N EARLY 1993, the U.S. Environmental Protection Agency (EPA) was finalizing a set of national standards to regulate beneficial use of municipal sewage sludge as an agricultural soil amendment and fertilizer. EPA believed that both water reclamation and sludge beneficial use programs could benefit from an independent assessment of the concerns that have been raised by food processors regarding utilization of these materials on food crops. In mid-1993, at the suggestion of EPA, and with the support of a number of cosponsors (see end note), the National Research Council (NRC) — the operating arm of the National Academy of Sciences — formed an expert committee to review the current state of the practice, public health concerns, existing guidelines and regulations and implementation issues. To ensure the independence of NRC committees to deliberate on issues apart from any political or financial influence, the committee members serve as unpaid volunteers, and study sponsors cannot provide oversight or review of the reports. The 14 members included experts in the areas of soil and crop science, ecology, wastewater and sludge treatment, risk assessment, toxicology, infectious disease, public health, economics and law. They represented a range of perspectives from their positions in universities and agriculture extension, state public health agencies, food companies, environmental advocacy groups and municipal wastewater treatment plants. As a matter of nomenclature, the term "biosolids" is currently in use by the wastewater treatment industry as well as EPA in an effort to distinguish municipal sewage sludge that is treated and managed for beneficial purposes. However, during the course of the NRC study, the committee was charged to evaluate "sewage sludge" and chose to use that term instead throughout.

After 17 months of study that included several field visits and a workshop on land application, the NRC released a report in March, 1996 (Use of Reclaimed Water and Sludge in Food Crop Production) that confirmed properly treated and managed municipal wastewater effluents and sludge can be safely and effectively used in food crop production. It concludes that the irrigation of crops with reclaimed water or the use of treated sewage sludge as a soil amendment pose negligible risk to crops, consumers or the environment when applied at agronomic rates and according to existing Federal regulations and guidelines. The committee found no documented reports of outbreaks of infectious disease associated with exposure to adequately treated and properly distributed reclaimed water or sludge applied to agricultural land. Still, the committee concluded that general acceptance of using sludge on cropland will depend on the ability of municipal authorities and private contractors not only to comply with government regulations but also to provide well managed and reliable waste treatment and beneficial use programs that are responsive to community concerns.

GREATER RESTRICTIONS

Over the past 20 years, municipalities have faced greater restrictions on certain sludge disposal practices, such as ocean and...
landfill disposal. Of the approximately 5.3 million metric tons per year of sludge presently being generated by U.S. municipalities, about 36 percent is land applied for several beneficial purposes such as agriculture, landscaping and reclamation of drastically disturbed lands; about 38 percent is landfilled, 16 percent is incinerated, and the remainder is surface disposed by other methods (EPA, 1993). Because cropland application of both sludge and wastewater represent important management options, municipal officials have a vital interest in the feasibility of these practices. EPA's response to this problem has been the development of federal standards (Code of Federal Regulations Title 40, Parts 257, 403, and 503; EPA, 1993), otherwise known as the "Part 503 Rule." Part 503 emphasizes the beneficial use of sludge by defining acceptable management practices and setting limits for certain chemical pollutants and pathogens for municipal sludge that is put onto the land (the regulations also cover forest or range land and special disposal sites as well as agricultural land).

One of EPA's major concerns for implementing this new program was the food processing industry's reluctance to accept the practice. When EPA first promulgated criteria for land application of municipal wastewater sludges to cropland in 1979, some food processors questioned the safety of selling food crops grown on sludge-amended soils and were concerned about potential liability problems. Although the National Food Processors Association (NFPA) does not disagree with the scientific findings of the current NRC report regarding the negligible risk of properly treated and managed sludge to food crops or public health, it has not modified its official position of not endorsing "the application of sludge to lands that may or will be used in the production of foods for human consumption." (NFPA, 1993). The reasons have to do with potential liability, marketing and public perception concerns. Still, Rick Jarman, of the NFPA thought "the NRC report is a fair presentation of food processor concerns and should be very helpful in the decision making process." Dr. Abu Ayanaba, a soil microbiologist with Del Monte Foods in Walnut Creek, California and a member of the committee noted that the "NAS report has motivated some food processors to begin reexamining their policy." Dr. Ayanaba reported the formation of a task force on the subject by the Northwest Food Processors Association, one of the more proactive food processor groups. A recent conference in Sacramento, California (California Biosolids Conference, 1997) focused on management and policy issues by bringing together government regulators, food processors, farmers, and the scientific community.

The beneficial reuse of municipal sludge has been less widely accepted than irrigation and crumb rubber applications.

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As long as sludge is properly treated and applied to or incorporated into unsaturated soils, the committee concluded that the risk of ground water contamination from sludge is not a concern.

The committee recommended not to use the salmonella test as a sole indicator of Class A quality because the test, as currently prescribed, lacks sensitivity.

The strategy for regulating pathogens in the agricultural use of sludge is similar. The Part 503 rule requires the use of either Class A pathogen criteria, in which the sludge is considered to be safe for direct public contact, or Class B pathogen criteria, in which site and crop restrictions are required. Class A (safe for public contact) microbial standards or process standards for sludge are adequate for public health protection. The committee noted a degree of concern.
over two aspects of EPA's Part 503 rule. The first concern is over the rule's prescription for using either of two types of tests — salmonella or fecal coliform testing — as alternative indicators for Class A sludge. The committee recommended not to use the salmonella test as a sole indicator of Class A quality because the test — as currently prescribed — lacks sensitivity, and an unsanitary batch of sludge may too easily qualify as Class A by this method.

Bob Bastian, with EPA's Office of Wastewater Management, reported that EPA has a task force and is currently reviewing the guidance on microbial testing of sludge. The committee report recommends that "...until such time as more precise methods are developed and accepted, the present test for salmonella should be run in concert with the fecal coliform test or in situations in which the fecal coliform results are in question, such as may happen under some operating or storage conditions."

The second of the committee's concerns deals with the use of Class B sludge on pasture land. Based on a review of U.S. studies, Part 503 requires a 30-day waiting period before cattle can graze on Class B sludge-amended fields. The rationale for the waiting period is to allow a suitable length of time for die-off of helmhinh ova, a parasite which can be transmitted to humans via improperly cooked, contaminated meat. helmhinh ova are among the most environmentally resistant of the infectious agents, and the time required for their reduction would be more than sufficient for the reduction of bacterial and viral pathogens. From a public health point of view, the public is protected from these parasites largely through public health education (e.g., the need for thorough cooking of meat) and by government meat inspection. Managing the disposal of human waste to grazing land provides additional control. The committee noted a recent investigation in Denmark (Isolé et al., 1991) indicating that the beef tapeworm (Taenia sp.), one of the helmhinh group, may survive in sludge treated fields for up to one year. Although the evidence comes from a single study and the concern is relatively minor, the committee recommended that EPA should reexamine the length of the waiting period for grazing following sludge application to pastures. Generally, the fewer viable eggs of Taenia species allowed on grazing land, the better; however, the actual risk of too short a waiting period may not be measurable.

HARMFUL CHEMICALS

The committee found that reclaimed water that has received a minimum of secondary treatment normally falls within generally accepted guidelines for irrigation water quality, such as those presented by Westcot and Ayers (1985). Most states require higher levels of treatment for irrigation of food crops. States that regulate the use of reclaimed water for crop irrigation have focused on the risk of infectious disease and have not typically set human health criteria for harmful inorganic (trace elements) and organic chemicals in the reclaimed water. Instead, reliance is placed on the wastewater treatment processes to reduce these constituents to acceptable levels in reclaimed water. Chemical production and use bans, industrial pretreatment programs, and municipal wastewater treatment programs have been effective in reducing the levels of toxic constituents in wastewater effluents to acceptable levels.

Potentially harmful trace elements and certain persistent organic chemicals in raw municipal wastewater become concentrated in the sludge during the treatment process, and, with repeated applications of sludge to the land, these chemicals may accumulate in the soil. The Part 503 rule set criteria for concentrations of 10 trace elements in sludge: arsenic, cadmium, chromium, copper, lead, mercury, molybdenum, nickel, selenium, and zinc (criteria for chromium, molybdenum, and selenium have since been rescinded or are under review by EPA). The rule is based on a risk assessment approach that considered the effects of these trace elements and organic chemicals of concern on crop production, human and animal health, and environmental quality.

The committee found little of concern for the consumer of food crops because, except for cadmium, these trace elements are not ordinarily taken up by crop plants in amounts harmful to human consumers.
Crops grown on acid soils generally accumulate higher concentrations of most trace elements than crops grown on neutral or calcareous soils.

EPA regulations for cadmium in sludge are sufficiently stringent to prevent its accumulation in plants at levels that are harmful to consumers. Unlike trace elements, which are relatively stable, toxic organic chemicals tend to be removed from the effluent during wastewater treatment through volatilization and degradation. Further decomposition occurs during the irrigation process and in the soil. Consequently, only negligible quantities of toxic organic chemicals in the effluent or sludge from municipal wastewater systems — those relatively resistant to decomposition — will persist in soils for an extended period. In general, toxic organic chemicals, especially those that persist in the soil, are not taken up by plants when the water or sludge application rates are commensurate with crop needs. Therefore, the committee concluded that the immediate or long-term threat from organic chemicals to humans consuming food crops produced with reclaimed irrigation water or sludge is negligible so long as good agricultural practices are followed.

IMPORTANCE OF USING AGRONOMIC RATES

The nutrients (mainly nitrogen) in treated effluents are generally considered a supplemental fertilizer source, but they are not as easily controlled as commercial fertilizer applications. Since the crop's demand for water does not necessarily correspond to its demand for nutrients, the quantity and timing of wastewater irrigation are important. Wastewater applications at times when the plant nutrient needs are low can lead to excessive vegetative growth, affect crop maturity and cause leaching of nitrate nitrogen, leading to nitrate contamination of ground water. Therefore, both nutrients and water rates need to be monitored and controlled. The NRC report noted that the potential risk of ground water contamination by viruses and bacteria can be minimized by adequate disinfection of reclaimed wastewater and by slow infiltration rates.

With sludge, concerns have been expressed over the long-term effects of trace elements after repeated sewage sludge applications, especially where soils are acidic or may become acidic as they are in the northeastern United States (McBride, 1995). In general, crops grown on acid soils accumulate higher concentrations of most trace elements in their tissues and are more susceptible to phytotoxicity than are crops grown on neutral or calcareous soils. In practice, when these symptoms are observed, the soil is limed to correct the problem. In fact, problems associated with soil acidity are normally corrected through routine management operations because — almost without exception — acid soils are limed prior to cropping. There is over 20 years of research experience with using municipal sludge on agricultural land. Therefore, as long as agricultural use of treated sludge is in keeping with current regulations and acidic soils are agronomically managed, no adverse effects are anticipated.

Municipal sewage sludge is a source of nitrogen and phosphorus in crop production, and the addition of organic matter may improve the physical properties and productivity of soils. When used at agronomic rates for nitrogen and phosphorus, sewage sludge can usually satisfy crop requirements for many other nutrients as well, with the possible exception of potassium.

As in all farm operations, proper management is needed to avoid the buildup of nitrates. Typically, sludges comprise approximately one to six percent organic and inorganic nitrogen on a dry weight basis. The soluble inorganic forms are immediately available to plants, but the organic forms must first be mineralized to plant available forms. For sludge to be efficiently used as a source of available nitrogen, the mineralization of organic nitrogen must be taken into account to avoid overfertilization and potentially excessive nitrate-nitrogen into ground water.

Most sludges supply more than enough phosphorus to satisfy crop needs when applied as a source of nitrogen. In certain soils, available phosphorus may be excessive, particularly where animal manure is plentiful and where impacts to surface water quality are of concern. In these situations, the report recommends that soil phosphorus levels should be monitored and sludge application rates be adjusted to correspond to crop phosphorus rather than nitrogen needs.

As with all agricultural soil amendments, sludge use must be managed properly to avoid contamination of surface or ground waters. For example, land application sites should be examined for their potential for flooding and erosion of material into waterways. As long as sludge is properly treated and applied to or incorporated into unsaturated soils, the risk of ground water contamination from sludge is not a concern. The chemical contaminants and pathogens in sludge are not mobile in soils, and their transport through unsaturated soil to ground water as a result of sewage sludge application at agronomic rates is unlikely.

PUBLIC PERCEPTION AND LIABILITY

The public is concerned about the health and environmental risks associated with beneficial land application of sludge, particularly in agricultural operations, that has only recently been implemented or considered. Some of this concern is not scientifically supportable, and should be addressed with educational and early public involvement in the design of land application programs. In addition, private sector forces can deter violations of the law and mismanagement by the various parties involved in reuse programs. Private sector forces include common law liability, market forces and voluntary self regulation such as codes of conduct, worker training and certification, and audits.

Insurance coverage and indemnification contracts for the farmer are useful means of self regulation and protection against cer-
tian kinds of economic harm. However, the committee thought that a broader approach will be necessary to satisfy all concerns of the farmer, food processors, general public, and the affected community. Public concerns about real or perceived risks create business risks and militate against agricultural use of sludge and reclaimed water despite the federal or state regulatory safeguards. The report concludes that “proponents of cropland application of sludge and wastewater must address such public concerns if they are to achieve their goals.”

Jane Forste is Technical Services Director for Bio Gro, Inc., a company that works with municipalities and farmers on a variety of sludge management programs across the country. She agrees that the biosolids industry needs to face these implementation issues head on, and is currently working with others, notably the Water Environment Federation and the Northwest Biosolids Management Association, to develop an industry standard “Code of Good Practice” for sludge management. She noted that municipalities are becoming more cognizant of the need for community acceptance, and that such items as compliance verification are now becoming a standard part of any bids that go out to private contractors that treat, distribute, or apply sewage sludge to the land. As a state regulator for the Washington State Department of Health, committee member Tom Long emphasized the importance of a key individual that the community can turn to with questions. “The key will be whether or not there is a trusted individual whom people can contact with questions and concerns,” said Long. “Usually, people come to the local health department, but with EPA pulling back from financing the sludge program, the problem will be whether state or local officials have the resources to adequately oversee every application site.”

OTHER REGULATIONS AND INSTITUTIONAL CONTROLS

From a regulatory perspective, it is important to remember that EPA’s Part 503 rule augments a wide array of existing institutional programs and controls over the disposition of municipal wastewater and sludge. For example, federal and state regulations govern the handling and treatment of toxic waste and the protection of surface and ground waters. While neither the U.S. Food and Drug Administration nor the U.S. Department of Agriculture have specific regulations for the use of sludge or wastewater in food crop production, there is a comprehensive regulatory program that oversees the processes of food crop harvest, food production, and retail sale and handling. These regulations mandate appear adequate to manage most of the risks associated with land application, but they must be funded and implemented to be meaningful safeguards.

Sludges that do not meet beneficial use criteria standards as defined by Part 503 must be disposed of according to federal and state regulations as applicable. Both the general public and state and local regulators should be aware that the Part 503 rule is not the only control over agricultural use of sewage sludge.

Gary D. Kraus, Program Officer for the Water Science and Technology Board of the National Research Council, Washington, D.C., was the Staff Director for the Committee on Use of Treated Municipal Wastewater Effluents and Sludge in the Production of Crops for Human Consumption. Dr. Albert L. Page, Professor of Soil Science and Chemistry and Chair of the Department of Soil and Environmental Sciences at the University of California, Riverside, was Chair of the Committee.


REFERENCES


