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DISPOSAL OF SLUDGE TO SEA

Editors: M. C. DART and S. H. JENKINS



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DISPOSAL OF SLUDGE TO SEA

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Editors

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EDITORIAL

The disposal of sludge to sea is a subject that has aroused considerable controversy on account of the potential hygienic and pollution hazard that careless, uncontrolled sludge dumping could cause. Therefore, while some countries have taken steps to control their coastal waters from pollution by sludge discharged from vessels by strict enforcement of legislation, others have abandoned such disposal procedures or are phasing them out. The conflicting views that exist on the acceptability of the practice of sea disposal of sludge made it desirable to examine the extent to which pollution of the sea resulted from sludge disposal and the evidence and methods by which such pollution was measured. These were the main objectives of a conference of the International Association on Water Pollution Research that took place in London during September/October 1981 which gave rise to the papers and discussions recorded in this volume. Because of the widely differing attitudes towards sea disposal, a further objective was to establish the conditions under which sludge disposal could be hygienically practised without ecological damage or adverse economic effects and to assess the effectiveness of existing legal powers and international agreements to control marine pollution from various sources.

In order to achieve these objectives papers were invited from experts able to report on the role of the international conventions in promoting control measures for preventing marine pollution and the results that had been achieved, and, from engineers, administrators and scientists reporting on the results of sea disposal of sludge on the same sites over a period of many years. However, although the emphasis was on the practical aspects of sea disposal, original scientific papers were included that dealt with the ecology of marine waters and sediments, with bacterial contamination arising from sludge disposal and with research needs.

The proceedings of the conference represent an important contribution to the subject of sludge disposal to sea because of the combination of views on the subject by politicians, administrators, engineers and marine scientists. These views deserve to be examined carefully by policy and decision makers since they reveal that policies meant to stand the test of time are best founded on field data and experience obtained over a long period, combined with practical control measures of industrial wastewater discharges and sludge disposal practices that are reasonable enough to gain general support.

International agreement to reduce marine pollution is shown by the fact that the Oslo Convention for the North East Atlantic that came into force in 1974 for the prevention of pollution from vessels has been joined by the Helsinki and Barcelona Conventions for the Baltic and the Mediterranean, while the London Dumping

Convention for controlling dumping in the oceans of the world has received the signature of a large number of countries. Clearly, agreements on such a scale can only be implemented through national legislation and at a pace that varies according to national circumstances.

One of the most important conclusions drawn from the Conference is the need to develop monitoring programmes and to ensure their co-ordination by the various international commissions. The purpose of such programmes is usually to obtain information for the establishment of dumping sites or the control of pollution from existing sources. However, the protection of marine waters on a global scale calls for an input of information from all sources if the total long term effects of pollutants are to be measured and marine resources protected. The results of such monitoring programmes may modify the views of those who have either advocated or condemned the use of the sea as a receptacle for sewage sludge. On the other hand they may show that the policy of indirectly removing potential toxicants from sludge by controlling industrial wastewater discharges to sewers so as to render sewage sludge fit for use in agriculture is having the effect of making sea disposal a more acceptable practice. With this policy becoming more common it should be possible on ecological and economic grounds to decide whether sludge disposal to sea should be considered as one of the safe options that may be available. That this choice is becoming recognised internationally is clear from the London Conference papers and discussions that are recorded in this volume of proceedings.

M.C. Dart
S.H. Jenkins

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ERRATA

Ocean Dumping to Sea vs. the Alternatives

I.L. BOGERT and L.J. SOKOL, pp. 1-8

Page 1: Under the title, "Ocean Dumping of Sludge vs. the Alternatives", add the author's address as follows:

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Page 2: 4th paragraph, 4th line, change "prepared" to "prepare"

Page 3: 1st paragraph, 4th line, change "reconditioner" to "conditioner".
2nd paragraph, 9th line, change "delimma" to "dilemma"

Page 4: 4th paragraph, 10th line, change "which creates" to "which could create"

Page 5: 1st paragraph, 2nd line, change "The USEPA sludge and fell within" to "the USEPA. The results of laboratory testing indicated that the Authority's sludge falls within"

2nd paragraph, 6th line, change "5,200:1".

On the 7th line after the word capacity add the phrase "and a discharging time of 37.5 minutes during the summer, worst case when a pycnocline exists at a depth of 10 meters in the receiving waters"

5th paragraph, 2nd and 3rd lines, change "criterion for" to "criterion (0.01 x LC₅₀) for". On the 4th line, change "the dilution achievable is 5200:1" to "the minimum dilution achievable for the suspended particulate phase is about 1,00:1"

Page 7: 1st paragraph, 5th line, change "test" to "text"

3rd paragraph, 2nd and 4th lines, change "Drexler" to "Draxler"

Page 8: 1st paragraph, 2nd line change "reasonable to "unreasonable". Also, under the heading REFERENCES - 5 - change "Drexler" to "Draxler"

Sludge Disposal to Sea: North American Viewpoint
W.F. GARBBER, pp. 109-125

Page 110: 3rd paragraph, line 14 "the FWCA" should read "the FWPCA"

Page 111: Regulation B. should read "National Pollutant Discharge
Elimination System (40 CFR, Part 125)."

Regulation C. should read "Federal Construction Grants
Regulations (40 CFR, Part 35, Federal Register September 27,
1978)"

Page 112: Regulation K. should read "Ocean Discharge Criteria (45 CFR
9548)".

Page 122: Line 19 should read "Outfalls in the benthic area affected".

OCEAN DUMPING OF SLUDGE VS. THE ALTERNATIVES

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ABSTRACT

Studies have been conducted in the East Coast Region of the United States challenging USEPA's determination that municipal sewage sludge dumpers fail to meet ocean dumping criteria.

Laboratory testing of liquid phase and bioassay and bioaccumulation of the Bergen County (New Jersey) Utilities Authority's digested sludge has been performed. The results indicated that the digested sludge falls within the required criteria and would not cause an adverse harmful effect on the marine environment. Inherent in the EPA's interpretation of the law is that other land-based alternatives to ocean dumping are not only feasible, but offer less relative environmental risks. The case against EPA's interpretation is increasingly apparent from studies indicating more severe risks from land-based alternatives.

BACKGROUND

In 1977, the Congress of the United States enacted Public Law No. 95-153 amending the Marine Protection, Research and Sanctuaries Act of 1972. The 1977 Amendment prohibited the dumping after December 31, 1981 of any sewage sludge which would be deleterious and harmful to the marine ecosystem and human health. Reference standards for measuring these harmful materials were published in January 1977, and are generally referred to as Title 40, Code of Federal Regulations 220, et seq.

The 1977 Congressional enactment is a good example of how the political process can result in legislation which is well-meaning but not well-balanced due to insufficient involvement by the scientific community during the legislative drafting. Congress acted after the New York/New Jersey area experienced a "red tide" scare and a substantial fish kill. Although there was no evidence to relate either of these incidents to the dumping of sewage sludge in the ocean, Congressmen from the area led the fight in committee and eventually prevailed in both Houses of Congress to enact one of the harshest environmental laws in our history.

P.L. 95-153 prohibits the dumping of most sewage sludge after December 31, 1981 without any discretion to the United States Environmental Protection Agency (EPA) to provide waivers or enter into modified plans and agreements with the municipalities responsible for sewage sludge treatment and disposal. A review of the Con-

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The Authority decided upon filter presses which produced a 35 to 40% solids cake and composting as an interim measure to meet the 1981 deadline until long-term facilities could be designed and constructed. It intended that the composted material be used as a soil reconditioner or landfill cover in the solid waste landfills operated in the nearby Hackensack Meadowlands.

The cost of design and construction of the dewatering facility could be justified for the interim composting project because the dewatered sludge would also be required for any incineration process.

Once the land-based alternatives were being seriously considered, several problems arose. With regard to composting, the U.S. Department of Agriculture conducted a study at a full size, operational system at their facility in Beltsville, Maryland. They developed scientific evidence regarding the generation of aspergillus fumigatus spores being carried beyond the composting site, thereby endangering the health of those who suffer from respiratory and cardiac conditions in nearby areas. There was some conflict as to the distance within which a substantial portion of these spores could travel, but the Bergen County Utilities Authority was faced with a significant dilemma since its plant in Little Ferry, New Jersey is located near a large population center which includes many hospitals, medical centers and nursing homes. To give you a better idea of the scope of the problem, within a ten-mile radius of Little Ferry is included virtually all of Manhattan, the Bronx and northern New Jersey.

Other investigations disclosed that incineration posed environmental problems which could be more dangerous to the population than ocean dumping. Sewage sludge may contain a large concentration of heavy metals and incineration of these heavy metals could emit these into the atmosphere. This would become a particular problem if the burning temperatures in the furnace exceeded 2,000°F. At those elevated temperatures for incineration, which are highly efficient for the combustion of cellulosic wastes and organics, there is evidence that heavy metals emissions in stack gases from incinerators are a public health concern. Even with pollution control devices such as electrostatic precipitators and scrubbers, significant quantities of heavy metal oxides are thought to exhaust into the atmosphere. The hazards posed by cadmium, mercury and lead in the atmosphere are obvious in a densely populated area.

The reason for locating sludge disposal facilities within these densely populated areas was because the cost of transportation to sparsely populated areas would be too great. In fact, the only sparsely populated areas which are near the northeastern part of the United States are in the ocean.

The Authority also investigated landfilling of dewatered, digested sludge without composting, as a low-cost alternative. The landfills lie within five miles of the sewage treatment plant, and since the sewage sludge generated is only 4% of the total solid waste generated, its contribution to environmental problems appear to be insignificant. Whatever problems there are in landfills from solid waste would not be materially changed by the introduction of this amount of sewage sludge.

Despite vigorous efforts by the Authority to convince State and local official to allow the landfilling of dewatered sludge, it was eventually rejected. The DEP argued that the heavy metals and PCB's contained within the sludge could be leached from the landfill into the groundwater creating other environmental hazards.

OCEAN DUMPING ALTERNATIVE

After several years of work and the expenditure of hundreds of thousands of dollars, it became more and more apparent that the most cost-effective and environ-

mentally acceptable method of disposal of sewage sludge from a secondary treatment plant is to continue dumping in the ocean. State and Federal officials have started to agree with this conclusion, but indicated that they would close the traditional dump site located in the New York Bight, which is roughly 12 miles equi-distant from the shores of New York and New Jersey, at the entrance to the Hudson Canyon. Instead, they would designate a site 106 miles offshore, beyond the continental shelf. The substantial increase in the depth beyond the continental shelf allows for greater dilution and, therefore, less environmental hazards. It also minimizes the possibility of sludge on the ocean bottom where it can enter the food chain.

The problem with this solution was the cost of transporting to the 106-mile site. Sludge has been disposed of by tugs and barges which are not ocean-going vessels. There are few sludge hauling vessels available that can make the trip to the 106-mile site. The costs of such a trip is four times greater than disposing of it at the 12-mile site. If disposal to the 106-mile site is mandated, then consideration should be given towards dewatering of sludge in order to save on transportation costs since removal of the water content would mean considerable savings in trips and in fuel and barging charges.

The sewerage agencies such as the Bergen County Utilities Authority saw itself in a difficult position. On the one hand, the Bergen County Utilities Authority had to comply with the law, but on the other hand, it saw its primary mandate as that from the people of Bergen County to dispose of sewage in the most economical way possible. It recognized that the cost of sludge disposal is another tax on people and business, and since the northeast United States, including New Jersey, has been under severe economic pressure because of the high cost of energy, land, labor and other resources, it was losing industry and jobs to the "sun belt" portion of the United States. If it were to now overburden industries with excessive sewage treatment charges, it would be another nail in the economic coffin of the region.

The Authority decided to fight back. Studies were performed to analyze the sludge characteristics and to perform various bioassay tests required by the EPA. Its attorneys and engineers concluded that its sewage sludge could possibly meet the standards set forth in the law permitting continued ocean dumping. The key was measuring the environmental effects after the sludge had been diluted after dumping and the sludge is thoroughly dispersed. Digested sludge which comes from a secondary treatment plant has the consistency of molasses, with a very small particle size. Its particle size distribution is such that a substantial portion remains permanently suspended at high dilution levels and only a small portion would eventually settle to the ocean bottom. It is the sediment which creates the greatest environmental problem.

P.L. 95-153 concludes that pollutants containing carcinogenic organics such as PCB's and heavy metals may be ingested by aquatic life and concentrated over a series of cycles finding its way into the food chain and, thereby, endangering human health. It is apparent that these contaminants when diluted and either dissolved or suspended in the ocean, would approximate the background level of these materials in the ocean and would pose no hazard to the marine ecosystem or human health. Only the sediments at the ocean bottom could enter the food chain by being concentrated in shell fish which live at the bottom of the ocean and then caught by commercial fishermen or eaten by other fish or sea animals that would eventually be caught by fishermen and served to humans.

SLUDGE TESTING RESULTS

The Bergen County Utilities Authority's studies determined that their digested sludge met the ocean dumping criteria established by the USEPA sludge and fell within the required criteria.

Table 1 shows a comparison of the diluted, liquid phase of the Authority's sludge with the required Marine Water Quality Criteria for mercury, cadmium, PCB and DDT. The diluted concentrations are calculated based on barge discharging method as outlined in the USEPA permit for ocean dumping. The permit requires a barge speed of three knots or more and a discharge rate of 15,500 gallons per minute or less. The dilution factor was calculated to be 5,200:1 for a barge of 400,000 gallons capacity. The dilution can be varied by increasing barge speed or decreasing discharge rate.

As shown in Table 1, the BCUA sludge complies with the water quality criteria for mercury, cadmium, PCB and DDT.

TABLE 1 Comparison of the Diluted Liquid Phase of BCUA Sludge
with Marine Water Quality Criteria

<u>Parameter</u>	<u>Water Quality Criteria ($\mu\text{g/l}$)</u>	<u>Concentration ($\mu\text{g/l}$) in Liquid Phase</u>	<u>Diluted Concentration ($\mu\text{g/l}$)</u>
Mercury	0.10	45.2 (max.)	0.0086
Cadmium	5.0	330 (max.)	0.063
PCB	0.001	4.4	0.001
DDT	0.001	<0.05	<0.001

Bioassay results of the suspended particulate phase were performed on the Authority's sludge. The testing results are presented in Table 2. The worst case is that of *Menidia* with an LC_{50} of 6700 mg/l. At this concentration or a dilution factor of about 150:1 (sea water:sludge), there is a mortality of 50% of the organisms tested as compared to the control.

TABLE 2 LC_{50} of Suspended Particulate Phase Bioassay on BCUA Sewage
Sludge

<u>Organism</u>	<u>LC_{50}, mg/l (1)</u>
<i>Skeletonema Costatum</i>	9,000
<i>Mysidopsis bahia</i>	8,100
<i>Menidia menidia</i>	6,700

(1) LC_{50} is the lethal concentration at which there is 50 percent mortality relative to the control.

Comparing this LC_{50} value with the Limiting Permissible Concentration (LPC) criterion for the sludge in the receiving water indicates that at a maximum discharge rate of 15,500 gallons per minute, three knots speed and a traverse of about 2,000 meters, the dilution achievable is 5,200:1. Therefore, based on the LPC criteria in the suspended particulate phase bioassay, the Authority's sludge is in compliance with the ocean dumping criteria.

Table 3 shows the results of biocaccumulation after survival of organisms exposed for ten days to the suspended particulate phase of sludge. Note that digested

sludge does not have a solid phase and therefore suspended particulate phase was substituted. As can be seen, concentrations of cadmium, mercury, PCB and petroleum hydrocarbons in the tissues of organisms that survived ten-day exposure to the suspended particulate phase of the sludge are either lower or not significantly greater (statistically) than concentrations of the constituents in tissues of organisms exposed to the culture water control ($\alpha = 0.05$). These results indicate that the potential for the constituents of the sludge to accumulate in the human food chain is insignificant.

TABLE 3 Bioaccumulation Tests - Tissue Analysis of Organisms Surviving 10-day Exposures

<u>Constituent/Organism</u>	<u>Mean Value, $\mu\text{g/g}$ wet weight</u>	
	<u>Culture Water Control</u>	<u>Suspended Particulate Phase of Sludge</u>
<u>Cadmium</u>		
Grass Shrimp	0.30	0.93*
Hard Clams	0.173	0.087
Atlantic Silversides	0.197	0.175
<u>Mercury</u>		
Grass Shrimp	0.110	0.250*
Hard Clams	0.072	0.065
Atlantic Silversides	0.002	0.003*
<u>PCB's</u>		
Grass Shrimp	0.01	0.01
Hard Clams	0.06	0.02
Atlantic Silversides	0.01	0.01
<u>Petroleum Hydrocarbons</u>		
Grass Shrimp	936.7	713.3
Hard Clams	186.7	116.7
Atlantic Silversides	9.3	9.3

*Statistical analysis indicates no significant difference between control and sludge, therefore no bioaccumulation occurring.

CURRENT SITUATION

While the Authority's scientific studies were being conducted, significant progress was being made in the courts. A Federal judge in the case involving the City of New York ruled that there was insufficient scientific evidence to support the closing of the 12-mile site or the banning of ocean dumping of sludge, and the various authorities of New York and New Jersey areas have proceeded to negotiate consent orders with the Federal government allowing continued dumping in the ocean beyond December 31, 1981. As of this date, it is still an open question as to whether the 12-mile site will remain open to sewage dumping, but we believe that a strong argument can be advanced to support such continuation.

In Congressional hearings conducted on April 1, 1975, the EPA referred to a statement prepared by Dr. R. Lawrence Swanson of the National Oceanic & Atmospheric Administration (NOAA) presented to the New York State Select Committee on environmental conservation on February 20, 1972. In his statement, Dr. Swanson discussed the physical, chemical, biological and sedimentary aspects of the New York Bight

12-mile site as affected by the sewage sludge dumping. He concluded that there is no evidence of a massive general movement of sludge toward Long Island beaches (and we would parenthetically include New Jersey beaches), and that 40 years of sewage dumping have produced a rather stable distribution of organic-rich muds in the Bight. (The test of this statement is included in the report entitled "Ocean Disposal in the New York Bight - Technical Briefing Report No. 2," April, 1975, prepared by the EPA Region II.)

We would argue that if a site has already been contaminated, and if the evidence is that there is no migration of hazardous materials from that site, why not continue the use of that existing site. Dr. Swanson, in a hearing on October 4, 1979 before the EPA Region II, said "that it would be better to use an existing dump site than to adulterate a pristine area of the continental shelf."

Similar conclusions regarding the transient effects of sewage sludge dumped into the ocean were reported by A. F. J. Drexler of the National Marine Fisheries Service, Highland, New Jersey and published in the April, 1979 issue of the Journal of the Water Pollution Control Federation. Mr. Drexler investigated the dynamic processes that follow a single sludge dump, and found that immediately after discharge, the sludge was mixed in the upper few meters of water, and the particulate material began to settle. He concluded, "There is no evidence for the accumulation of sludge such as that which exists for dredging spoils; however, if it is being dispersed, sludge dumping, relative to primary production and estuarine export, is a minor contributor of organic carbon to the New York Bight as a whole."

We submit that it is environmentally acceptable to designate specified sites on the continental shelf for the dumping of sewage sludge and, more particularly, to leave the current 12-mile site in the New York Bight available for such dumping. Whatever environmental problems have been created at that site already exist, and to argue about the restoration of a "postage stamp" on the face of the ocean when there is no evidence that there is a migration from that site to contaminate or endanger other parts of the ocean or adjoining beaches makes no sense. Generation of sewage sludge is a fact of life. It must be disposed of, and the most environmentally-acceptable sites lie within the ocean and not on the land. Economics also dictate that we remain in the ocean rather than expend considerable sums of taxpayers' money on the construction of land-based facilities when those facilities may pose environmental hazards far worse than those which are alleged for ocean sites.

Based on the foregoing studies, the present USEPA criteria for ocean dumping can be met by sewerage authorities with proper control and monitoring. However, reassessment of these criteria also appear appropriate since USEPA in establishing the Ocean Dumping Regulations and Criteria placed minimal emphasis on costs in comparing with other factors.

CONCLUSIONS

In conclusion, let us not make the same mistake again when a legislative body is considering the enactment of a statutes regarding the disposal of sewage, whether it be sludge or wastewater. Let us recognize our responsibility to provide the most accurate and well-balanced information to the legislators so that they can make a reasoned decision.

When we read the words of the amendment to the Marine Protection, Research & Sanctuaries Act, they sound perfectly reasonable. They say that after December 31, 1981, the law bans the dumping of sludge in the ocean "which may unreasonably degrade or endanger human health, welfare, amenities, or the marine environment, ecological systems or economic potentialities" (33 U.S.C. 1412 [a,b]). After the

expenditure of hundreds of thousands of hours and millions of dollars in agonizing over land-based alternatives, it was determined that there was no reasonable degradation or endangerment from the continued use of the 12-mile site located in the New York Bight for dumping of sewage sludge, and that, therefore, there was no statutory compulsion to stop it even after December 31, 1981. Certainly on balance, it would appear the environment is better off using an ocean dumping site than a land-based site.

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DISPOSAL OF SEWAGE SLUDGE TO SEA — ENGINEERING ASPECTS

W. T. Greer

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ABSTRACT

The selection of the sewage sludge dumping site in the Firth of Clyde off Garroch Head is compared with the selection of sites near Bell Rock and St. Abbs Head off the Forth Estuary, Scotland, almost three-quarters of a century later. Details are given of the special shore facilities which are required to dispatch sewage sludge to sea, and specific features of purpose built sludge ships are described. Reference is then made to the factors involved when discharging sludge at the sea dumping site. The emphasis in the paper is on the engineering aspects of the facilities required and operations involved in the sea disposal of sewage sludge.

KEYWORDS

Sewage sludge; sea disposal; overhead sludge tanks; ozone treatment of odours; activated carbon treatment of odours; sludge ships.

SELECTION OF SEA DISPOSAL SITES

The selection of sites for the sea disposal of sewage sludge is not determined primarily by engineering considerations. Economics dictate that sites should be as near to the dispatching sewage works as possible, but their location is predominantly established by considering other factors such as the existence of suitable sea current patterns and velocities, and the need to protect the marine environment and the living resources which it supports from any adverse consequences.

Since the passing of the Dumping at Sea Act in the United Kingdom in 1974, all disposal sites must be approved and licensed by the appropriate Government Departments. As almost three-quarters of a century separated the selection of the disposal grounds for the two Scottish Authorities involved it will be of interest to outline the factors which appear to have influenced their selection. Once disposal sites have been selected, the various operations involved and facilities required have important engineering aspects.