Abstract

With the passage of the Marine Protection, Research, and Sanctuaries Act of 1972, the U.S. Environmental Protection Agency has been given the lead role in the protection of the nation's oceans from the disposal of toxic pollutants. Through the establishment of a permit program, the U.S. EPA's Middle Atlantic Region has brought the indiscriminate disposal of municipal and industrial wastes under control. The goal is to eliminate ocean disposal of harmful waste by January, 1981 through the development of sound, reasonable and environmentally acceptable land based alternatives. Until that goal is attained, an intensive monitoring program has been established to assess the fate and effects of all pollutants dumped into the Region's waters.

INTRODUCTION

About ten percent of the pollutants entering the world's oceans are introduced as a result of someone's collecting wastes, putting them on a barge or ship, and taking them out for disposal at sea. Prior to 1972, there was little governmental control over ocean dumping. Disposal of waste materials at sea began with an application to the District Office of the U.S. Army Corps of Engineers. The application was circulated to other federal agencies and the Corps issued a "letter of no objection." The sole criteria for issuance or denial was whether navigation would be impeded or obstructed.

The revelations of the late 1960's and 1970's concerning dumping of nerve gas and petroleum off the Florida Coast, dumping of enormous quantities of sewage sludge, each day from New York and Philadelphia, and a number of other similar instances, spawned legislation to regulate ocean dumping. Relying heavily on the Council of Environmental Quality's April, 1970 report, Ocean Dumping -- A National Policy, and the Environmental Protection Agency's 1971 report, Ocean Disposal of Barge-Delivered Liquid and Solid Wastes from U.S. Coastal Cities, Congress passed the Marine Protection, Research, and Sanctuaries Act of 1972 which became effective April 23, 1973. The Congress has made the findings that:

...it is the policy of the United States to regulate the dumping of all types of materials into ocean waters and to prevent or strictly limit the dumping into ocean waters of any material which would adversely affect human health, welfare, or amenities, or the marine environment, ecological systems, or economic potentialities.

The Act is divided into three major parts. Of prime importance to ocean dumping is Title I which establishes criteria and regulations to control all future dumping. The Environmental Protection Agency has the prime responsibility for regulation of all dumping except dredged material. The Act, while banning certain materials, allows dumping under EPA permits. In establishing criteria for evaluation of permit applications, the Administrator must consider the need for the proposed dumping, the ecological ramifications of the dumping and the alternatives to ocean disposal available.

The Act was amended twice, once on March 22, 1974, to clarify the interpretation of oil as it relates to the requirements of the Federal Water Pollution Control Act, and again on November 4, 1977, to place a date final for all ocean dumping which does not meet the criteria. That date being December 31, 1981.

Pursuant to the Act, the Administrator of EPA promulgated regulations and criteria for ocean disposal on October 15, 1973 and Final Revised Regulations and Criteria on January 11, 1977. The Administrator further promulgated procedural regulations on November 28, 1977. These regulations and criteria constitute the entire body of rules governing ocean dumping.

The EPA and the Corps of Engineers (for dredged spoils) regulates ocean dumping through the issuance of ocean dumping permits. There are six categories: General, Special, Interim, Research, Emergency, and Ocean Incineration. The Regional Office is responsible for Special and Interim permits which are defined as:
Special Permits - issued for certain materials which satisfy all relevant ocean dumping criteria.

Interim Permits - issued for materials exceeding criteria. No interim permits will be in effect after December 31, 1981 and no interim permits will be issued after April 23, 1978 unless the dumper is on an implementation plan to meet the criteria or phase out dumping by December 31, 1981.

The criteria for determination of acceptability are divided into three parts; prohibited materials; constituents prohibited as other than trace contaminants; and materials which will not endanger or degrade the marine environment.

Prohibited - include biological, chemical, or radiological warfare agents; high-level radioactive wastes; and persistent inert synthetic or natural floating materials.

 Constituents prohibited as other than trace contaminants - organohalogen compounds; mercury; cadmium; oil; and carcinogens, mutagens or teratogens.

Materials permitted for ocean disposal - any materials not containing prohibited constituents or contaminants in no greater than trace concentrations.

REGIONAL ACTIVITIES

At the onset of the ocean disposal program, the EPA Region III administered four disposal sites as shown in Figure I. Site (1) is the old sewage sludge site. This site was authorized by the United States Corps of Engineers in 1961 for the disposal of the City of Philadelphia's sewage sludge. In 1966, the City of Camden began using the same site. The site was closed on May 8, 1973 and both dumpers were moved to Site (2), the new sewage sludge site. Dupont disposed of acid wastes at Site (3) from 1968 to 1977 at which time its dumping was moved off the Continental Shelf. Site (4) was designated as the arsenic site and had been used intermittently for a number of years by various industries but no records were kept until 1966. From 1966 to 1974 this site was used to dispose of caustic and white water oil emulsion from the Sun Oil Company. A summary of the total site usage is shown in Table I.

The Region has attempted to rigorously enforce the mandate set forth by Congress. Table II shows the status of permit activities within the Region. Each application received a critical review to determine if there was a real need to dump, what the potential environmental effects of dumping would be, and, how the effects could be minimized if dumping was necessary. All permits that were issued contained requirements that the dumper develop alternatives as soon as possible.

Presently, there is only one active dumping site in the Region. This site (Number 2) is used by the City of Philadelphia. Except for Dupont and Crompton & Knowles, Inc., which have been moved to the '106' site controlled by Region II, all other dumping which originated within the Region has been phased out. The remaining dumpers are on strict schedules to phase out all dumping by 1981.

MONITORING

To comply with the intent of the Act, that permits be conditioned upon knowledge of effects on the marine environment, Region III initiated an intensive field monitoring program in May, 1973. The objectives of the program were to provide a system for the evaluation, control and regulation of ocean disposal.

The design of the monitoring program was based upon the assumption that the ocean is a

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**TABLE I OCEAN DISPOSAL**

<table>
<thead>
<tr>
<th>Site</th>
<th>Gallons x 10^6</th>
<th>Kilograms x 10^6</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Old sewage sludge site (1961-1973)</td>
<td>960.4</td>
<td>3,746.4</td>
</tr>
<tr>
<td>2. New sewage sludge site (1973-1977)</td>
<td>718.4</td>
<td>2,802.4</td>
</tr>
<tr>
<td>3. Acid Waste Site (1973-1977)</td>
<td>964.5</td>
<td>3,696.8</td>
</tr>
</tbody>
</table>
TABLE II OCEAN DUMPING PERMIT APPLICATIONS

<table>
<thead>
<tr>
<th>State</th>
<th>Applicant</th>
<th>Issued/Denied</th>
<th>Phase Out</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delaware</td>
<td>Dupont-Edgemoor</td>
<td>issued</td>
<td>1980</td>
</tr>
<tr>
<td></td>
<td>Rollins Env. Serv.</td>
<td>issued</td>
<td>1975</td>
</tr>
<tr>
<td></td>
<td>Barcroft Lo.</td>
<td>denied</td>
<td></td>
</tr>
<tr>
<td>District of Columbia</td>
<td>U.S. Army Corps of Engineers</td>
<td>denied</td>
<td></td>
</tr>
<tr>
<td>New Jersey</td>
<td>City of Camden</td>
<td>issued</td>
<td>1978</td>
</tr>
<tr>
<td></td>
<td>New Jersey Zinc</td>
<td>denied</td>
<td></td>
</tr>
<tr>
<td>Ohio</td>
<td>U.S. Air Force</td>
<td>denied</td>
<td></td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>City of Philadelphia</td>
<td>issued</td>
<td>1980</td>
</tr>
<tr>
<td></td>
<td>Sun Oil Company</td>
<td>issued</td>
<td>1975</td>
</tr>
<tr>
<td></td>
<td>Modern Transport - Sewage</td>
<td>issued</td>
<td>1975</td>
</tr>
<tr>
<td></td>
<td>Modern Transport - Industrial</td>
<td>issued</td>
<td>1975</td>
</tr>
<tr>
<td></td>
<td>ABM Disposal Ser.</td>
<td>denied</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Integrity Shipping Company</td>
<td>denied</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Whitmoyer Laboratories</td>
<td>denied</td>
<td></td>
</tr>
<tr>
<td></td>
<td>McAdoo &amp; Allen, Inc.</td>
<td>denied</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Crompton &amp; Knowles, Inc.</td>
<td>issued</td>
<td>1979</td>
</tr>
<tr>
<td>Virginia</td>
<td>Hampton Roads Sanitation District</td>
<td>denied</td>
<td></td>
</tr>
<tr>
<td>West Virginia</td>
<td>Dupont-Belle</td>
<td>issued</td>
<td>1976</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>Ansul Co.</td>
<td>denied</td>
<td></td>
</tr>
</tbody>
</table>

dynamic medium and that any material injected into it will be acted upon by physical, chemical and biological processes. The interaction of the processes has been described by Ketchum quite well. Our program is split into two distinct tasks. The first is to assess the immediate effects of the pollutants upon impact into the ocean. The second is to determine the ultimate fate and effects on the marine environment.

Prime objectives of the short-term study were to determine safe discharge rates (F.R. 198 pt. II, 1977) and to determine how the pollutants behaved. These objectives were accomplished by determining the initial dilution factors, the dispersion with time, and the toxicity on the organisms as the pollutants were diluted.

The prime objectives of the long-term study were: first, to determine an environmental baseline from which the effects of the dumping can be compared; second, to determine the ultimate fate of pollutants and the pathways by which pollutants are distributed; third, to assess the impact of these pollutants on the marine biota; and last, to predict the potential for impact before irreversible effects occur.

To determine the dilution and dispersion of the wastes, plume tracking experiments have been conducted on the acid wastes and the sewage sludge being dumped. For sewage sludge a good correlation exists between total suspended matter and extinction coefficient. Transmissiometer profiles with separate CSTD's and hydrocasts for heavy metals and bacterial content were made in the barge wake during special surveys in 1975 and 1976. Figure II indicates how the material dispersed with time.

Conclusions from the sludge plume studies were that the plume does not penetrate deeply into the water column; the plume remains as a narrow ribbon for several hours with maximum concentrations near the surface and the centerline of the long axis; and, initial dilution was approximately 1:4200, and after four hours 1:10,000, for metals and 1:100,000 for coliform bacteria.

Through the permit system, EG & G, environmental consultants, conducted plume studies of Dupont's acid waste. Instead of transmissivity, EG & G used pH and iron to identify the plume. Interestingly, they found initial mixing to be about 1:5,000 and after four hours 1:100,000. This compared roughly with the sludge dispersion.

In conjunction with the studies of initial dilution and dispersion, EPA has the various wastes tested for toxicity. Bioassays have been shown to be a valuable analytical technique where chemical examination alone of complex industrial and municipal wastes does not provide sufficient information on their effects on the aquatic biota for the protection of the aquatic environment.

Short-term bioassays are used as a range-finding technique to indicate relative toxicity of a complex waste. Long-term bioassays are used to determine effects on life cycles such as growth, reproduction, development of sex products, maturation, spawning, success of spawning, hatching success, survival of larvae or fry growth and survival of different life stages, behavior, and bioaccumulation.
The results of these assays were used to define release conditions under which the wastes would present no harm to the marine environment. As an example, Dupont was required to conduct both acute and chronic toxicity bioassays. Assays were done on Acetaria tonsa (a marine copepod), Cyprinodon variegatus (a fin fish), and Mysisidopsis bahia (a marine shrimp). Figure III shows how the data from these bioassays are used to determine the release time for a barge.

Long-Term Studies

The Region has spent the bulk of its efforts in establishing the long-term trends associated with specific dumping practices. Trend surveys have been conducted on a semiannual basis since the program's conception in 1973. More than twenty surveys have been conducted. Emphasis has been placed upon the bottom environment because long-term changes or trends associated with disposal of wastes are more detectable in this less transient system. The sands and shellfish do not move about as much as do fin fish, plankton, and water.

Persistent contaminants, those which do not readily degrade, contained in industrial and municipal wastes are a primary environmental concern. As an example, heavy metals and chlorinated hydrocarbons are persistent contaminants and represent a hazard to marine life.

One portion of our surveys centered on studying the distribution of selected metals in the bottom environment, specifically in two common species of shellfish. Both Dupont and the City of Philadelphia dumped many metric tons of metals annually. Dupont's waste accounted for most of the iron, manganese, titanium and vanadium dumped in this area of the continental shelf. Philadelphia sludge accounted for most of the copper, silver, lead, nickel, and cadmium. Two species of shellfish, Arctica islandica (mahogany clams), and Placopecten megellanicus (sea scallops) were collected over a wide area of the Mid-Atlantic shelf and analyzed for 13 heavy metals. The data were then subjected to several statistical analyses. Among these were the One Way Analysis of Variance and Duncan's Multiple Range Test. Dr. Gerald G. Pesch, an EPA research biologist at the EPA's Environmental Research Laboratory in Narragansett, Rhode Island, gave a detailed explanation of how the statistical tests were used to show causal relationships between metals in the organisms and the wastes dumped. Based in part on Dr. Pesch's work, an EPA hearing officer concluded that Dupont should move its dumping activity to an area off-the-continental shelf which has a lower level of productivity, has no potential marketable quantities of shellfish, and due to the greater depths and distance to shore, should provide for much greater dispersion and dilution of the wastes.

Community structure of micro-organisms also provide a tool for trend analysis. In 1975, study of the infauna community indicated an aberrancy south of the municipal sludge release site. A grid of stations at relatively close intervals was established and indicated several areas of apparent sludge accumulation immediately to the south of the release site. Investigations of these areas indicated accumulations of organic carbon, metals characteristic of the sludge waste, PCB's (a synthetic organochlorine) and coprostanol (a steroid biochemical excreted from the intestines of warm-blooded animals and indicative of sewage pollution). In April 1978 EPA and the Food and Drug Administration conducted a joint expedition to assess the extent of distribution of sewage indicator bacteria (coliform, fecal coliform) associated with municipal sludge dumping. Previous investigations indicated the general absence of these indicators of public health significant in the water column, except immediately behind the barge while dumping. The preliminary results did indicate, however, the presence in sediments. The results of the April 1978 survey conclusively showed contamination in the bottom sediments in an area of at least 165 nautical miles square.

Independent of EPA's field surveys, the City of Philadelphia was required to do prediction studies on its sludge. A mathematical model simulating the hydrographic characteristics of this Region and the nature of the wastes, done by Raytheon Corporation under contract to the City of Philadelphia, indicated the probable repositories of barged waste materials. The model's prediction of this area of probable impact correlates very well with the actual field data collected by the EPA.

Region III's concern in the sludge dumping has led to the requirement that the City phase out
A Public Hearing was held at Tom's River, New Jersey in May of 1977 to review the move. The final decision was made by Thomas C. Jorling, Assistant Administrator for Water and Hazardous Materials in EPA Headquarters. He concluded that while there was conclusive evidence of impact, "...the economic impact of the closure of the present site (Philadelphia sludge site) to shellfishing for an additional three years is not significant."

Special Studies

The Region has worked in cooperation with many different agencies to develop new research techniques useful for ocean application. Some of the more successful programs are described below.

Remote Tracking of Wastes

The University of Delaware and the National Atmospheric and Space Administration has developed a technique for synoptically observing currents and monitoring pollutants. A Lagrangian current tracking system using radio-signal-emitting current drogues has provided EPA with a new picture of how the currents transport materials dumped at sea. These results have proved especially useful in our attempts to determine the ultimate fate of pollutants and to better understand the data we had collected relating to heavy metals in sediments. Remote multispectral imagery from the Earth Resources Technology Satellite (ERTS-I), and medium and high altitude aircraft have been used to provide a visual trace of the actual pollutant plume.

In-Site Bioassays

As described earlier in this paper, bioassays provide us with insight as to how the pollutants affect the biota. Laboratory static and flow-through bioassays attempt to approximate the real world but in-site bioassays provide the ultimate in combining all of the synergistic and antagonistic effects into a single assay. EPA's National Marine Water Quality Laboratory in Rhode Island fronted this work in our area using specially designed benthic cages in which scallops (Placopecten magellanicus) were placed for three months. While the immediate results were inconclusive, the technique shows great promise.

Parasitology and Histopathology

The National Marine Fisheries Services Laboratory, Oxford, Maryland is doing research on the parasitology and histopathology of the rock and Jonah crabs (Cancer irroratus and Cancer borealis) at the sludge disposal site. Initial conclusions are that the incidence of discoloration and gill fouling is a function of proximity to the sludge dumpsite. Further work is also being done to correlate this work with black necrotic lesions in the Cancer crabs, usually found near the sewage sludge disposits.

ALTERNATIVES TO OCEAN DUMPING

Region III has taken a restrictive approach toward applying the criteria embodied in the Act. The Region has required all dumpers to actively seek alternatives to ocean dumping. The marine environment is only a part of the total environment which must be used for the ultimate disposal of wastes, and problems which affect the marine environment and solutions to these problems must be viewed in terms of their interrelation with the total environment. Some acceptable form of disposal must be developed for each waste that is phased out of ocean dumping. Considerable research is going into the development of alternative methods of disposal which will reduce the environmental effects of the ultimate disposal of the unavoidable residue - be it solid, liquid, or gas - either on the land, in the water, or in the air. EPA is concerned particularly about the problem of the ultimate disposal of sewage sludge, which will be produced in ever-increasing quantities as municipalities install more advanced forms of sewage treatment.

EPA plans to continue its comprehensive program for municipal wastewater sludge management, including the development of a strategy to coordinate the various Agency activities regarding sludge management. This program will concentrate on demonstration of new technologies which will recycle or reuse sludges, or recover residuals contained in the sludges. For example, new technologies are being examined to determine if there are cost-effective methods for processing of sludge into products including metals recovery, organic acids, fertilizer bases, soil conditioners, methane, and the recovery of process heat. The program will also provide guidance for controlling land disposal practices under the Resource Conservation and Recovery Act of 1976.

One alternative which has been successfully demonstrated is the composting of sludge with various bulking agents such as wood chips, bark or solid waste. EPA has a joint project with the Department of Agriculture in Beltsville, Maryland and has conducted a composting demonstration program in Bangor, Maine. Composting stabilizes the sludge and if designed properly can kill pathogens in the process. The land area required for composting as a means of stabilizing sludges is small, and in some cases an energy saving can be realized by using this method. The product resulting from composting has been shown to be an excellent soil conditioner.

In November 1976, the City of Camden was ordered by EPA to discontinue the dumping of its sewage sludge. The City was, however, allowed 18 months to dispose of this residue at a more remote
site and implement an alternative. EPA recommended the composting of its wastewater sludge by the forced aeration system developed in Beltsville, Maryland, by the Agricultural Research Service and Maryland Environmental Service. As a result of the joint efforts of the Camden County Municipal Utilities Authority, the City of Camden, the New Jersey Department of Environmental Protection, EPA, and Cook College, a program of plant rehabilitation, site improvement, composting facility design and construction, and research was initiated. By June 1978, ocean dumping ceased.

Another alternative being used by many cities is the direct application of liquid or dried sludge to farm land. EPA estimates that about 25% of the municipal sludges are currently being disposed of in this manner. This method has been frequently used to provide all or part of the fertilizer requirements for growing forage crops and grain. Such direct applications of sludge have also been used to reclaim strip mined or otherwise disturbed lands (shifting sand dunes, mine spoils, etc.). EPA has initiated studies to survey the results of such programs to document more adequately current nationwide practices in land application of sludges.

The City of Philadelphia is required to end ocean dumping of sewage sludge. To meet the 1980 deadline, Philadelphia has a program underway to select and implement alternatives. Land application of sludge to strip mines is being instituted on a pilot basis and large scale composting is presently being implemented. The City is exploring other technologies such as the EPA funded Eco-Rock research process which produces highway aggregate material by means of co-fusion of incinerator ash and sludge.

In addition, Philadelphia has begun a sludge giveaway program (Philorganic) using aged lagooned sludge as a source. Following installation of de-watering equipment they hope to use stabilized daily-generated sludge as the source. Philadelphia has promulgated pretreatment regulations effective July 1977 in order to improve the quality of the sludge by reducing concentrations of heavy metals entering the treatment plants.

The Dupont Company has been ocean dumping its metal laden, acid wastes since 1968. EPA gave Dupont a choice of implementing a costly waste treatment system or an equivalent recycle process. The Company was able to devise a plan of resource recovery of ferric chloride from its two major waste streams. Dupont forecasts marketing of all ferric chloride by 1980.

References