Potential Health Hazards Associated with the Disposal of Sewage Sludge on Agricultural Soils in Western Oregon.

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ABSTRACT

This research project was undertaken to determine the extent of potential health hazards associated with the land application of anaerobically-digested sewage sludge. This study was restricted to the microbiological aspects and complemented an Oregon State Agricultural Experiment Station project which has examined heavy metal accumulation and other non-biological hazard possibilities. The principal justification of the research presented in this report was due to concerns as to whether the cool, wet, climate which occurs in the Willamette Valley over much of the fall, winter, and spring months would extend the survival times of fecal bacteria applied in sewage sludge to such a degree that ground or surface waters could become significantly contaminated. This was an important consideration because of the continued expansion of land disposal of sludges by municipalities in western Oregon.

The major research findings include: 1) The fecal streptococci were found to be unsuitable as indicators of recent pollution in soil. These organisms must be used with great caution, if at all, when monitoring fecal contamination in the environment, 2) Fecal coliform bacteria were mostly filtered out within the top 100 cm of soil and only a few cells reached this depth even at two sites which contained perched water tables near the soil surface for extended periods, 3) The expected prolonged survival of coliform bacteria during the winter was not observed and the winter die-off rates resembled those obtained for the summer sampling, 4) Based on the research data obtained in this study it would seem that undue constraints on the year-round application of sewage sludge to Willamette Valley soils, in proper amounts, would not be warranted as far as the transmission of bacterial disease agents is concerned.

DISCLAIMER

I. INTRODUCTION

Recent increases in the practice of applying sewage wastes to soil used for the growing of plants have made it desirable to evaluate not only the beneficial results of such applications but also any attendent problems. Several benefits are recognized and some are clearly of major importance. Depleted plant nutrients can be replaced in the soil. Soils can be improved in physical structure and some soils of very poor structure can be reclaimed. Waste water can be utilized directly for crops or stored underground for later use after purification by passing it through the soil. Pollution of streams, rivers, lakes, and oceans with sewage wastes can be prevented or largely avoided. In view of these benefits and as a result of government regulations and programs, more than 1,000 communities in the United States are currently landspreading sewage wastes and many more are contemplating it (Sullivan et al., 1973).

Although the above benefits have great practical significance, there are problems concerning toxicity to plants, animals, and man as a result of high concentrations of heavy metals in some sludges and potential pathogens and/or allergens present in sludges or developed in them during composting. Problems from heavy metals are long-lasting since, once in the soils, these metals may not be removed or changed into unavailable forms for a long time. Enteric and other pathogens, on the other hand, may persist for periods from a few days to a few years but eventually will be destroyed or lose infectivity.

Major increases are currently taking place in the United States in the application of sewage wastes to agricultural land, and there are serious questions relating to whether such applications involve hazards from human disease organisms. Evidence on the matter is still inadequate. Processed sewage wastes often contain residual pathogenic viruses, bacteria, cysts of protozoa, and ova of helminths, but most sewage-related disease outbreaks have been attributed to use of raw sewage waste water, raw sludges, or night soils on food crops consumed raw, to contamination of drinking water from septic tanks, or to consumption of raw shellfish from sewage-polluted waters. Although subject to relatively high levels of exposure to pathogens in aerosols, waste water treatment plant workers appear to be unaffected, but data on this is limited. Percolation of waste water at a moderate rate through soils of medium to fine texture removes most bacteria and viruses; pathogen movement in surface runoff water may present a greater hazard for spreading disease. Techniques that completely disinfect sludges may fail to stabilize them so that putrefaction is a problem. Proper composting stabilizes raw sludge and destroys most pathogens. Certain fungi and actinomycetes generated during composting may have allergenic potentialities of import for workers at sludge composting sites.

The research reported in this document was undertaken in order to: (1) monitor the survival of fecal coliforms in soils to which sewage sludge was amended, and (2) to evaluate the fecal streptococci and assess their suitability as indicators of fecal pollution in soil systems. All field research was conducted on soils which are representative of several of the major types located in the Willamette Valley, Oregon.

II. LITERATURE REVIEW

The research literature dealing with health hazards of biological etiology from the land application of human waste was recently reviewed by Burge and Marsh (1978). Much of the following information is adapted from their review, with additional information added of more recent origin or related specifically to conditions in the Pacific Northwest.

2.1 Pathogenic Organisms Found in Sewage

The principal pathogens found in sewage can be divided into four groups: bacteria, protozoa, helminths (intestinal worms), and viruses. These organisms and the diseases they cause are represented in Table 1 (Burge and Marsh, 1978).

Sewage treatment generally reduces the numbers of these organisms, but evidence is abundant that effluents and sludges contain detectable amounts of each of the above four groups. Table 2, taken from Kabler (1959), is a partial representation of data showing percentages of organisms removed from waste waters by various sewage treatment processes.

The occurrence of pathogens in sewage wastes can be demonstrated by an example from Colorado. In that state, as in other parts of the Southwest, sewage wastes are used for crop irrigation. Research on row irrigation of vegetable crops grown in the state has been reviewed by Sepp (1971). Effluent water that had received primary treatment and chlorination contained only about 1% of its initial level of coliform and enterococcal organisms, but numerous ascaris eggs and amoeba cysts were present. About 50% of the samples of river water receiving the sewage effluent and used for irrigation contained salmonellae. No shigellae were isolated while amoeba cysts and ascaris ova could be isolated from the river water. Two of 34 vegetable samples contained ascaris ova and two were from a field irrigated with river water that received raw sewage.

In examining sewage for pathogens, Heukelekian and Albanese (1956) found tubercle bacilli in raw sewage from four tuberculosis sanitoria but not from three municipalities. They found that trickling filters and activation did not remove tubercle bacilli from sewage waters but chemical coagulation with $FeCl_3$ and slow sand filtration did. The sludges produced by primary and secondary processes contained tubercle bacilli that were not destroyed by anaerobic digestion or by air drying of the sludges.

Processed municipal waste water and sludges may contain all of the four groups of pathogens shown in Table 1 (Dunlop, 1968; Foster and Engelbrecht, 1973; Kabler, 1959; and Sepp, 1971). In a paper dealing with enteric viruses, Berg (1966) has stated that neither secondary treatment nor chlorination removes all viruses from effluent. Mack et al. (1962) found the greatest number of virus particles in sewage during the summer and fall.

Viruses are able to survive long enough in waste water, natural water, and other water supplies to allow transmission to humans, according to Podusha and Hershey (1972). Virus concentrations of 17.9 PFU (plaque forming units) per 100 ml in raw sludge and 0.85 PFU per 100 ml were found in digested sludge (Palfi, 1973). Digested sludge was considered a potential source of infection. Pathogenic bacteria, viruses, protozoa, amoeba cysts, and helminth eggs can survive sewage treatment and be included in the sludge; they are not always destroyed by anaerobic digestion (Fair et al. 1971).

2.2 Disease Incidents Associated with Land Application of Sewage

All of the disease outbreaks reported by Sepp (1971) involved the use of night soil, raw sludges, or raw waste water. Clearly, the use of night soil or raw sewage wastes in growing vegetables to be eaten raw can result in outbreaks of typhoid fever, cholera, ascariasis, amoebiasis, bacillary dysentery, enteric fevers, and diarrhea. Numerous infections of city dwellers with round worms were caused in Germany by the eating of sewage-polluted vegetables. Annual outbreaks of typhoid fever in Paris resulted from the eating of raw vegetables grown illegally on a sewage farm utilizing raw waste water. China has had many severe outbreaks of ascariasis and in some provinces practically all of the inhabitants were reported to have been infected as a result of fertilization of vegetables with night soil.

An outbreak of gastroenteritis in 1965 in the southwestern portion of Madera, Calif., was reported by Browning and Mankin (1966). Domestic water there came exclusively from two wells, one of which was later shown to be polluted. Investigation showed that this well was being polluted with raw sewage used to irrigate an adjacent sewage farm. A valve in the well piping system has been excavated for repairs and a gopher hole from the edge of the sewage farm led into the excavation. Openings were noted between the excavation and well pit and between the well pit and well casing. Although the disease agent isolated from the afflicted people, *Shigella flexneri*, was not found in the well, the well was heavily polluted with coliform bacteria. A dye poured into the excavation appeared in the water coming from the well.

Incidence of shigellosis, salmonellosis, typhoid fever, and infectious hepatitis was 24 times higher in communities in Israel practicing overhead irrigation of agricultural land with waste water than in communities not engaging in irrigation with waste water (Katzenelson et al., 1976). The only treatment of the water prior to use was a period of 310 days of standing.

Salmonellosis, responsible for more than two million cases annually in the United States, has not been frequently associated with sewage wastes, even though salmonella are readily detected there (Nat. Res. Counc. Comm. on *Salmonella*, 1969). The spreading of barnyard and poultry manure on land used for production of food crops has not been recorded as a significant source of salmonellosis, in spite of the fact that the same organisms which produce salmonella infection in poultry, cattle, and swine also produce it in man. Actually, most salmonellosis seems to arise from contaminated meat products, especially fresh pork and poultry as well as processed foods (Nat. Res. Counc. Comm. on *Salmonella*, 1969). In 1967, most cases of salmonellosis were attributed to faulty food handling practices in food service establishments or in the home. Such practices often involve incomplete cooking of contaminated meats or other foods or the contamination of foods to be eaten raw.

Salmonellosis, however, would still be transmitted from person to person even if processed foods were eliminated as a source (Nat. Res. Counc. Comm. on *Salmonella*, 1969). People can become carriers; although a permanent carrier is a rarity, many carriers are short-term convalescent or active cases. Infants, once infected, frequently become longterm carriers and cause familial outbreaks. Pets, including turtles, reptiles, birds, cats, and dogs can also be a source of the pathogen.

Activated sewage sludge spread on a hospital lawn has been implicated in an outbreak of salmonellosis in a hospital nursery (Nat. Res. Counc. Comm. on *Salmonella*, 1969). In another instance, several children were infected with salmonellosis from sewage sludge spread on the lawn of their home, according to the Maryland Department of Health and Mental Hygiene. The origin of the sludge was not known.

Leptospirosis outbreaks have been linked with contamination of water by urine from humans, pets, and livestock (Craun, 1974). Sixty-one Washington State teenagers were infected after swimming in an irrigation canal. The swimming hole was 183 m (200 yards) downstream from a site frequented by cattle shedding leptospires. The same malady in some Texas children was traced to the family's pet dogs. Serological tests in a central coastal region of the Caspian Sea showed that 47% of the humans and 40% of the livestock were antibody-positive to leptospires. The reactions most frequently encountered were against two species of leptospires common to both populations, indicating cross infectivity.

Survival of viruses in waste-water treatment processes and their introduction into surface water with waste-water plant effluents might be an important potential source of enteric virus diseases. Actually, the number of cases of enteric virus diseases is surprisingly small in relation to the estimated quantities of viruses in most waste waters (Grabow, 1968). Many claims were made in the 1930's and 1940's to the effect that drinking water was a vehicle of spreading poliovirus, but most investigators remain unconvinced of this (Mosley, 1965). Of the enteric virus diseases, only infectious hepatitis appears to be truly waterborne (Mosley, 1972). The predominant method of transmission of enteric