possible technique to reduce BOD on both the raw and neutralized concentrate as well as on the effluent from a partial aerobic digestion. With levels of 2–4% carbon a starting BOD of approximately 16,000 was reduced 20–30% with a 2 hr treatment. This was not enough to warrant further consideration. The results with partially digested waste having a BOD of approximately 1500 was reduced to BODs of approximately 150–200 which offered some promise but would not be low enough to enter the waste directly into the local streams. As a tertiary treatment to remove low level contaminants it has considerable promise.

Spray Irrigation

Spray irrigation will work where the decomposed organic matter can be used as a fertilizer and the water used as an irrigant. This would not be suitable in our particular location. The salts present in the waste water would be inimical to plant life. The presence of fatty matter also has a tendency of blinding the soil and killing plant life if it covers the plant with a film.

Deep Well Discharge

High pressure well discharge is being done in areas where it is allowed. Since our plant is close to water shed areas it would not be allowed.

The concentration and chemical characteristics of our waste waters constitute a problem in finding any conventional physical or chemical waste treatment process that could economically provide the required reductions. Based on the above findings, it was concluded that the best method of treating the waste water to produce a low

BOD effluent is a high efficiency activated sludge treatment process.

With this background we then undertook an engineering and economic study to determine the most practical way of using this information.

Four alternates for the disposal of concentrated waste waters have been evaluated, all of them entailing neutralization of the concentrated wastes after removal of the oil. Caustic is presently used for neutralization in order to maintain low suspended solids. The use of bagged slaked lime in conjunction with coagulant aids would be substantially less costly and, in addition, an approximate 25% reduction in BOD would be achieved through coagulation. After neutralization the waste would be clarified in a flocculation settling tank, the sludge de-watered on a vacuum filter, and the cake hauled away by truck. The effluent would be treated by one of four alternates.

Alternate 1 consists of diluting and treating the waste water in an activated sludge plant designed to remove over 95% of the BOD. This process involves aeration tanks where the waste would be aerated in the presence of activated sludge and nutrients. The treated waste would be settled in clarifiers and the activated sludge recycled back to the aeration tanks. The clear effluent would be chlorinated and pumped to the river. The river, however, is approximately 1½ miles away; consequently this would involve considerable pipe line costs.

Alternate 2 would consist of pretreating the waste to a level of 80% to 90% reduction in BOD and after dilution sending it to the local treatment plant. It would have a BOD content comparable to domestic sewage. The Boonton treatment plant operated by Jersey City to protect their watershed is presently operating beyond its capacity and is under court order to improve its capacity. Major expansion would be required to allow this approach.

Alternate 3 would be to discharge concentrated, pretreated, neutralized wastes without any biological treatment to the local treatment facility.

Alternate 4 would be to continue shipping concentrated wastes out by tank car to a distant treatment plant and set up a surface aerated lagoon for treatment of dilute, low level contaminated waters. A variation of this would be to transport the concentrated waste to the shore and send the waste out to sea. Because of the strength, these would have to be sent out over 100 miles making it much more costly than the present method.

The best method for Drew would be Alternate 3 which consists of sending all waters without biological treatment to a local treatment plant. This is best both on the basis of capital cost and annual operating costs. Also, we are not in the sewage treatment business and would prefer to leave it to those skilled in treatment plant operation. In addition, this alternate is compatible with the New Jersey State Health Department objectives which encourage regional sewage treatment plants. However, in order to do this many details remain to be worked out.

We have had to keep in continual contact with all the various town, county and state agencies that have been involved. We have not come up with the final answer, but the most promising is that both the state and the Morris County Municipal Utilities Authority are strongly recommending a regional sewerage system that will take care of the present and future needs of some nine towns in the area. Drew will be pleased to participate in such a scheme and will fully support this proposal. We have to continue exploring the feasibility of having our waters treated, with all the different government agencies. If this cannot be done, we will have to set up our own system, which, as we mentioned previously, would be based on an activated sludge biological system. We have to continue to keep in close contact with new methods of reuse and treatment to minimize the high cost of handling waste water.

Regardless of the answer to our local problem, there is a challenge here for all of our industry; every pound that goes out treated or untreated represents valuable material, either as recoverable raw materials or as reusable water. We can afford to dispose of them now, but the day is going to come when that answer will not be acceptable. Somewhere in the maze of physical treatments such as evaporation, filtration or coagulation there are techniques which alone or in combination would allow the complete reuse of all components to the extent that only modest amounts of water would have to be fed in. Economics and need will determine when this can be done.

In this summarized case history only the highlights of our effort have been noted. Much work has gone into analytical and monitoring techniques. Considerable laboratory development has taken place with the chemical and physical treatments that have been reported. Waste water treatment is complex and has required the attention of many people, both within the company and outside the company, in the form of consultants who are specialists in specific areas of knowledge. Even though we do not have the ideal low cost answer we have come up with solutions to some of our problems and have a good background for the next steps to be taken in handling our highly concentrated waste waters.

Grain Legumes—A Great Resource for the War on Hunger

Grain legumes, among the oldest crop plants, are defined as those leguminous plants, the seeds of which are known to be edible and are used primarily for human consumption. Peas, peanuts, beans and soybeans are members of this class. Remnants of beans, dating back at least 6000 years, have been found in caves in both the Old and New Worlds.

Legumes are rich in protein; they contain two or three times the protein of cereal grains. The protein is generally of good quality except for a deficiency in the sulfur-bearing amino acids methionine and cystine. Legumes are also a reasonably good source of calcium and iron. Peanuts and soybeans, rich in edible oil content, supply significant amounts of the vitamins thiamin and niacin, essential vitamins in which people who consume large amounts of highly milled cereals or corn are frequently deficient.

In addition to their nutritive value, there is another reason to explore the potential of grain legumes as a resource in the War on Hunger. For the most part, grain legumes will grow readily in those areas in need of increased amounts of protein. They fix instead of deplete nitrogen, thus improving the soil.

However, there are several roadblocks to increased cultivation and use of grain legumes. One such roadblock is economic. For example, in the West Indies, crops for cultivation are chosen primarily for their export value.

Another roadblock is cultivation. Although grain legumes are easy to cultivate, other crops may be easier still.

Storage of grain legumes has been another barrier to their use. In Africa, beans have been stored in large cloth sacks which permitted weevil infestation. The weevils subsequently consumed most of the bean nutrients.

Once the problems with cultivation and storage are solved, the problems of consumer use and acceptance must also be solved. Consumer education is most important.

Prospects are good for improved yields of grain legumes which will have a more desirable nutrient composition. Advances in processing are rendering harmless any undesirable components, while improving flavor and increasing adaptability for formulation into major foods.