



Project Summary

Sewage Sludge Viral and Pathogenic Agents in Soil-Plant-Animal Systems

G. T. Edds and J. M. Davidson

In this study, a multi-disciplinary approach was used to determine the ultimate fate of various toxic elements or pathogens associated with Florida and Chicago municipal sludges when applied to soil-plant-water systems as an alternative method for the utilization of recycled digested municipal sludges. Determination was made of the physiologic, pathologic, growth, and reproductive responses of cattle, swine, and poultry that were fed sludges, grains, or forages from soils pretreated with urban liquid digested sludges, as well as health effects in mice receiving liver or kidney tissues from steers and swine exposed to such feeds or contaminants.

There were minimal differences in growth performance or egg production in cattle, swine, or poultry fed forage or grain from soils pretreated with a variety of urban sewage sludges. Cattle and swine tissues, when fed to mice, resulted in alterations of the normal mineral balance as well as reproductive performance. Tissues from animals intended for human consumption exposed to sarcocyst contaminated sewage sludges may serve as health hazards for animals and humans.

Application of urban sludges at 19.8 ton/hectare produced equivalent plant growth stimulation for corn, barley, wheat, and sorghum as commercial fertilizers. Certain bacteria, commonly associated with sludges, disappear in a few days after soil or

plant application. However, certain viruses and parasites were shown to persist. New and improved methods were developed to monitor persistence as well as assay for the presence of drugs or other hazardous materials.

This Project Summary was developed by EPA's Health Effects Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Discussion

This research was initiated to determine if digested sewage sludges could be applied to a soil-plant-animal system to improve soil fertility, increase forage and grain production, and provide animal feeds necessary for optimal animal growth or performance without posing a hazard to plant and animal production or human health. The studies also included the persistence and movement of pathogens, drugs, or chemicals in soils, plant products, or animal tissues.

Beef steers were fed digested municipal sludges incorporated into feedlot diets and feeds (corn grain, forage, sorghum silages, and bahia-grass pastures) produced on land treated with sludge. These studies were conducted to determine the effects of these feeding programs on animal performance, carcass quality, and concentrations of

selected toxic elements in liver, muscle, and kidney tissues. The performance and carcass data of treated steers in all of the studies were generally not different from the control steers.

The effect of feeding sewage sludge on reproductive performance in female swine during successive gestation-lactation periods was evaluated. These studies indicate that breeding, farrowing, and rebreeding weight were reduced. Lactation and gestation weight changes were lower and fewer pigs were farrowed in sow groups fed 10 to 20 percent sewage sludge in their diets.

Duplicate experiments of 21 days duration were conducted with day-old broiler-type chicks and laying hens to study the influence of replacing one-half of all the normal dietary corn complement with corn grown on soil fertilized with municipal sludge. Corn from the sludge-amended soil did not adversely affect final body weights or daily feed intake. Substitution of a sludge with high metal concentrations or equivalent levels of certain hazardous metals altered growth and laying performance.

Toxicity from feeding dried sewage, included in a normal swine starter ration, may occur from a deficiency of available protein or other essential nutrients, or from the accumulation of hazardous chemical residues. Cadmium exposure induced microcytic and hypochromic anemia. Cadmium also induced differences in the activity of liver serum enzymes in pigs exposed to aflatoxin B₁ or warfarin. This is the first demonstration of the cadmium blocking effect on the microsomal enzyme system in pigs. Of seven pigs fed 10 percent Gainesville sludge, four had *Sarcosporidia* in the myocardium, and the hearts of two of four pigs fed 20 percent contained the parasite. Among cattle fed Pensacola sludge, 19 of 32 contained *Sarcosporidia* in the cardiac muscle, while cardiac muscle of six of 17 controls were parasitized. The presence of *Sarcosporidia* in hearts of swine and cattle fed sludge may be of public health significance.

Land spreading of sewage sludge is probably the most practical means of disposal for municipalities and cities. Uptake of certain metals by forage and grain crops from land treated with sludge may create health risks. Pre-1978 sludge from Chicago contained large quantities of copper, zinc, lead, and cadmium. The Pensacola sludge was high in zinc. Metal uptake by the corn plant was directly associated with

soil pH. The higher the soil pH the smaller the quantity of metal uptake. Sludge application to bermuda grass at the 24 ton/hectare rate compared favorably with mineral fertilizer as a source of plant nutrients.

Samples of sludge, feed, feces, and animal tissues (kidney, liver, spleen, and blood) were analyzed for pathogenic bacteria. Pathogenic bacteria were not found to be a significant hazard.

Viruses were not detected in topsoils eight months after spreading Pensacola sludge. Enteroviruses represent a minimal hazard, either through translocation through grain or forage or with regard to groundwater contamination.

Samples of sludge, soil/sludge mixture, feed, and animal tissues (kidney, liver, fat, muscle) were analyzed for chlorinated hydrocarbon pesticide residues and also polychlorinated biphenyls. Little, if any, pesticide residues were present in sludges used in this research project.

Conclusions

Land spreading of urban sewage sludge is probably the most practical means of disposal. Sewage sludge was shown equivalent or superior to commercial fertilizers for production of certain crops under Florida conditions. However, uptake of metals by forage and grain crops may create certain risks. Metal uptake by the corn plant was directly related to the soil pH; higher pH levels reduced their uptake. Levels present in grain were less than in the forage. Cadmium levels in forage from soils pretreated with certain sludges resulted in high levels in liver and kidney tissues of cattle consuming such forage. However, performance and carcass data of treated steers in these studies were not different from the data obtained with the control steers. Clinical chemistry tests and pathologic lesions suggested cumulative toxic effects including liver damage.

The 1979 steer trial, where animals grazed on forage from soils pretreated with Pensacola sludge and spraying of the sludge on the growing plants, resulted in presence of *Sarcosporidia* sp. in the cardiac and skeletal muscles. This may be of public health significance.

Incorporation of dried sewage sludge at 10 to 20 percent of swine rations produced depressed weight gains and the 21 day weaning weights were lower in

pigs from sows consuming the sludge-containing diets. The kidney cadmium levels of sows receiving the 10 and 20 percent sludge levels were increased significantly, i.e., four ppm for controls and 17 and 24 ppm for the sludge rations; both lead and cadmium were increased in the liver and kidneys of weanling pigs. Reproductive performance was more suppressed in the second generation sows than in the first.

Growth trials with Cobb broiler chicks compared the effects of poultry rations with zero, three, and six percent dried Chicago sludge. Increased levels of cadmium in the liver and kidneys occurred in those chicks receiving the increased levels of the sludge. However, none of the production criteria, i.e., production, daily feed intake, feed efficiency, egg weights, nor body weights, were adversely affected in Leghorn hens receiving such modified diets.

Having demonstrated that increased cadmium levels occurred in tissues from cattle and swine consuming feeds from sludge amended soils, these liver and kidney tissues were dried, ground, and incorporated into mouse diets. The finished diets contained a 15 percent level of protein and five percent levels of kidney and liver tissue. Metals were translocated through the cattle and swine tissues with increased levels of cadmium, nickel, chromium, and lead in liver and kidney tissues of mice. These increases in mice were associated with decreases in number of mice weaned in the treated versus the control groups.

Analysis for pesticide residues in the various sludges indicated that little, if any, chlorinated residues were present. It was concluded that these sludges presented no hazard from the aspect of pesticide residues.

Samples of sludge, feed, feces, and animal tissues (kidney, liver, spleen, and blood) were analyzed for pathogenic bacteria. Contamination was a major problem, both when collecting specimens during the trials as well as at slaughter. No enteric pathogens or *Mycobacteria* were isolated from these samples. There was one isolation of *Staphylococcus aureus*, and two isolations of *Streptococcus pyogenes* during the cattle and swine trials. Two group B *Salmonella enteritidis* isolates were obtained from the feces of animals on a sludge amended diet plus three isolates at a later date from the same group. The very few positive isolates suggested that these three types of digested

sewage sludges posed no significant health hazards from bacteria.

Finally, when digested sludge was added to a lagoon at Jay, Florida, enteroviruses were readily detected in grab samples from the lagoon. The level of sludge-associated viruses dropped to low or undetectable levels following disposal of sludge on land and during periods when addition of digested sludge to the lagoon was suspended. Enteroviruses were not detected in wells located on the sludge disposal site or near the lagoon.

Recommendations

Present EPA guidelines on allowable levels of certain contaminants, including metals, would assure availability of homogeneous urban sewage sludge which could be utilized in soil enrichment programs for crop or forestlands. Further research is necessary to assure safe rates and frequency of application of sewage sludges, along with other essential elements, to enhance crop production. If urban sewage sludges for production of certain crops are shown to be contraindicated, this information should be made available. Since certain metals, including cadmium, lead, nickel, and chromium, have been shown to be accumulated in animals consuming forage or grain from sludge-amended soils and therefore have potential hazard to animal health and mankind, it is proposed that further research be done to establish safe guideline levels in feeds intended for meat producing animals.

The presence of *Sarcocystis* sp. in muscle from cattle and swine consuming sludge or forage and grain fertilized with sewage sludge incorporated into their diets suggest that this potential animal and human health hazard may be associated with consumption of urban sludges. Methods to eliminate this hazard or prevent its infectivity must be established prior to utilization of sludges for crop or animal production. Other parasites, including infective stages of ascarids, may persist in sludges. Destruction of parasites or preventive programs to eliminate them from sludge must also be developed. Therefore, it is recommended that research to establish the incidence, diagnosis and factors predisposing to *Sarcocystis* infection in cattle and swine associated with sludge utilization be initiated.

Finally, since viruses of hazard to animal production and human health have been shown to be present in certain urban sewage sludges, further research to characterize these viruses and assure their reduction to nonhazardous levels should be continued and completed expeditiously to allow land application of sewage sludges as plant nutrients.

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The complete report, entitled "Sewage Sludge Viral and Pathogenic Agents in Soil-Plant-Animal Systems," (Order No. PB 81-179 103, Cost \$18 50, subject to change) will be available only from:

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