The fume stream entering the catalytic area must be above the minimum temperature for the oxidation to occur, there must be sufficient catalytic surface area available to permit completion of the reaction and there must be sufficient oxygen available to meet the oxidation demand of the material being converted.

A. R. DUDLEY, Humble Oil & Refining Co., Baytown, described another plant for the recovery of hydrogen sulfide for use in a refinery.

W. E. BURNS, Phillips Chemical Co., Bartlesville, Oklahoma, pointed out that an ammonia manufacturing plant must save all ammonia produced. The present practices at Bartlesville make it possible to recover 450 tons of ammonia each year that have a value of $15,000.

VIRGIL LEHMBERG, Shell Oil Co., Houston, gave in some detail the results of experiments on the losses from storage tanks painted in different colors. It was found that the tank painted a dark color may lose as much as 2.4 times as much material as one that has been painted white.

There were numerous exhibitions of equipment and these attracted the attention of the 350 registrants at the meeting.

Toxicity Considerations in Pollution Control

~~DEFENDANT~~'S EXHIBIT P 70 A

by JACK T. GARRETT

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WHEN A NEW product is to be manufactured it behooves the manufacturing plant to determine the effect, if any, of the waste products on the receiving stream. The determinations should answer the following questions:

1. Will the effluent, as discharged, adversely affect human life?
2. Will the effluent, as discharged, adversely affect aquatic life? In discussing any effect on human life it is assumed that no manufacturing plant would wilfully discharge sufficient quantity of any material to cause the receiving stream to become acutely toxic to human life. The effects referred to here are of a more insidious nature.

What, for example, would be the long term effects on human life of drinking water containing X concentration of a certain compound over a period of many years? The answer to this question is not available in many cases, and is not readily obtainable. The effects of some waste materials are known. Soluble fluoride salts in certain concentrations are known to cause adverse effects on the bony structure and the teeth in humans and animals if ingested in drinking water for extended periods of time. There are a few other such examples but for the vast majority of compounds the long term human effects of minute quantities in drinking water are not known.

Little Data Available

In spite of the fact that precious little data are available on this subject there have been no major catastrophes from the discharge of industrial wastes. Industry, however, cannot take full credit for this record. The major credit should be given to the biological life in the stream itself. Most of the wet process wastes discharged from industry today are in the form of biologically oxidizable organic compounds and the stream biota utilizes this material for food. Even in the case of highly toxic substances such as the organic nitriles, the stream bacteria will degrade these compounds if given time to adjust their enzymatic systems. It is the standard practice today of at least one major chemical company to determine the ultimate fate of any toxic substance in the receiving stream. It would be to the credit of industry in general if more companies followed this practice.

The problem of the possible deleterious effects of industrial wastes in drinking water on humans or animals is not one of recent origin. Public health officials have discussed the problem for years and have conducted limited research in the field. Recent emphasis on pollution problems have highlighted this very complex question. Research is now underway at the Taft Sanitary Engineering Center of the United States Public Health Service (USPHS) on some aspects of the problem. Mr. E. J. Cleary, Executive Director and Chief Engineer of the Ohio River Valley Water Sanitation Commission (ORSANCO) in a paper presented at the 26th (1953) Annual Meeting of the Federation of Sewage and Industrial Wastes Association asked this very cogent question, "What toxic effects to man and animals may result from continued consumption of water contaminated with industrial wastes?"[1] This statement represents a clear challenge to industry.

Chronic Toxicity Data

The situation is not by any means all bad because chronic toxicity data, obtained in long term animal feeding studies, are available on many compounds. These data are sometimes available in the literature, but all too often, they have not been published. They are frequently available from companies that manufacture or market the particular product. This type of information should be obtained when available and used in studying effluent problems.

The most serious toxicity problem

TABLE 1

Toxic Levels of Acrylonitrile and Other Waste Components (7)

...pound	Max. P.P.M. at which no deaths occurred	Min. P.P.M. at which deaths occurred	24 hr. Median Tolerance Limits	Min. P.P.M. Total Deaths
Hydrogen Cyanide	0.050	0.075	0.069	0.100
Lactonitrile	0.100	0.250	0.215	0.500
Acrylonitrile	20.000	30.000	24.500	30.000
1-Cyano-1, 3-Butadiene	50.000	60.000	71.500	70.000
Acetaldehyde	60.000	70.000	70.000	————

facing the manufacturing plant in providing for waste discharges is concerned with the effects on aquatic life. This does not mean that the effects on human life are of no consequence. It simply means that the discharged substances are normally in such low concentrations that no effects on human life would be expected. On the other hand, these concentrations do affect aquatic life because they are being discharged into the medium in which this life exists.

Data are necessary on the effects of pollutants on aquatic life for several reasons, the principal reason being that the appearance of dead fish in the receiving stream has long been considered the ultimate evidence of bad industrial practice. In addition to this ...n, damage to aquatic life is a vio- ... of many state fish and game ...s. A third reason is the offense to the aesthetic senses. The smell of dead fish is one that is seldom tolerated with any degree of appreciation by the public.

Effects of Chemicals

A tremendous amount of data on the effects of chemical materials on aquatic organisms are available in the literature. There are at present some very excellent compendiums of these data. Probably the finest such work published in recent years are the two books published by the State Water Pollution Control Board of California. These are *Water Quality Criteria* published in 1952 and *Water Quality Criteria*—Addendum No. 1 published in 1954. One of the very excellent old references for data of this kind comes from the U. S. Department of Commerce, Bureau of Fisheries Bulletin No. 22, *Detection and Measurement of Stream Pollution*, by M. M. Ellis. This latter volume was published in 1937, however, and much of the material is out of date. There are available through the "Critical Review of Literature" which appears annually in *...vage and Industrial Wastes*, a fine series of literature reviews on this subject. The United States Department of Health, Education, and Welfare, Public Health Service publishes a series of bibliographies on public health subjects. Some of these bibliographies are on the subject of the effects of industrial wastes on aquatic and marine organisms. Two examples of these publications are *Public Health Bibliography No. 10* on "Industrial Wastes Relating to Fish and Oysters" and *No. 13* relating to "Undesirable Effects Upon Aquatic Life by Algicides, Insecticides, Weedicides." In addition to the specific sources indicated here, there are many journal sources such as the industrial waste journals, ichthyological journals, and journals of fishery biology. Many journals published by State or regional AAAS (American Association for the Advancement of Science) groups contain valuable references in this field. If specific information cannot be found in the available literature a query to the Biological Section of the Robert A. Taft Sanitary Engineering Center in Cincinnati, Ohio, may be rewarding because at this laboratory a very fine, bibliographical file on the subject has been developed.

Available Toxicological Information

If after critically examining the literature, the manufacturer finds that data on the material in question are not available, it would be prudent to initiate action to obtain them. There are several ways in which this can be done. The most common method of obtaining toxicological information is to have it performed by either university or private consulting laboratories. If the manufacturer has the equipment and laboratory space he can do the job himself if he desires. If the latter course is followed, the services of a biologist should be obtained to consult on the methods used and the interpretation of the data developed. The cost of this research is small if the goal of the research is to obtain simple toxic levels to be used as guides in waste treatment design. Of course, much more extensive work can be done which would develop a more complete story of the toxic effect on the biological life in the receiving stream. These more academic studies cost more money and take considerably more time. In any case, the work should be done because industry today cannot afford to be wrong.

There are many methods of performing biological tests on suspected pollutants. Industry is generally interested in methods that are both simple and require little time. There are some methods in the literature for these tests.[2,3,4,5] Most tests of this type are based on toxicity of a specific material to fish themselves. There have been many acceptable tests perfected in which other forms of aquatic life have been used. For example, diatomes, microcrustacea, and aquatic insect larvae. Most of these latter tests require the services of a trained biologist and rather extensive equipment and time. Probably the reason why most industrial work is done on fish is because of ease of handling the specimen, relative ease in recording effects, and because of the psychological value in actually using fish. This latter reason should not be overlooked because, to the general public, work of this nature on fish would seem a natural thing, whereas work on smaller aquatic animals would seem highly academic.

Acrylonitrile

It is appropriate to conclude this discussion with a case history. Several years ago Monsanto Chemical Company decided to construct facilities at its Texas City Plant to manufacture acrylonitrile. In studying the effluent problem at this site several significant facts were uncovered. The effluent would outfall into a section of Galveston Bay where fishing and boating were popular. In addition, the particular section of the bay in question was restricted in tidal flush-out by the Texas City dyke, and was commonly called the "Texas City Pocket." It was also discovered by examining the literature that there was no data available on the effects of acrylonitrile, hydrogen cyanide, or any of the known waste components on marine organisms. It was found, however, that some years before the University of Houston had determined the effects of aluminum chloride on marine organisms for the plant.[6]

The problem was discussed with the University of Houston professor who had supervised the work on

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Pinperch as Test Fish

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Aluminum chloride. He stated that the University could not undertake the project and get the results in time to be of use to the plant in establishing goals for abatement research. In the course of the discussions it was suggested that the Director of the Marine laboratory of the Texas State Game and Fish Commission be contacted for his views on the subject. This laboratory, which is operated by the state, is completely equipped and is close to a readily available source of test specimen. After extensive discussions with the Marine Laboratory Director it was decided that the work would be performed by plant personnel at the Marine Laboratory with the advice and assistance of the Laboratory staff. The results of this work which were published in the *Texas Journal of Science*,[7] are shown in Table 1.

The data developed in this study were used as guides in planning the waste treatment facilities that were ultimately constructed at the Texas City Plant. In addition to the above use, these data were, and still are, used to evaluate the effectiveness of the waste treatment. The effluent objective was set at one-tenth of the 24 hours median tolerance limit. This is an extremely restrictive limit but under the circumstances it was felt that no greater limit was justified. The fact that there have never been any difficulties encountered in finding all types of healthy fish and other forms of marine life in and around the plant outfalls, attests to the soundness of this decision.

Some time after the cyanide work was completed it was decided to determine the toxic limits of some chlorinated compounds. This was considered necessary because no such data were available in the literature and small quantities of these compounds were in the effluent streams. The work was again performed at the Marine Laboratory of the Texas Game and Fish Commission with the help and advice of the laboratory's staff.

Pinperch as Test Fish

A year had elapsed between the two projects and during the intervening winter a very serious freeze had occurred along the Gulf Coast of Texas which affected the fish population considerably. The specimen used (Pinperch or *Lagodon rhomeboides*) were not nearly so prevalent. Even those that were trapped for use were not as hardy as were those used in the previous work. For this reason the data are not nearly as significant as those obtained in the cyanide work. This is also the reason that the work has never been published. These data appear in Table 2.

TABLE 2
Toxicity Levels of Some Chlorinated Solvents Tolerance

Compound	Less than ½ deaths	More than ½ deaths
1, 2-dichloroethane	150 ppm	175 ppm
1, 1-dichloroethane	250 ppm	275 ppm
1; 1, 2-trichloroethane	150 ppm	175 ppm
1, 1, 1-trichloroethane	75 ppm	100 ppm

The experiments in which these data were obtained were carried on for a period of 48 hours. It was originally intended that 48 hour median tolerance limits would be calculated. However, due to the difficulties encountered with the specimen these calculations were never made.

Because it was felt that these figures only represented the general range of toxicity, one-tenth of the lesser figure in each case was used as the effluent objective.

There are certain limitations that must be considered in toxicity studies on aquatic or marine fish. One of these limitations is that of possible synergism. The interaction of non-toxic concentrations of many individual compounds may lead to a toxic effect. This, of course, can be determined by testing the effects of the combined waste on appropriate aquatic or marine organisms. However, it is seldom possible to accurately determine beforehand the concentrations of individual waste components.

The other major fault with fish toxicity studies per se is the fact that they do not take into consideration the effect on the predatory cycle at work in the receiving stream. In short, fish toxicity studies do not give any indication of the effects of the compound being tested on the lesser forms of aquatic or marine life. To quote Dr. Charles E. Renn of John Hopkins University on the subject, "Living things are essentially devices for collecting and dissipating energy. When organic wastes are added to water, energy is added, and the bacteria, protozoa, and an ascending predatory hierarchy of animals tie the carbon, hydrogen, and nitrogen and sulfur in the waste to oxygen. It is desired to burn as much carbon to carbon dioxide as possible with as little living residue as possible. This is best done by having one animal prey on another, the predator fed to another, and so on. With each conversion there is a loss of energy as carbon dioxide. If a system is loaded with materials that limit the variety of life that can be supported it is impossible to take advantage of this wasteful chain of predation."[8]

Lack of Comprehensive Data

This entire dissertation points up the lack of comprehensive data on the effects of industrial wastes on living organisms. It also indicates that many scientific disciplines are required to properly evaluate and abate water pollution. The chemical industry has long attempted to handle their waste problems with chemists and engineers alone, perhaps the addition of personnel trained in the life sciences and the medical sciences would make the abatement team more complete.

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