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SEWAGE SLUDGE—LOOKING UPSTREAM: THE PRECAUTIONARY PRINCIPLE

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ABSTRACT

The health care industry makes a unique contribution to the potential public health and environmental impacts of sewage sludge production and disposal. As materials flow into and out of health care facilties, potentially hazardous substances, like mercury, solvents, and pharmaceutical compounds, are introduced into the waste stream and ultimately into sewage sludge. Although the hazards posed by these practices are often not fully understood or the risks quantified, concern about impacts on public health and the environment is fully justified. How to deal with the uncertainties surrounding the impacts of these practices becomes an ethical as well as a scientific question. A precautionary approach to materials manufacture, use, and disposal encourages us to look upstream and to re-design products and systems in ways that primarily prevent problems rather than dealing with them at the "end of the pipe." Early warning systems, shifting the burden of proof, alternatives assessment, and monitoring programs are suggested as interventions that might be used as part of a precautionary approach to addressing the generation and disposal of sewage in an industrial society.

Many of the potential public health and environmental impacts of sewage sludge disposal can be traced upstream to engineering decisions, product manufacturing and purchasing practices, and even to the basic and applied research agenda of the academic-industrial complex. In the large and growing health care industry, product manufacturing and purchasing decisions directly affect both the volume and toxicity of the waste stream. For example, mercury-containing products used in hospitals or medical research facilities must ultimately be disposed of. Whether disposed of as hazardous waste, municipal waste, flushed down the drain, or recycled into other commercial products, discarded mercury will eventually find its way into the ambient environment, where it may enter the food chain and bioaccumulate to harmful levels. Alternatively, if manufacturing practices are changed so that products are formulated without mercury, the problem is solved well upstream.

Academic hospitals and research laboratories in Boston's Longwood area have struggled with this problem for years. Mercury discharges to the sewage system are periodically in violation of effluent standards, and tracing the problem to its source has been an enormous challenge. Improved handling of products containing significant amounts of mercury has only partially addressed the problem. A wide variety of lab chemicals, pharmaceuticals, and cleaning products that contain trace amounts of mercury, often unidentified on the label and sometimes unknown to manufacturers, make this a stubborn problem that will not go away. Mercury trapped in indoor piping provides a continuous reservoir for mercury discharges into sewage effluent. Sewage sludge then serves as a medium for re-introducing mercury into the ambient environment where it poses a threat to human and wildlife health. Solving the problem with end-of-the-pipe controls is only partially helpful. Success is far more readily achieved by simply avoiding the use of mercury-containing products initially.

Several years ago, Health Care Without Harm, an international coalition of more than 300 organizations in 37 countries concerned with the public health and environmental impacts of the medical-industrial complex, initiated an effort to make medicine mercury-free. Now, the American Hospital Association and the U.S. Environmental Protection Agency (EPA) have entered a partnership called Hospitals for a Healthy Environment to accomplish that goal, among others, by 2005. Ultimately, however, mercury must be eliminated in many different commercial products in order to solve the problem of mercury discharges to sewage treatment plants. Many hospitals have also re-examined their practice of disposing of a variety of solvents in sewage discharge pipes and have discovered that solvent recycling is not only more environmentally friendly but that it saves money.

Beginning several years ago in Europe, and now in the United States, concern about the discharge of pharmaceuticals directly into sewage effluent has steadily grown. Hormonally active agents that disrupt normal development of aquatic species pass through sewage treatment plants in biologically active forms and contaminate surface waters or sewage sludge spread onto land. Pharmaceutical products, such as antidepressants, cholesterol-lowering drugs, hormones used in birth control pills and in the meat and poultry industries, anti-inflammatories, and pain medications are among those that have been identified in surface waters and sewage sludge. Many of them come out of homes in human excreta, as well as out of hospitals or pharmaceutical facilities. The rate at which concentrations of these biologically active compounds are increasing is uncertain, but just identifying them may be the first hint of an emerging problem of real significance.

As we grapple with the potential problems associated with having designed a system forced to deal with a co-mingled industrial and human waste stream, it is useful to think about how to approach the emerging concerns with a precautionary or preventive public health perspective. Simply stated, the precautionary principle holds that when there is plausible evidence or threats of harm, precautionary action should be taken, even if some cause-and-effect relationships are not fully understood, or despite residual scientific uncertainty. Threats of significant harm are obviously of more concern than trivial threats. Significant harm, however, may not be immediate, local, or easily recognized. It may, for example, be delayed for years, widespread, and even tend to be obscured in the background "noise" of non-specific public health and environmental endpoints that cannot be attributed to single causes.

Scientific uncertainty can also take various forms. Statistical uncertainty, usually surrounding the value of single variables in a system, can fairly easily be reduced or quantified by simply gathering more data. Model uncertainty, however, may be much more difficult to handle. Models of complex systems, like contemporary sewage discharge and disposal systems, are constructed and studied with many different assumptions and simplifications. The interaction of variables within complex systems is rarely fully understood and can only be estimated. Model uncertainty is much more difficult to reduce than statistical uncertainty. Fundamental uncertainty is even more problematic. Here we often don't know what we don't know, and if we are ignorant, it becomes difficult to ask the right questions. Sewage sludge, for example, is a complex mixture of chemical and biological agents. *De novo* synthesis of novel chemical compounds in the effluent or sludge and changes in the characteristics of biological organisms in this complex mixture are not well understood. It is doubtful that they will ever be. Every sewage effluent is somewhat unique, depending on its initial composition and treatment conditions.

Risk assessments of sewage sludge disposal options typically focus on single known contaminants and attempt to estimate the probability of harm associated with each of them. No risk assessment is capable of dealing with the extensive model and fundamental uncertainties inherent in current sewage disposal practices in a practical way that truly addresses the realities of this complex system. As a result, we are presented with estimates of risks associated with exposure to a few heavy metals, a single class of organic compounds, and a few biologic organisms, while a large number of other complex chemicals, bioaerosols, and microorganisms are ignored. Complex systems and mixtures do not lend themselves to this kind of risk assessment. Yet, risk assessors are taught how to use risk assessment as the tool for estimating risks. Never mind that sewage sludge is a complex mixture of chemicals and microorganisms that has not been and cannot be fully characterized. The task is similar to that of a carpenter who has only a hammer in his toolbox. Everything begins to look like a nail.

How might we begin to think about the problems posed by sewage sludge in a precautionary way? There is no single answer and a fully participatory decision-making process is likely to generate a number of options that have not as yet received serious consideration. For example, the lessons learned from mercury show that fundamentally altering the composition of the waste stream by product reformulation and substitution can be helpful. Changes in materials manufacturing practices, including "green chemistry," can favorably alter the nature of waste effluent. Strict attention to pharmaceutical prescription and disposal practices can reduce discharge of these biologically active compounds into the environment. Engineering solutions, including redesign of waste handling systems into closed loops, will reduce environmental releases.

Establishing public health and environmental monitoring systems will help to identify problems as they emerge. Early warning systems are essential for preventing harm rather than addressing it after it has occurred. Preventive measures also typically save money and resources over the long term.

Epidemiologic studies of communities of people living near sewage disposal facilities suggest the plausibility of harm that is not yet completely understood. Evidence is sufficient, despite residual uncertainties, to indicate that some people are experiencing adverse impacts. Commercial enterprises that profit from land spreading or incineration of sewage sludge, despite uncertainties about the safety of the practice, could be required to post performance bonds as a means of providing resources to help to mitigate harm that may become apparent as the practice is more thoroughly studied.

These are only a few examples of interventions that might be used as part of a precautionary approach to addressing the generation and disposal of sewage in an industrial society. Complex problems and complex systems require innovative solutions. Tools suited for solving simpler problems are not necessarily suited for more complex tasks. The general public and the world's ecosystems are not well served when decision-makers require proof of harm and insist on resolution of scientific uncertainty before being willing to take steps to prevent harm to present and future generations.

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