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Current Pollution Control Practices in the United States

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ABSTRACT

An overview of pollution control practices in the United States is presented here, with particular emphasis on those factors which motivate and direct current practices. A more in-depth discussion is provided of certain areas, particularly those items which might be unique to the USA. More emphasis has been placed on wastewater-related issues. The largest dollar expenditures and technical efforts have probably gone to solving these problems in the oleochemical field. Some example projects are presented to demonstrate the significant points.

OVERVIEW OF FACTORS AFFECTING POLLUTION CONTROL DECISION-MAKING

The keynote of this paper is the need to address environmental problems in the oleochemical industry in the USA from a standpoint which considers all factors. Resolution of one problem without considering its overall implication usually serves only to create another problem.

Implementation of current pollution control practices is significantly affected by a variety of factors. These will generally come under one of four categories: (a) government regulatory control; (b) in-plant control and process modification; (c) available and developing technology for wastewater, or stack emission treatment; and (d) interaction of air, water and solid waste problems.

Although this all seems simple enough, those who work in the field on a routine basis recognize that this is often like an air-inflated balloon bulging on one side—as one pushes in the bulge, another often forms on the other side. Decisions cannot be (and usually are not) made without consideration of all factors as well as the details and cost implication associated with each alternative solution. Often one consideration receives compromise at the expense of another.

For example, a decision as to whether to build a waste-treatment facility at an existing processing plant is usually initially motivated by government direction or regulation. The further decision as to what type of treatment plant should be built is often predicated on what can be done with solid sludges, and what reduction to waste load can be made through process control.

In some very rare instances, one might choose, as an alternative, to close one's plant entirely or, more realistically, to eliminate a certain product line.

GOVERNMENT ENVIRONMENTAL REGULATORY STRUCTURE

Environmental matters are regulated everywhere in the USA on both federal and state levels and often also by local municipal and/or county ordinances.

The Environmental Protection Agency (EPA)—the Federal Agency—is divided into 10 regions throughout the country. The EPA generally issues guidelines and regulations for industrial and municipal environmental enforcement, and overviews similar state programs dealing directly with generators of air, water and solid wastes. In practice, then, industry must deal with regulations issued by both federal and state governments. If a local government is involved, it usually also has its own regulations, particularly with respect to discharge of pretreated industrial wastes to sanitary sewage systems. A much smaller number of municipalities have their own active air pollution control and hazardous waste administrations. Nonhazardous solid wastes are almost universally dealt with on the local level.

This is conducive to confusing and often conflicting sets of regulations concerning a given problem with which industry must deal. Regulations and, more importantly, governmental enforcement postures vary greatly. The confusion is extended further for larger companies in that programs, regulations and enforcement vary significantly from state to state and even one federal EPA region to another, thus causing similar plants to be faced with dissimilar requirements.

The environmental regulatory programs have been in place for ca. 15 years. As a result, some of the state and regional inconsistencies are beginning to dissipate somewhat with time.

One current issue of great concern is toxic and hazardous waste controls as well as location and clean-up of old, inadequate dump sites. Unfortunately, these sites are often associated with chemical processing operations—existing or abandoned. In the minds of some, the job is not as far along as it should be. As a result, the impetus to take corrective measures at many of these sites originates in the form of public protest. This often leads to decisions based on emotion rather than fact.

PROCESS AND IN-PLANT CONTROL OF WASTE GENERATION

In the earlier years of the environmental movement, there was insufficient effort directed towards waste load reduction through in-house control. This was due to a variety of reasons. Quite often industry was faced with short time frame schedules for pollution abatement issued by regulatory agencies. The result was to hurry up and build something for wastewater and air emission treatment. Another factor was that, initially, much of industry simply did not recognize the opportunities to reduce waste load through process control.

This, combined with rising costs of raw materials and energy, has directed virtually all industries, including those in oleochemicals, to look very hard at existing processes and even products in some instances. Conversion of batch processes to continuous (and vice versa, in a few instances) installation of towers for cooling water recycle, condensate collection systems, vessel clean-out containment and reuse, and a wide variety of similar measures have been implemented throughout industry to reduce waste problems.

A particular example that comes to mind is a resin processor who was using a gas phase catalyst in a polymerization reaction. The catalyst costs were high and air emissions from process tank vents were not being met. Under a management process review, it was determined that the gas feed was extremely excessive for the reaction conditions required. With very slight process modifications this company was able to reduce its catalyst raw materials cost by 50%—and bring the process stack vent into acceptable air emission levels without additional emission controls.

The study and application of waste load reduction through process control is becoming widespread throughout the chemical and oleochemical industry. However, it is our observation that there is still much room for improvement. This is particularly true in smaller companies which perhaps have always operated profitably in the past and thus had less incentive to investigate this. Many also may lack expertise or time to devote to the problem.

Within oleochemical processing, significant gains have been made in the areas of recovery and reuse of secondary process or "waste" materials for a variety of fuel and reuse applications. Recovery of vessel and line clean-up for secondary product reuse control recovery and reuse of product and raw material spills and similar steps have been taken to reduce significantly organic loadings in wastewater streams.

In certain large operations, the very magnitude of water supply needs and wastewaters generated have necessitated the significant reuse and recycling of numerous water streams. One of the best examples is the wet corn milling-corn sweetener industry. This field is related to oleochemical processing as a crude supplier through corn oil refining and soapstock acidulation. This industry has become extremely sophisticated in recycling waters and recovering waste byproducts at numerous levels of quality and quantity demand within a given corn processing complex. Potential wastewater problems from in-plant product spillage are so severe that in-plant spill diversion and recovery are commonplace.

TREATMENT TECHNOLOGIES

Water

Wastewater problems have dominated the environmental scene. The current concern with hazardous solid wastes has overshadowed this recently; however, the major costs within the oleochemical field have been and probably will continue to be in wastewater.

The wastes obviously vary greatly from one oleochemical industry to another. The principal parameters of concern are pH, oil and grease (Freon extractables), suspended or filterable solids, and organic constituents expressed as biochemical oxygen demand (BOD), chemical oxygen demand (COD) or total organic carbon (TOC). Certain dischargers are concerned with various other organics such as phenols and halogenated organics. A few such industries have wastes containing heavy metals such as chrome or lead.

An idealized flowsheet for the type of wastewater treatment scheme used is shown in Figure 1. This would relate to most oleochemical operations but would not include those which have heavy metal problems and some generators that have certain trace organics in their wastes. Wastes from oleochemical processing vary substantially from one plant to another in the COD/BOD ratio—a measure of the relative biodegradability of the waste commonly used in the USA. Certainly, therefore, the specific nature of facilities within the general description in Figure 1 vary greatly.

Flotable oils are common to virtually all oleochemical wastes. Large quantities of settleable solids are less common. Some processes deal with oils which are heavier than water. Techniques which have been commonly used to remove oils and solids include simple gravity separators, cyclone separators and chemically assisted dissolved air flotation.

The consideration of other environmental impacts, particularly sludge disposal, is beginning to reshape the approach to techniques which were previously thought to be relatively straightforward solutions. For example, the use of metal salts such as alum or ferric sulfate for coagulation and removal of solids and emulsified oil virtually always results in an unrecoverable sludge. The current tendency is to look for polymers, pH adjustment and similar techniques—often as a modified process in an existing dissolved air flotation cell—to produce a flotable material that can be economically reused for raw material or byproduct value.

A more recent waste process innovation, developed by myself and others, is the use of a low-pH/high-temperature system to remove and recover emulsified oils through a hydrolysis process. If the processing plant is already using acidulation for one purpose or another, the acid and heat have already been purchased indirectly and are present in acidulation wastes. This technique has been used in a variety of unsophisticated forms in the past; however, several full-scale treatment facilities are now in operation which use the process in a more precise, optimized fashion.

A variety of biological treatment methods have been successfully used to treat oleochemical wastes. This is further expanded when one considers the pretreated discharges that are effectively handled in municipal systems. The type and number of biological treatment methods, aeration equipment, etc., have expanded to the point where they are limited virtually only by one's imagination. All are in use in one location or another.

Oleochemical wastes often vary from traditional biological designs in that they are low-volume, high-strength wastes, rather than high-volume, low-strength wastes. Therefore, aeration design is often based on oxygen uptake rather than vessel mixing requirements. Recent developments in biological treatment have centered around ways to increase mixing and oxygen efficiencies and reduce horsepower demands. This has resulted in several new designs of aeration equipment. The use of biotowers (trickling filter) for BOD reduction has also seen a dramatic increase in recent years. These are primarily in response to spiraling energy costs.

One problem common to biological facilities in this application is the maintenance of treatment operations during long nonproduction periods. Control of operational parameters, addition of materials and artificial waste feed sources have been used to control this.

There are very few oleochemical plants employing tertiary treatment in the true sense of the word—treatment beyond extended biological degradation or polishing ponds. Those which do have tertiary treatment employ activated carbon, ozonation, chlorine dioxide or other physical-chemical techniques. This is usually aimed at a specific pollutant such as phenol.

Air

The oleochemical industry in the USA does deal with air emissions, primarily in the form of organic and solvent vapors. Some plants deal with extensive particulate solid emissions, particularly where coal-fired boilers are used.

Abatement technologies have been applied where in-house controls, condensate recycles and similar source reduction techniques cannot resolve the problem. Abatement technologies are in the form of caustic scrubbers, stack precipitators and similar processes. In general, the oleochemical industry has not experienced air problems so severe as to require development of unique processes or solutions.

The one possible exception is the control of odor emissions from barometric recycle towers from deodorizers and similar processes. The use of closed-loop heat exchangers to a clean water cooling tower is becoming widespread to solve this problem.

Solid and Hazardous Wastes

The rapidly increasing governmental control of these items has resulted in a substantial increase of recovery and recycle of a wide variety of waste materials. This is often done through methods or processes which were uneconomical until now.

In terms of handling hazardous waste, massive regulatory programs have recently been put in effect to regulate the generation, storage, treatment and disposal of hazardous wastes. These regulations address every conceivable aspect of the subject and it is too broad to be covered here. Certainly it is safe to say that control and regulation have been greatly increased.

One notable item is ultimate disposal. To obtain approval of an on-site ultimate disposal point has become very difficult—even to the point of being impossible. The number of commercial sites which are open to receive hazardous wastes is limited, and prospects of new approvals are not good, primarily due to local public sentiment at any given potential site. This is creating a major economic/environmental issue which will have to be addressed in the relatively near future.

A particular problem relative to the oleochemical industry is disposal of waste process sludges containing nickel from hydrogenation. Although nickel has not been specifically named by regulation as a toxic material, it is becoming increasingly difficult to dispose of these sludges anywhere except in a landfill approved for hazardous materials.

CASE STUDIES

The theme of this paper is the need to address environmental problems in the US oleochemical industry from a standpoint which considers all factors at each plant location. I have selected a summary of case histories of two plant environmental problems in which I have recently been involved. Both plants are owned by the same company and are in virtually identical processing of oleochemical products; plant A is somewhat larger than plant B. Both originally discharged inadequately pretreated wastes to municipal sanitary sewer systems with no reasonable hope for increases in BOD load allocation. Also, both plants utilize an acidulation process which is a major waste load contributor. Pertinent data for the two plants are given in Table I.

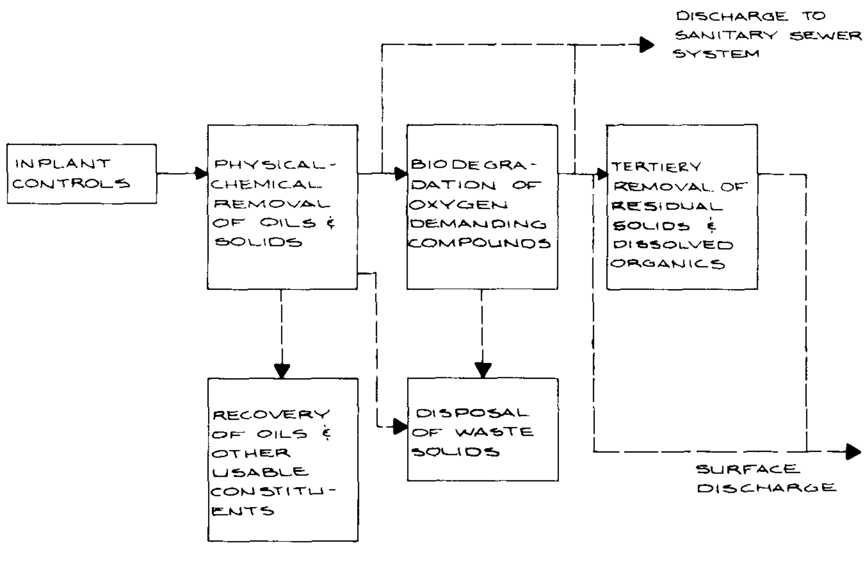

FIG. 1. Basic waste treatment diagram.

TABLE I

Item	Plant A	Plant B
Capacity (lb/day)	1,000,000	600,000
BOD limit (lb/day)	6,000	2,800
Total current load, BOD (lb/day)	10,000	14,000
Waste load from acidulation, BOD (lb/day)	3,500	8,000

An analysis of the situation for each revealed that BOD is the most critical parameter. If BOD could be met, all other parameters would be met coincidentally, except as later noted; therefore, only BOD information is presented.

At plant A, a thorough investigation of the problem was conducted. Certain in-plant steps could be made to reduce waste load somewhat, but generally the loadings were in line with what would be anticipated for this type and size of operation. After some testing, treatability studies and alternative cost investigation, it was decided that a low-pH/high-temperature treatment facility could best be used to accomplish the desired results. The acidulation wastes could be used to create a hydrolysis effect. This would remove a significant quantity of the residual BOD which was largely associated with the insoluble oil and grease content of the waste streams.

The facilities were designed and constructed and are now producing an effluent well within the city's requirements. Moreover, the process allowed recovery of substantial quantities of a salable byproduct. Considering byproduct sales and sewer use charge reduction, the overall project had about a 4-year simple payback on initial capital and continuing operating costs. A simplified flow diagram is shown in Figure 2. The facilities are obtaining the removal of ca. 96% of all nonacidulation (insoluble) organic pollutants contained in the waste stream.

The story at plant B is, unfortunately, less satisfactory. After an analysis of the situation, it was apparent that the waste load was out of line for the size of plant. The problem appeared to be the acidulation process. Under these conditions, the city's limits could not be met without substantial additional treatment in the form of a biological system. But this would cure only the symptom, whereas a solution to the real problem was required.

The acidulation operation was investigated and found to be inadequate in several areas relating to both the physical facility and operations. This was costing the client both product loss and increased sewer use charges. Steps are being taken to rectify this. The total waste situation will then be reevaluated with the hopes that a similar low-pH/high-temperature system can produce the desired results.

In this particular case, a variety of inadequacies were determined regarding the acidulation process. These included inadequate acid feed and soapstock mixing, poor recycling of the middle phase for reprocessing and inadequate control of separated phase draw-off. Operational and physical changes are being implemented to correct these deficiencies.

A final complication at plant B is an unnecessarily restrictive limitation on oil and grease. This is due to the high biodegradability of the oils in question. Meeting the limit now in force would require extensive additional treatment for that purpose only. Plant A originally had such a limit proposal, but the company had the foresight, and was able, to negotiate it out of its final agreement with the city. I hope that this will also happen for plant B.

The problem of unreasonably low pretreatment limits for oil and grease is widespread in the USA. A variety of studies have shown that these types of oils are highly biodegradable and compatible with domestic wastes. We have found it necessary to attack the problem one city at a time.

It should be noted that the plant A waste treatment facilities were not the least expensive from a capital cost standpoint. A conventional dissolved air flotation system could have been employed for ca. 60% of the cost. However, the overall economics and consideration of other environmental impacts made the installation of the facilities ultimately selected a much better choice.

This example is not intended to promulgate this solution for every waste handling problem but to demonstrate how two separate, but virtually identical, plants responded to environmental problems in a total approach manner.

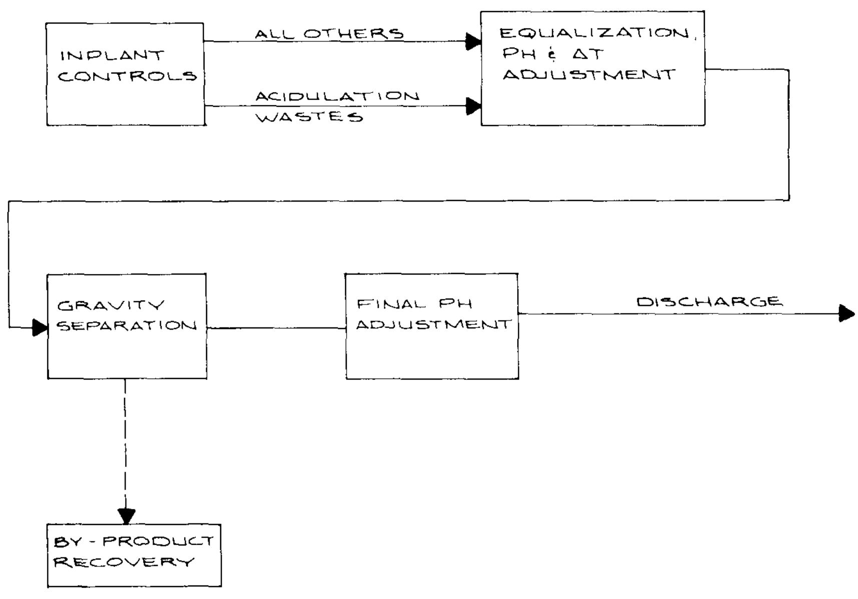

FIG. 2. Low-pH/high-temperature treatment diagram.

FUTURE DIRECTION AND EMERGING TECHNOLOGIES

Research and development is continuing in several areas to create new solutions to old problems–and new solutions to new problems.

In the area of in-plant control, certainly every plant is constantly evaluating new ways better to control loss and resulting environmental problems. The overall desirability of such changes always appears as a moving target. Fluctuating energy and raw materials costs and changing environmental regulations constantly affect these decisions.

In the area of water pollution, anaerobic treatment of organic wastes is gaining in popularity. This has been limited in the number of actual installations; however, its use is now under serious consideration on a variety of industrial wastes, whereas it was never before considered.

There has been an increase in the use of mutagenic bacteria for treating organic wastes in the USA. This will likely expand—and more so in very specialized areas and start-up of existing biological plants after upset conditions. This technology has been its own worst enemy in some respects, as its marketers created an almost carnival sideshow atmosphere regarding its capabilities. This has served to deplete their credibility even in areas where some genuine benefits could be derived.

I believe that the next major breakthrough in waste treatment in the USA will be in the use enzymes. We are actively engaged in basic research and development in this field.

In the field of hazardous and solid waste, a continual tightening of handling and disposal will force industry to extend its work in the recycling and recovery of materials previously defined as wastes.

The big unknown, of course, is the future of environmental regulation and consideration of its benefits relative to other social and economic needs of society. This is anybody's guess.