POLLUTION ENGINEERING AND TECHNOLOGY/3

Wastewater Renovation and Reuse

edited by Frank M. D'Itri

Wastewater Renovation and Reuse

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Nothing in life is to be feared, it is only to be understood. Now is the time to understand more, so that we may fear less.

Marie Curie

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PREFACE

An international conference on problems of renovating and recycling municipal wastewater was held at the Bellagio Study and Conference Center in Bellagio, Italy, July 16-21, 1975. This meeting was organized by the Institute of Water Research at Michigan State University and was supported by the Rockefeller Foundation. It brought together a small group of scientists who have made significant contributions to the study of wastewater renovation. The conferees represented Denmark, the Netherlands, Israel, the United Kingdom, Hungary, Canada, West Germany, Mexico, and the United States.

The objectives of the conference were fourfold: first, to exchange information on the most up-to-date wastewater renovating and reuse technology throughout the world with primary emphasis on the detection and deactivation of viruses and pathogenic organisms; second, to determine the possibility of utilizing the nutrients in wastewater for the cultivation of fish as a protein source for human beings; third, to examine the social impact of wastewater reuse in different countries and methods which can be employed to gain public acceptance for its use; and finally, to stimulate more cooperative international research among scientists who must solve these complicated problems.

Since the interdisciplinary approach to wastewater renovation and reuse is essential to bring to bear the many talents required to solve this multifaceted problem, the conference was designed to encourage a maximum of discussion between participants and to share information about current areas of study and future research.

This brief overview of the general scope of the twenty papers makes no attempt to evaluate their relative contributions. Rather, it is intended to offer the reader a few of the major points that were raised and the reactions to them. The authors not only describe their immediate research, but they include rather comprehensive overviews of similar types of research that are in progress or were previously conducted in other places as well as the historical

precedents and analyses. In some cases, the economics involved as well as the legal issues and social attitudes were also explored.

Although they share the same general area of expertise, wastewater renovation and reuse, a group of twenty scientists with different specializations and backgrounds representing nine countries were bound to have a variety of perspectives. Sometimes similar but often quite divergent in their views, they confronted one of the most important issues in both highly developed and more primitive societies today. Highly industrialized nations have a problem of wastewater disposal while underdeveloped countries, particularly those in arid parts of the world, need to develop low cost, low technology methods of conserving water.

As all nations have an obligation to conserve scarce energy resources the scientists agreed that wastewater is increasingly being regarded as a natural resource because of the fertilizers that it contains. Therefore, many experimental projects had been designed to develop effective ways to utilize wastewater as fertilizer for aquatic and terrestrial growth of plants and animals. This raised important questions about the possible health hazards associated with bacteria and viruses that may concentrate in the wastewater and then pass up the food chain to higher animals and ultimately to human beings. A second concern was that toxic metals would render the soil permanently sterile after long accumulation or contaminate the groundwater supplies.

All of the experts agreed that it is essential to collect information as soon as possible about the effects of using wastewater for aquatic and terrestrial plant and animal life in order to determine positive and negative effects. They stressed the importance of interdisciplinary studies and cooperation to design the new facilities that will be required, and the dissemination of expertise involved in growing plants and animals to be monitoried as well as testing methods for toxic contaminants and pathogens where the kind and quality of the wastewater is constantly changing.

In the review of current information, one outstanding factor was that reclaiming wastewater is an ancient practice that is widely

accepted in some areas, particularly in arid countries. Therefore, some information is available about the practice and its acceptability. In India fish are sold directly out of the waste lagoons, and in Mexico City the parks around Chapultepec Palace are irrigated with wastewater from the sewage treatment plant. At Santee, California, children swim in a pool and fish in recreational lakes that are fed by reclaimed wastewater.

A wide range of other experiments utilize wastewater or attempt to improve its quality in one way or another. Where the results have been negative to date, the unsuccessful methods point the direction for others that can be more successful. Depending on the supply of freshwater, pressure may be greater to remove the wastewater than to recycle the nutrients; and these may be mutually exclusive goals with the present technology.

To recycle the nutrients, wastewater is being applied in a number of aquatic experiments. In Florida the growth of cypress wood is being increased by nutrients when the wastewater is pumped into cypress domes (Odum). In all cases the wastewater is pretreated and diluted. Thus, pilot projects have been established to treat wastewater and use the nutrients in food chains. Freshwater was added to wastewater for hydroponic experiments to grow vegetables (Gordon). And in a marine aquaculture pilot plant tertiary treatment removes the nitrogen to protect waters along the coastline through a complex experimental food chain in which algae, shellfish, and invertebrates assimilate the nutrients and, in turn, feed lobsters and blackback flounders. Polishing the wastewater with the growth of seaweed is the final step before it is discharged into the sea (Ryther).

Although much concern was raised at this conference and in other places about public health issues connected with wastewater reclamation, it was pointed out that the public accepts without question much indirect recycling of wastewater in surface water supplies that are heavily polluted with municipal and industrial wastes. Drinking water supplies drawn from rivers that have received waste discharges

upstream endanger the health of millions of people. Chlorination inactivates bacteria but not the many enteric viruses that can cause disease (Kristensen). While ozone might help control them, proper treatment facilities have not been installed. American standards should be as high for water drawn from surface supplies as for recycled wastewater that is consumed (Shuval). Regretably, very few contaminants are listed for American drinking water; in contrast, the USSR now prohibits over 400 and continues testing.

Where waterways are contaminated with poisonous materials, fish can serve as indicator organisms to point out the effect of disease bearing viruses or carcinogens. More study is needed on tumors in fish and other animals as reference models for human beings in whom 85 percent of cancers are caused by the effects of air, food, and water (Sonstegard). On the other hand, where the wastewater is free of contaminants, fish can help improve the wastewater treatment. They can be grown commercially on nutrients in the manures of cattle and chickens. The public may accept small fish raised in wastewater ponds if they are later released into the open sea or fattened in clean water. And the commercial fish ponds in Israel are a prototype of economical, low technology systems that may be applicable in areas with limited resources and non-industrial wastes. Aquaculture could be combined with cattle farms where excess manure is available as in the Israeli kibbutzim (Allen and Hepher).

Water has been known to be a vector of human pathogenic bacteria, viruses, protozoans and helminths associated with enteric diseases at least since Snow studied cholera in London in 1854; but much more information is required not only about their effect on fish but also on plants and animals if the wastewater is sprayed on the soil. Spraying sewage on the land was a popular method of disposal in the Nineteenth Century, but it was halted when better sanitary practices were implemented. The reinstatement of old techniques must include better monitoring of potential pathogens.

Nitrogen in wastewater can be either a nutrient or a pollutant depending in large measure on the rate of denitrification (Broadbent).

It can be removed either by algae in water or by plants grown in soil (Ball). In some cases the roots of plants take up nutrients and improve the soil quality by subsequently raising the humus content (Vermes, Broadbent). Because of the possibility that pathogens will also be carried to the plants with the nutrients, industrial and fodder crops with less public health risk are grown at Debrecen, Hungary (Vermes), and Braunschweig, Germany (Tietjen). In Mexico wastewater is used to irrigate parks, for industrial cooling water, and on farms; but concern was raised about fecal coliforms and viruses being passed to the consumer (Aguirre). And a 1970 cholera outbreak in Jerusalem was attributed to contaminated farm produce (Shuval).

Since the risk of infection may be greater if viruses are inhaled instead of ingested, shelter hedges were built at Braunschweig to prevent this as well as wind erosion of the land (Tietjen). Moreover, viruses associated with solids appear to survive in the soil for at least 28 days and may travel much farther than was previously thought (Wellings). If they penetrate to the groundwater, they follow its course and have been recovered in 10 foot deep wells as well as several feet outside a cypress dome where the clay retaining layer had been punctured (Wellings). More precise techniques are needed to measure the bacteria and viruses in water and those associated with solids. Currently, many findings report only part of what is present, which endangers sensitive individuals who may be infected by very small quantities. Moreover, the process requires highly experienced people in specialized laboratories to isolate some of the enteric viruses (Lund).

In addition to viruses, coliforms, and other pathogens that may transmit and cause diseases, chemical contaminants may be carcinogenic, mutagenic or teratogenic, especially where the wastewater has a high percentage of industrial wastes. The primary recommendation was that these contaminants be kept out of the wastewater altogether. This prevents their accumulation; slow if the wastewater is sprayed on the land or more rapid if the contaminants are concentrated in sludge. Crops may be damaged initially and then the soil might be

permanently sterilized. Cadmium in rice has caused serious illness in Japan already. Until the contaminants are kept out of wastewater, a second alternative is to isolate them in limited areas (Purves). Another possibility is to limit the contamination by proper cropping systems on sewage sludge amended soils. Thus, while corn accumulates lead in the stems and leaves but not the grain, it can be used as grain but not silage (de Haan).

Wastewater is contaminated by widely varying components in different places and at various times. Therefore, a central research problem is to maintain and monitor the wastewater for consistency. Usually it has already been released before a sample can be analyzed. Therefore, faster, better monitoring techniques are needed as well as storage for the water until the results are received to insure that it meets proper standards, especially if it is to be used for drinking (Shuval).

In addition to reviewing the major research by participants, a second theme of the conference was to suggest what should be done in the future both in the specific fields and in general. As priorities for future research were set, public health, especially the fate of pathogenic viruses in wastewater, was the first priority followed by technical and economic issues (Toenniessen, Bahr). Economic issues predominantly focused on the costs of different types of wastewater reclamation processes in comparison with those used traditionally and also the needs in different areas of the world. Some areas with more technology and higher living standards are in need of labor saving methods (Tietjen) whereas developing countries need simpler technology that is more labor intensive (Aguirre). Cost and quantity of available land also affected the selection of treatment methods (Gordon), and the group was conscious of the need to offer alternatives for the various situations.

Although health and technology were accorded the highest priorities for immediate research, legal, political, and social concerns were considered as important. However, the health and technical problems must first be resolved in order to present a solid