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AFFLUENCE VERSUS EFFLUENTS - MARINE WATER POLLUTION CONTROL IN THE USA AND IN THE DEVELOPING COUNTRIES

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Abstract

This paper (i) explains the evaluation of the technology for treating sanitary and industrial liquid wastes as it has developed over the past century, (ii) notes that this technology was based virtually entirely on discharge of the treated effluents to rivers or other confined waters including coastal estuaries/bays, where the dissolved oxygen concentration was the salient parameter controlling design of the treatment processing system, (iii) notes that it was not generally recognized until the early 1960s that treatment for disposal to open or unconfined ocean waters represents an entirely different situation wherein the controlling parameters are floatables and coliforms, (iv) notes that management of the U.S. Government's national program of water pollution control has passed from essentially an "Engineer's Domain" to an "Attorney's Domain", and under the latter the present EPA requirements for treatment of waste effluents discharged to unconfined ocean waters are counter-

productive and are resulting in waste of many billions of dollars, especially for west coast cities, (v) recommends that EPA sponsor preparation of a "Manual of Appropriate Design Practice for Disposal of Sewage and Industrial Wastes from Coastal Communities", which would evaluate, on a scientific and economics basis, the relative costs and levels of protection afforded to the regional ecology for the three alternatives of discharging the waste effluents to inland rivers, to confined estuaries/bays, and to the unconfined ocean water, and (vi) recommends that U.S. AID sponsor a new activity by U.S. EPA whereby, for valuable EPA manuals on environmental pollution control, an extra chapter would be added which would interpret the basic data to prepare guidelines for waste management practices which would be appropriate for the developing countries.

Introduction

One of the most fundamental questions of concern in evaluating man's impact on "Spacecraft Earth" is the extent of degradation of ocean waters caused by discharge into the seas of wastes from man's activities, and whether such degradation will likely lead to irrevocable loss of precious ocean resources essential for man's continuing well being. Because the bulk of the waste discharges into the seas have occurred over the past century, since the advent of accelerated population growth and large-scale urbanization and industrialization, it is timely now to review and assess the accumulated experience, to attempt to determine the merits and demerits of ongoing waste disposal practices, and to develop conclusions for guiding future practice.

Unlike the problem of waste disposal to inland fresh waters, which is regarded as a localized in-country affair, because the oceans are international they tend to be considered to some extent as common domain, as evidenced by the recent efforts to formulate a universally acceptable "Law of the Seas". In the spectrum of internation concerns about the ocean, the pollution parameter is one of the major issues along with rights for navigation, aquatic fisheries, and seabed mineral extraction.

The present evaluation is based on review of the literature on marine waste disposal as affecting marine environment and ecology, most of which has been published over the past three decades, plus experiences gained from monitoring of effects of waste disposal on marine ecology for marine waste disposal systems which are of major size or which discharge into especially sensitive marine ecological zones.

Evolution of Waste Disposal Technology in USA

Sewage Treatment Technology Prior to 1960

Treatment of wastes prior to discharge to environment (to receiving waters in all but a few cases) is a modern practice, barely a century old, which came into being in the western world when the growth of cities and the resulting volumes of sewage collected by municipal sewerage systems reached magnitudes that seriously depreciated downstream beneficial water uses. This included streams or other confined waters to which the wastes were discharged, including confined coastal waters and bays.

The entire technology of sewage treatment which evolved was thus related to control of pollution from man-generated wastes discharges to confined waters (water bodies of limited volume). Such treatment became necessary when the amount of waste discharges exceeded the natural assimilative capacities of the receiving waters, thus resulting in pollution, that is, degradation of water quality due to discharges exceeding the assimilative capacities. Under such conditions it was found necessary to use treatment measures, not to remove all of the waste substances, but to reduce the amount to the level within the assimilative capacity. It was found that protection of these waters to sustain their beneficial uses (water supply, fisheries, swimming and recreation, and environmental aesthetics) required essentially two treatment steps, (i) removal of settleable materials (sludges) and of floatable materials such as greases, to prevent deposition of these materials on shorelines and the associated nuisances and public health hazards, and (ii) removal of the remaining organic materials in the waste flow, namely colloidal and dissolved organics, sufficeint to reduce the concentrations of these organics to levels which would not deplete the dissolved oxygen concentration of the waterway to very low or septic levels, which would turn the entire waterway into a "sanitation mess" unfit for practically all beneficial water uses (excepting their uses for waste disposal and for navigation). Thus the design technology which evolved, primarily by engineers in the USA and Western Europe, in addition to removal of settleables/floatables to prevent sludge bank formation in the waterways, was based essentially on use of the parameter of dissolved oxygen (DO), to reduce the DO demand of the degradable organic matter in the effluents discharged to the confined waterways, to be within the capabilities of the waterways to absorb the degradable organics without reducing the waterway DO to levels below those considered necessary for the particular beneficial uses of value. The salient parameter for matching treatment needs with environmental effects was the DO content of the waterway, and the key parameters for measuring the DO loading to be imposed by the discharged effluent were the biological oxygen demand (BOD) and the suspended solids (SS) of the effluent.

A common requirement, up to about 1960, was to procure a "20/30" effluent, meaning 20 mg/l BOD and 30 mg/l SS. This was accomplished by a combination of "primary treatment" or removal of settleables and floatables by gravity separation, followed by "secondary treatment", meaning use of some biological oxidation process such as activated sludge or trickling filtration, the two together being called "complete treatment" although the actual removals of organics were usually of the order of 90 percent or less. Both primary and secondary treatment resulted in production of sludges with considerable organic content, which were further processed by biological stabilization (usually anaerobic digestion), resulting in a fairly stable sludge product which could be readily dewatered and thus made suitable for disposal in rural areas (usually onto farmlands where it was of value for its soil conditioning properties plus a small but significant concentration of nutrients).

In addition to the above processes, the overall sewage treatment system also included chlorination of the effluent, to reduce its content of pathogens to acceptable levels, and use of the coliform determination to measure the probable level of pathogenic hazard in the receiving water before and after chlorination.

The above represented standard practice for treating municipal sewage to about 1960, except that, following the Second

World War, the characteristics of the municipal sewage were significantly altered by the increasing discharge to the system of affluents from industrial manufacturing plants. At first the industrial loadings were largely organic, hence their impact was simply to require more capacity in the municipal sewage treatment systems, but as industrial processing steadily expanded their effluents contained increasing amounts of hazardous substances, including toxic, inflammable, explosive, corrosive and other materials which could either cause physical damage to the sewerage system, or impair its biological treatment processes, or pass through the treatment system to damage downstream beneficial water uses. As a result, regulations were developed by the governmental agencies to require individual industries to remove hazardous substances from their wastes before discharging them to the public sewerage system (Ludwig, June 1978). The hazardous sludges from such in-plant treatment systems, together with solid hazardous wastes produced by the industry, were usually disposed of by landfilling and sometimes by incineration.

The landfilling was done at sites where presumably no groundwater pollution hazards were involved or by using especially designed fills with liners and other measures which presumably afforded suitable protection of groundwater from contamination by hazardous substances leaching from the filled areas.

During this period, up to 1960, in a relatively few cases the sewage effluents were discharged into the open sea, or unconfined marine water, and for these the sewage treatment processes employed were planned essentially the same as for discharge to confined waters. The engineers who planned them hardly thought otherwise.

An additional source of ocean pollution resulted from dumping of wastes from ships, including bilge waters, and from oil spills from tankers or from port facilities handling crude or refined petroleum products. The solution of this problem, however, has not depended upon land-based treatment plants but on control of the ships and oil transfer facilities. Also, while such spills are "dramatic" events, because their effects are readily visible to the public, actually their total amounts and total impacts on marine environment and ecology are quite small compared to land discharges.

The Present Technology

During the decades of the 1960s and 1970s the basic concepts for appropriate treatment of liquid wastes were markedly changed, as part of the general trend toward much better attention to protecting natural resources which stemmed from the Environmentalist-Conservationist Movement (ECM) beginning in the 1960s. As is well known, this period was characterized by the emergence in the USA of the ECM with so much power that it pushed the regulatory requirements for waste disposal ahead very rapidly, so that, by the 1970s and ever since, the regulatory pressures for water pollution control (emanating mostly from U.S. EPA) have far transcended the technology. That is, the pressures for cleanup reached levels where the traditional engineering approach (how to apply scientific knowledge to solve real world problems in an economic manner) was more-or-less abandoned in order to meet pre-conceived desired levels of environmental quality more-or-less regardless of costs.

This was clearly evident by the push by EPA for "tertiary treatment", generally meaning use of expensive physical/chemical (rather than biological) processes to "work over" the effluents from secondary treatment, to achieve further reductions of BOD and SS together with reductions in nutrient substances such as phosphorus and nitrogen and reduction in the other "refractory" substances remaining in secondary treatment plant effluents in low concentrations, including residuals of heavy metals and synthetic organics. While tertiary treatment had a glamorous appeal (it was also termed "advanced waste treatment"), it was very costly per unit of removal obtained, virtually doubling the total treatment costs just to obtain the small extra removals. Subsequent monitoring of downstream water quality has not, in most cases, turned up evidence of downstream improvements to justify the high extra costs (Ludwig, 1971).

The lesson learned is that the relationship between extra treatment process removals and improvement in downstream ecology is much more complex than had been assumed in the implementation of the tertiary treatment program. An excellent example of this is the current very confused picture of Chesapeake Bay as reported by recent U.S. EPA publications, where the famed striped bass fishery has been markedly depreciating over the past decade despite the application of tertiary treatment and other measures for reducing total pollutant discharge into the Bay down to levels believed to be sufficient as judged by all known water quality parameters. It is now realized that, despite these protection measures, the "balance" between physical/chemical constituents in the Bay waters may nevertheless have shifted in some subtle manner which has depreciated certain bottom grasses (in favor of other plant species, presumably) which are vitally important to the striped bass. Thus the treatment/ecological impact relationship is not at all well understood, this despite the tremendous magnitude of EPA's research program on such relationships over the past two decades.

Another very significant change in the nature of the national water pollution control program in the USA, again as a result of the "big push for accelerated cleanup" sponsored by the ECM, was the shift of administrative management of the program from the U.S. Public Health Service, where the program was essentially engineer managed, to the new U.S. EPA where control has shifted almost totally from engineers to attorneys. Ever since, the concept of efficiency in cleanup, wherein costs of treatment are related to and justified by improved beneficial water uses, has not been of primary importance but has been replaced by what may be called the "legal approach" whereby the Decision Makers (attorneys) manage the entire program to achieve a "simplistic uniformity" regardless of cause-and-effect relationship between treatment costs and measurable benefits accrued.

In this context the changes in downstream water quality, as measured by the established parameters, are simply deemed worthly of the cost, and benefit/cost analyses are conducted accordingly. One of the most basic elements of the "SUA" (Simplistic Uniform Approach) was the upgrading of the engineer's earlier credo that all wastes should have at least primary treatment (to avoid sludge bank formation), to the new credo that all wastes must have no less than secondary treatment regardless of place of disposal; that is, regardless of the oxygenating capacity of the receiving waters. While the first credo makes engineering sense, the second credo represents the actual opposite of engineering, and it is the second credo that has led to great controversy in the USA in the field of marine waste disposal.

Marine Waste Disposal in California

The Engineer's Era

With respect to disposal of waste into the marine environment, the west coast of the USA has been the "action center" because there the deeper unconfined ocean waters are readily accessible, whereas in the east the gradual slope of the continental shelf places the unconfined waters, in most cases, beyond the zone of economic accessibility. In the west coast the earliest recognition of the actual resources of the unconfined seawaters for absorbing wastes took place in California, especially in southern California with the pioneering work of Mr. A.M. Rawn, Chief Engineer of the Los Angeles County Sanitation Districts. This led to construction of a major submarine outfall system discharging into unconfined waters offshore of White Point, with treatment limited to conventional primary treatment, and to a similar system for the Orange County Sanitation Districts discharging offshore in the vicinity near the city of Santa Ana (OCSD, 1946).

Both of these systems included rigorous continuing monitoring programs for determining whether any of the discharged sewage materials were being returned to the shoreline zone and, in the case of the Orange County outfall, whether return of coliform organisms was sufficient to exceed the State's established standard for beach waters of 10 total coliforms/ml. Both systems operated very economically and quite satisfactorily based on the records of the monitoring programs which employed all of the known pollution indicating parameters.

In 1950, water pollution control regulatory authority in California was transferred to the State Water Resources Control Board. Based on studies conducted for the State by E.A. Pearson of the University of California at Berkeley, the Board took the pioneering step of requiring comprehensive monitoring of the effects of all significant waste discharges to marine waters, including both confined estuarine/bay areas and unconfined open seas, and including use of all the conventional water pollution parameters including DO, BOD, SS, pH, major cations and anions, nutrients (N,P,K), heavy metals, oil/greases, and others, plus analyses for benthic biota and for accumulation in bottom sediments of heavy metals and petroleum compounds.

Ten years later a vast backlog of monitoring data had been accumulated, and a special study was sponsored by the Board for evaluating the significance of the accumulated data. The results of this study (Ludwig and Onodera, 1962) concluded that (i) the conventional sewage treatment concepts, based essentially on the DO parameter, while applicable to confined estuarines/bays, had little if any application to waste discharge into unconfined seawater, (ii) the only meaningful parameters relating to disposal to uncomfined waters were those for coliforms plus a new parameter termed "floatables", that is, all materials which rise to the surface and thus can be returned to the shore by onshore winds, (iii) the oxygenating and diluting capacity of the unconfined seawater are virtually unlimited, hence oxygenation of degradable organics using secondary treatment is of virtually no value for wastes discharged to such zones, (iv) with the exception of materials settling out in the vicinity of the end or discharge points of the submarine outfall pipe system, all other constituents are rapidly diluted and cease to exist in terms of detectability, including heavy metals and other toxics, (v) the increase in levels of such materials in the open ocean environment, considering all of the liquid waste discharges reaching the oceans around the world, should be insignificant, i.e. should not result in any significant increment which would degrade marine ecology, (vi) the natural organics contained in the waste effluent exert a positive influence on marine ecology by furnishing valuable nutrients which are normally scarce in the open sea environment, (vii) while the bottom ecology in the vicinity of the outfall will certainly be degraded, the total affected area is virtually of no statistical influence, and (viii) for disposal into the unconfined ocean waters the primary treatment process alone should be suitable, given an outfall reaching sufficiently offshore to reach the unconfined water zone, except that the removal of floatables accomplished by conventional primary treatment should be improved (given greater attention), (ix) for such disposal it would be unnecessary to remove the settleable sludge from the waste, in view of the ocean's virtually unlimited waste absorption capacity, and because sludge disposal represents a big part of overall treatment plant costs, the most appropriate treatment system would be one not removing the settleable solids at all but one focused on removal of floatables, with a sufficiently long outfall, and in some cases not even the floatables need be removed, that is, they would be carried out to sea and eventually degraded and stabilized.

Following the pattern set by the Los Angeles County and Orange County systems, in the 1960s the cities of San Diego and Los Angeles both constructed and operated similar systems, again with rigorous monitoring which showed excellent protection of the environment. Another submarine outfall system was constructed for discharge of waste clay slurries from mining of high-quality beach sand, in the open waters offshore from the famed Seventeen Mile Drive zone near Monterey, California. This represents one of the most sensitive fragile marine ecological zones in the world, and rigorous monitoring showed the system gave excellent performance in protecting of this resource (Engineering-Science, 1963). Still another similar major system was planned and implemented for Honolulu/Oahu in the 1970s, based on detailed evaluation of treatment level alternatives versus needs for protection of the precious and fragile recreational values of the marine ecosystem (Engineering-Science, 1972).

In addition to the comprehensive monitoring of the waste disposal systems discharging to the ocean, a supplementary and complementary comprehensive research and development project was initiated in the 1960s, again with Los Angeles County Sanitation District leadership, with mostly EPA funding. This project, known as the Southern California Coastal Water Research Project (SCCWRP), which is administered jointly by the local governments operating marine waste disposal systems in Southern California, is still continuing. Its scope, depth, and magnitude have transcended by far all other studies of impacts of wastes on marine environment, and its publications include a series of reports which have virtually rewritten the technology in this field (SCCWRP, 1970-84). With the large funding levels made posible by both strong local governmental support plus that from EPA, and under the excellent and stimulating leadership of Mr. Willard Bascom, SCCWRP has furnished a solid and extensive data base of facts on effects of wastes on marine environment and ecology. It is of interest to note that SCCWRP's findings and conclusions have essentially confirmed all of the findings and tentative conclusions referred to above, first made in 1962.

Another important contribution by the State of California Board was preparation of a comprehensive manual on the technology of marine waste disposal monitoring (CSWRCB, 1972). This pioneering contribution is still appropriate and is widely used.

The Attorney's Era

The pattern of waste disposal developed and required by EPA for disposal to confined waters, despite its uniformity, nevertheless makes sense for most inland disposal situations, because for most of these the DO resources are definitely limiting. Moreover EPA's push to upgrade practices for inland disposal of digested sludges has also been constructive, (i) in recognizing that those sludges may contain sufficient pathogens to be a significant communicable disease hazard, especially to animals grazing in lands where the sludges are commonly discharged, and (ii) in leading to use of the forced-air BARC composting process, the first economic composting process which comprehensively destroys pathogens, for processing of sludges prior to disposal in farmland areas (Ludwig, 1983). In addition, EPA's "Superfund" program for management of hazardous wastes, while very expensive and highly controversial as to its cost effectiveness, at least has focused attention to the need for much better management of hazardous wastes and, inter alia, prohibits any discharge of these materials to the marine environment.

The EPA's position on disposal of liquid wastes into unconfined ocean waters, unfortunately, seems to make no engineering sense at all, that is, neither scientific nor economic sense, and uniformity seems to be the "name of the game". Despite strong protests and prolonged Congressional hearings on the subject, despite the excellent records of performance of submarine outfalls/primary treatment systems on the west coast, and despite the conclusive findings of SCCWRP, all of the major ocean disposal systems of the west coast are being converted to secondary treatment systems at huge construction costs, to say nothing of the extra very high annual power and other operations costs which presumably will continue on forever. One of these situations, for the City of San Francisco, is discussed in a recent issue of Civil Engineering (Murphy and Eisenberg, 1985), which notes that secondary treatment was required even with a submarine outfall 23,400 feet long, one of the world's longest. This article describes San Francisco's situation as "lucky", in that even higher levels of treatment were not required.

Importance of Estuaries

Another resultant of the ECM's push for better understanding of impacts of wastes on ecology is the large-scale program of research on the role of estuaries in the overall world ecosystem, leading to firm conclusions which recognize these zones as the most precious of the earth's areas for aquatic reproduction purposes, thus quite reversing the earlier concept that such swamps represented mosquito-borne communicable disease hazards which properly should be "reclaimed" by draining or filling. In addition, the U.S. Corps of Engineers, as the primary agency of the USA engaged in dredging of coastal areas, including disposal of spoils into coastal areas including swamps, sponsored a major and pioneering research project for developing technology on how to conduct dredging/spoils disposal with minimum adverse impacts on ecology and with use of measures for offsetting inavoidable residual adverse effects (U.S. Corps of Engineers, 1979).

These various research and development projects furnished a substantial data base for evaluating the relative role of estuarine waters, the interface between the rivers and the oceans, as compared with the rivers and ocean waters as appropriate receiving waters for waste disposal purposes.

Marine Waste Disposal in Developing Countries

Bare-Bones Engineering

As described above, the present practice of marine waste disposal in the USA corresponds to an Era of Affluence, possible and affordable in a country with enough affluence to be willing to allocate high costs for protecting environmental resources which had hardly been of public concern only a few decades earlier. The change came about following World War II when a very sizeable percentage of the adult population had enough affluence to spend vacation periods in the outdoors, engaging in fishing, skiing, hunting, swimming, boating, and other outdoor sports, and to participate as active members in wildlife and conservationist organizations, in such numbers as to establish a very powerful lobby which clamoured for and got action on the part of the government. No such affluence exists in the Developing Countries (DCs), hence there is no significant popular movement dedicated to environmental protection. Under the circumstances the case for environmental protection must be made by appeal to the social consciousness of the Decision Makers (DMs) of the government, who are usually forced by circumstances to concentrate their efforts on solving the immediate problems resulting from the advent of rapid population growth, rapid urbanization, and rapid industrialization. Under these circumstances it is not easy to gain the interest of the DMs in supporting environmental protection programs, but it is not impossible. Rather it is possible and feasible if the proposals are presented with solid justification on economic as well as socio-economic grounds.

This means not only use of the engineering/economic based approach, but adaptation of it to prepare projects requiring minimum costs and which are clearly cost effective and devoid of expenditures intended for preserving environmental resources which are clearly outside the limits of the DC's financial and economic resources. This also means abandonment of the ongoing USA concepts of appropriate environmental standards, and means setting environmental standards levels consistent with the status of the local economy. As shown in Figure 1, environmental standards are not absolute but depend on levels of affluence, hence for the DCs the appropriate pollution cleanup targets will not match those of U.S. EPA today but will correspond to those practiced in the USA in earlier eras (Kiravanichetal, et al, 1985).

Case Examples

A considerable number of very successful marine waste disposal systems have been implemented in the DCs over the past two decades, following the design concepts of 1962 noted above, based on use of a submarine outfall extending far enough offshore to reach unconfined waters, with provision for treatment only for removal of floatables, to be furnished as a second step provided that monitoring of impacts of the system on marine environment shows this to be needed. An outstanding example is the submarine outfall disposal system serving the entire city of Rio de Janeiro (Brazil), which extends several kilometers offshore from the famed Ipanema Beach area and which has provided excellent protection of Ipanema, Copacabana, and the other renowned beaches in the region. While the basic plan for this system included provisions for removal of floatables if needed, the rigorous monitoring program (which was commenced some ten years before the outfall was built) has shown this not to be necessary (Engineering-Science, 1967).

Other examples where this same design basis has been very successfully utilized (and in which the writer has participated), include the sewage disposal systems serving the metropolitan/urbanizing areas of Accra (Ghana) (Engineering-Science, 1965), Montevideo (Uruguay) (Ludwig, 1960), and the coastal cities of Puerto Rico (Engineering-Science, 1971). Examples in the planning stage include systems for serving coastal communities and industries in the Eastern Seaboard region of Thailand (Ludwig, Aug. 1982) and the metropolitan capital area of Abidjan (Ivory Coast) in Africa (Ludwig, June 1982). For the case of the Abidjan system, which involves assistance from the World Bank, the plan will eliminate the present drainage of sanitary and industrial wastes into the extensive coastal lagoon region in the midst of which Abidjan is located, and which is the capital area's most precious environmental resource, for purposes of recreation and environmental aesthetics as well as fisheries.

With respect to disposal of industrial wastes per se, as compared to sanitary sewages, the advantages of disposal to unconfined ocean waters is even greater than for sanitary sewages. Figure 2 shows, for disposal to confined waters, that the required treatment processes can be very complex and costly because of the diverse types of pollutants, including toxics, which are commonly found in industrial wastes. For disposal to unconfined waters the problem is relatively simple, and especially if the industrial effluents can share with sanitary wastes in use of a common submarine outfall (Ludwig, 1978).

An excellent summary of the use of the technology of appropriate use of unconfined marine waters for waste disposal, as described above, is given in the proceedings of the Regional Conference on Marine Waste Disposal held at Trieste (Italy) in 1972, sponsored by the International Asssociation on Water Pollution Research (IAWDR, 1972). Three of the conference's conclusions are quoted as follows:

> "The effective use of the sea or marine waters for the final disposal of adeguately treated wastes is an economic social and ecological necessity. With adequate source control of objectional materials plus treatment to remove those objectionable materials not removable at the source, an adequate dilution-dispersal system can produce minimum adverse ecological effects and possibly even beneficial effects on sea or ocean ecology. Such disposal systems will provide greater protection to the regional ecology than other alternatives."

"It appears that for open sea wastewater disposal, the minimum cost and optimum benefit system would entail a primary treatment plant giving special attention to the floatables removal plus an adequate submarine outfall to achieve sufficient initial dilution of the waste into the sea water (at least 70 to 100 parts of sea water per part of waste water) and a considerable transport time to the beach areas (or other areas) needing a high degree of protection."

"For open sea wastewater disposal systems there appears to be little if any justification for costly wastewater treatment processes (such as secondary or tertiary treatment). Contrary to popular belief, secondary treatment plants, while effective for reducing BOD and suspended solids, do not achieve much extra removal of coliforms nor of refractory materials such as organic toxicants and biostimulants. In fact, secondary treatment plants actually introduce additional biostimulatory factors."

One of the salient points brought out in this summary relates to the relative degrees of adverse effects of disposing of waste effluents into inland rivers or to estuaries or other confined waters as compared to use of a submarine outfall for reaching the open sea. A common "mis-notion" on the part of marine ecologists is that waste effluents should be discharged to the inland rivers or to the estuaries, following proper treatment (meaning primary/secondary treatment), thus avoiding damage to the marine environment. Aside from not including due consideration of the relative ecological values of the riverine and estuarine environments compared to the ocean, this notion hardly appreciates the fact that the primary/ secondary treatment processes do not remove much of the toxics in the wastes (the processes are intended to remove degradable organics), hence these toxics will in any case flow into the sea and on the way will also permeate the riverine and estuarine zones which generally represent much more fragile and valuable ecologies than the ocean area of concern.

Major Capital Areas in Southeast Asia

Of the various capital areas of Southeast Asia, both Manila and Kuala Lumpur have metropolitan sewerage systems underway. The system of Manila, largely constructed over the past several years with World Bank assistance, when completed will discharge the waste effluents via submarine outfalls into the offshore waters of Manila Bay. The system at Kuala Lumpur (Ludwig, 1986), now being considered for upgrading with assistance from the World Bank, will depend for treatment mostly on use of plastic-media trickling filters, with the effluents discharged to the river system which flows downstream some 20 km before reaching the coastal port zone at Kelang (Engineering-Science, 1985). In this case the urbanizing and port areas downstream of Kuala Lumpur are also planning to implement their own sewerage systems, to prevent the downstream zone from turning into a sanitation mess. The downstream treatment problem will be compounded by the fact that Kuala Lumpur will use up most of the dissolved oxygen capacity of the Kelang riverine system which drains the Kelang Valley region.

The situations at Bangkok and Jakarta lag far behind those of Manila and Kuala Lumpur.

Jakarta

The problem of many major capital cities is the non-affluence of the bulk of the population, who are mostly former farm families recently migrated to the capital, where, poor as they are, they are better off generally than their relatives who remain in the country. Under these circumstances, there is no hope in the foreseeable future for affording construction in their living areas of a comprehensive sewerage system (such as that at Kuala Lumpur). Instead it will be necessary to continue to depend for excreta disposal on use of individual subsurface leaching units for most of the poor people areas, with sewers limited to the commercial, affluent residential, and industrial zones. Although a comprehensive plan of sewerage and sanitation was prepared for Jakarta in the 1970s, implementation of the sewerage system will be a slow process, and only the first phase of construction, covering about 10 percent of the city, has been funded (Ludwig, 1984). As a result the river system passing through and draining through the city is usually septic/black in the dry season due to inflows of both sullage and solid wastes. Other than for their uses for navigation, practically all the beneficial uses of the Jakarta rivers have been lost, including fisheries, water supply, recreation, and bathing and washing.

In addition, due to contributions from industries, the pollutants reaching the Bay of Jakarta contain appreciable amounts of heavy metals or other toxics which are accumulating in the bottom sediments. To prevent continuing accumulation to levels which would contaminate the bay fisheries, consideration is now being given to establishing a project for systematic collection and safe disposal of the hazardous wastes produced by industries throughout the metropolitan area.

Bangkok

Bangkok is located a short distance from the Gulf of Thailand, on both sides of the Chao Phya River which is Thailand's major river draining the main central/northern zone of Thailand. Along with the Chao Phya, three other major rivers also drain into the Upper Gulf, and the continuing urban growth in the zone (now about 6 million population) is progressively transfering the Bangkok/Upper Gulf region into a megalopolis which will likely extend the urbanizing complex all the way to the sea (Ludwig, June 1973). The four rivers, in their lower reaches passing through the urbanizing region, are heavily polluted in the dry season and no longer support any beneficial uses except navigation. Moreover their discharges into the Upper Gulf have markedly reduced the very lucrative Upper Gulf fisheries. Unfortunately, no comprehensive plan of water pollution control has ever been prepared for Bangkok or the overall urbanizing region. The urgently needed first step in bringing the situation under control is to prepare such a plan (Kiravanich and Ludwig, 1979) so that an appropriate regional system can be gradually implemented on a step-by-step basis. As it is, without the plan, it is not possible to delineate the appropriate components for the regional system nor to give them meaningful priorities.

Summary and Conclusions

Summary

(a) The majority of major cities of the world are located on or near the oceans and hence the non-managed pollutants from these centers drain to the marine waters, passing into and down the river system, through the estuarine zones, and then into the unconfined ocean waters where their accumulated wastes (except for floatables) are diffused and diluted to non-detectable levels. Except for navigation, the beneficial uses of the rivers are lost. Moreover, before the waste materials are diffused into the open sea, they greatly damage the very valuable fishery reproduction in the shallow estuarine zones. While these shallow estuarine waters make up a negligible portion of the total marine water volume, they are all-important in terms of beneficial uses of interest to man.

(b) Because of rapidly increasing pollution of rivers, estuaries, and nearshore coastal waters due to increasing population and industry, sewage treatment practices have evolved over the past century for processing liquid wastes prior to discharge, essentially to reduce their organic pollution loads.

This technology has been oriented to suit the limitations of the shallow/confined waters into which the treated effluents have been commonly discharged, hence the treatment processes have focused on removal of settleable/floatables solids, which can form sludge banks in the shallow waters, and on removal of degradable organic materials which deplete the oxygen resources of the receiving waters. This technology has been engineer-oriented, with the type and degree of treatment chosen to match the receiving water conditions so as to protect the aquatic environment but also make use of its waste absorbing capacities.

(c) Beginning in the 1960s it has been found that, when the wastes can be directly discharged to the open or unconfined seawater by means of a submarine outfall, the receiving water conditions are markedly different so that the conventional parameters of BOD etc., used for conventional design of treatment systems, are not of significance, and instead the only parameters that do appear to be of significance are floatables and coliforms, both of which can be returned by onshore winds/currents to enter into the zone of shallow water to be protected. For most systems discharging into the open seas, it appears that only floatables removal may be required.

(d) In the USA, the U.S. EPA has, since the 1960s, taken over responsibility/authority for regulating waste discharges to environment, and the control of such regulation has progressively passed from engineers to attorneys, and as a result the use of engineering/economic solutions for solving waste management problems has been reoriented into an overly simplistic system of uniformity whereby the same minimum level of treatment is required for all wastes regardless of the capabilities of the receiving waters. As a result the communities and industries in the country located along the west coast and elsewhere (including the Gulf of Mexico), which can readily and economically build submarine outfalls reaching into the unconfined offshore waters, are being required to upgrade their levels of treatment from pirmary to secondary at the cost of hundreds of millions of dollars, with little if any real measurable gain in environmental protection. This is the opposite of good engineering practice.

(e) All of the available scientific data indicate that the optimal disposal system, where the non-confined seawaters can be feasibly reached by use of a submarine outfall, is to utilize such an outfall together with treatment only for removal of floatables. Thus the wastes do not enter into the shallow waters of sensitive ecology but instead are by-passed for direct discharge into the unconfined waters. The data indicate that the build-up in the ocean waters and bottom sediments of the constituents reaching the open sea will be negligible and of no significance in altering the overall ocean physical/ chemical/biological balances, even with discharges indefinitely into the future.

(f) In developing countries, where the affluence of the USA is non-existent and where most people are quite poor, the expensive non-cost-sensitive environmental control standards of the USA have little if any application. Instead, if water pollution control systems are to be approved and funded by Decision Makers, they must be clearly cost effective. In this context marine waste disposal systems have been and are now being planned and built in DCs which follow the logical submarine outfall/floatables removal concepts as noted above. Probably the most interesting of these is the system serving Rio de Janeiro, where a submarine outfall extending several kilometers offshore affords excellent protection of the beaches in the vicinity (Ipanema and Copacabana), with no treatment of the waste at all (because of the favorable offshort currents pattern).

Conclusions

(a) The conventional technology for design of systems for treating liquid wastes from municipalities and industries, which is based on essentially the dissolved oxygen parameter plus removal of settleable/ floatable solids which can form sludge banks in rivers and other confined receiving waters, has virtually no scientific basis for design of treatment systems discharging to open or unconfined marine water via a submarine outfall. For such discharges the applicable design parameters are removal of floatables and of coliforms, which might be returned to the nearshore zone of marine water which needs to be protected for swimming, fisheries, and other beneficial uses.

(b) Discharge to the open sea is advantageous, when the open sea can economically be reached by means of an outfall, not only because of much lower costs but because this affords much better protection of the regional ecological values and moreover furnishes valuable nutrients to support marine ecology. When waste effluents are discharged to rivers or confined estuaries/bays, their toxic constituents (which are only partially removed by conventional/economic treatment) thus permeate the ecologically sensitive confined waters while passing on to the relatively insensitive open sea zone.

(c) The current U.S. EPA practice of requiring secondary treatment for effluents discharged to the open sea, and which prohibits discharge of organic sludges to the open sea, represent the opposite of good engineering practice and is causing urban centers on the west coast of the USA and elsewhere to waste hundreds of millions of dollars.

(d) There is no real evidence that the toxic or pathogenic constituents contained in waste effluents discharged to the open sea will result in any harm to the marine environment. When diffused into the sea, the resulting additions to the ocean's basic levels of these constituents are insignificant, even for discharges over hundreds or even thousands of years.

(e) An urgent need which should be addressed by U.S. EPA is to produce a "Manual of Appropriate Design Practice for Disposal of Sewage and Industrial Wastes from Coatal Communities", which evaluates the costs and levels of protection to the regional ecology for three alternative places of discharge, (i) to the inland river, (ii) to the confined estuary or bay, and (iii) to the open sea, based on the known scientific facts relating to effects of wastes upon sensitive aquatic ecology. This would upgrade the use of alternative (iii) from its present status, whereby it is considered ecologically less desirable, to its proper status as the most ecologically protective. The presently available data indicate that alternative (iii) will be the most economic and will afford the best ecological protection, whenever the open sea is economically reachable by use of a submarine outfall.

(f) Another task which should be considered by U.S. AID, which would be extremely valuable to developing countries in promoting their environmental pollution control efforts, would be to sponsor a program by U.S. EPA for adding an additional chapter to EPA's many very valuable manuals on pollution control technology. As now prepared these manuals present the basic background data, then in the final chapter these data are interpreted to develop conclusions on appropriate treatment practices and standards for USA conditions. The purpose of the extra chapter would be to interpret the basic data to develop similar conclusions appropriate for developing country conditions. Thus, at very small investment, the USA could greatly enhance its program for assisting the DCs in solving their very difficult problems of environmental pollution control.

Bibliography

CSWRCD (California State Water Resources Control Board). Guidelines for the Preparation of Technical Reports on Waste Discharges to the Ocean and the Effects of Waste Discharges on the Ocean. Oct. 1972.

Engineering-Science, Inc. Report on Submarine Outfall Clay Slurry Disposal System at Seventeen Mile Drive on Monterey Bay. Prepared for San Luis Obispo Regional Water Quality Control Board by Engineering-Science, Inc., Arcadia, California, 1963.

Engineering-Science, Inc. Report on Metropolitan Sewerage System for Accra-Tema Urbanizing Region. Prepared for UNDP/WHO/ Government of Ghana by Engineering-Science, Inc., Arcadia, California, 1965.

Engineering-Science, Inc. Proposed Comprehnsive Plan of Sewage Disposal for Rio de Janeiro. Prepared for State of Guanabara, Rio de Janeiro, 1967.

Engineering-Science, Inc. Report on Master Plan of Sewage Disposal for Coastal Cities of Puerto Rico. Prepared for Government of Puerto Rico by Engineering-Science, Inc., Arcadia, California 1971.

Engineering-Science, Inc. Proposed Water Pollution Control Plan for Oahu. Prepared for City of Honolulu by Engineering-Science, Inc., Arcadia, California, 1972.

Engineering-Science, Inc. Report on Proposal Upgrading of Kuala Lumpur Metropolitan Sewerage System. Prepared for City of Kuala Lumpur by Engineering-Science, Inc., Arcadia, California, 1986.

IAWPR (International Association on Water Pollution Research). Summary Report of Regional Conference on Marine Water Pollution of International Association of Water Pollution Research. Trieste (Italy), Pergammon Press, 1972.

Kiravanich, P. and Ludwig, H. A Proposed Action Programme for Water Pollution Control for Bangkok/Inner Gulf Megalopolis Region. National Environment Board, Bangkok, 1979.

Kiravanich, P., Sirithan, P., and Ludwig, H. Environmental Quality Standards and Criteria, the Problem in the Developing Countries. National Environment Board, Bankgok, June 1985.

Ludwig, H. Report on Proposed Metropolitan Sewage Disposal Plan for Montevidea, Uruguay. Prepared for WHO/Pan American Health Organization, 1960.

Ludwig, H. _The Case for Advanced Waste Treatment, Circa 1971_. Water and Sewage Works, Dec. 1971.

Ludwig, H. _Water Pollution Control in Metropolitan Bangkok_. Prepared for National Research Council and USAID, Bangkok, June 1973.

Ludwig, H. _Criteria for Marine Waste Disposal in Southeast Asia_. Regional Conference of International Association of Water Pollution Research, San Remo (Italy), Dec. 1973.

Ludwig, H. _Aesthetics - A Key Factor in the Technology of Marine Waste Disposal_. Regional Conference of International Association for Water Pollution Research, San Remo (Italy), Pergammon Press, Dec. 1973.

Ludwig, H. _Environmental Reconnaissance for Zone of Pattaya_ Prepared for National Environment Board of Thailand, 1975.

Ludwig, H. _Guidelines for Preparation of Odinances for Regulating Sanitary and Industrial Waste Discharges for Municipalities in Indonesia_. Prepared for UNDP/Institutes of Hydraulic Engineering, Bandung, May 1978.

Ludwig, H. _Design of Marine Waste Disposal Systems for Industrial Wastes_. Regional Conference of International Association for Water Pollution Research, Sorrento (Italy), Pergammon Press, June 1978.

Ludwig, H. _Report on Recommended Plan of Water Pollution Control for Metropolitan Abidjan (Ivory Coast)_. Prepared for Government of Ivory Coast and World Bank, Abidian, June 1982.

Ludwig, H. _Environmental Assessment for Eastern Seaboard Development Planning Project_. Prepared for National Environment Board, Bangkok, Aug. 1982.

Ludwig, H. _Environmental Impact Assessment for Agriculture Waste Recycling Project_. Prepared for Asian Development Bank, Manila, 1983.

Ludwig, H. _Report on Jakarta Sewerage and Sanitation Project_. Prepared for World Bank, 1984.

Ludwig, H. _Report on Review of Proposal Metropolitan Sewerage System Improvements for Kuala Lumpur_. Prepared for World Bank, March 1986.

Ludwig, H. and Onodera, Ben. _Scientic Parameters of Marine Waste Discharge_. International Conference of International Association on Water Pollution Research, London, Pergammon Press, 1962.

Ludwig, H. and Scherfig, J. Determination of Floatables and Hexane Extractables in Sewage. International Conference of International Association on Water Pollution Research, Munich, Pergammon Press, 1967.

Murphy, G. and Eisenberg, Y. San Francisco Outfall, the Champ? Civil Engineering, American Society of Civil Engineers, Dec. 1985.

OCBS (Orange County Board of Supervisors). Report on Sewage Disposal Program for County of Orange. Prepared for County of Orange by Board of Consultants, Santa Ana, California, 1946.

SCCWRP (Southern California Coastal Water Research Project). Annual Reports for years 1970 to 1986.

U.S. Congress, Subcommittee on Water Resources. Modification of Secondary Treatment Requirements for Discharges into Marine Waters. Congressional Hearings, Washington, D.C., 24 May 1978.

U.S. Corps of Engineers. Final Summary, the Dredged Material Research Program. Vicksburg, Mississippi, June 1979.