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# PRIMARY PREVENTION OF CHEMICAL CONTAMINATION

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**ABSTRACT**

The current approach to addressing health and ecosystem risks from biosolids, or sludge, requires identification of so-called "safe" or "acceptable" levels of exposure and installation of controls to achieve such levels. This end-of-the pipe approach is inconsistent with the public health concept of primary prevention. Following an overview of the limitations in current approaches to understand and address risks of biosolids contamination, we present a new, preventative paradigm for addressing the hazards of sludge. We conclude that given the disparate and widely distributed sources of contaminants in biosolids and the amount of uncertainty in information about health and environmental effects, we need a new approach to this and other environmental dilemmas. This approach is embodied in the concept of the precautionary principle and public health goal-setting.

The current approach for addressing health and ecosystem risks from biosolids, or sludge, requires identification of so-called "safe" or "acceptable" levels of exposure and installation of controls to achieve such levels. This paradigm of health protection is based on a tertiary prevention, end-of-pipe approach to risks. It is completely inconsistent with protection of public health and sustainability. The first step toward addressing this problem is to determine whether we are asking the right questions, since the way we frame questions necessarily shapes how we solve them. The current public health approach to biosolids focuses on determining acceptable levels of human exposure to contaminants. The literature on health effects of biosolids reflects this, emphasizing acceptable levels of exposure for a limited number of chemicals and a limited number of end points. But why aren't we asking a different set of questions, possibly leading to a different set of answers? What are the root sources of those contaminants? Why are they there in the first place? Are there ways to prevent the entry of these contaminants in the first place? Are there alternatives that would reduce toxicity of production systems and products? Following an overview of the limitations in current approaches to understand and address risks of biosolids contamination, we present a new, preventative paradigm for addressing the hazards of sludge.

## CURRENT APPROACH TO ANALYSIS AND MANAGEMENT OF BIOSOLIDS CONTAMINATION

Before the problem of biosolids contamination can be addressed, it must be appropriately understood. Currently, biosolids, like most environmental hazards, are examined within the paradigm of risk assessment. Government agencies analyze exposure and toxicity of each substance found in biosolids, and produce a single number to express the "safe level" of exposure to that single toxic material. This approach is inextricably linked with an end-of-pipe strategy for managing environmental hazards, regulating toxics to the assessed "safe level."

There are serious limitations in current scientific risk assessment approaches in assessing biosolids risks, in terms of the data available, the scope of analyses, and uncertainties in the risk assessment figures. First, our knowledge of the toxicity for the vast majority of chemicals in commerce is severely limited. Studies by the Environmental Defense Fund and the Environmental Protection Agency found that of the almost 3,000 High Production Volume (HPV) chemicals (those over one million pounds in commerce), 93 percent lack some basic chemical screening data, 43 percent have no basic toxicity data, and most of the data available comprehend acute toxicity alone [1, 2]. Even less is known about the toxicity of chemicals in mixtures, such as those commonly found in biosolids.

The scope of most risk assessments limits a comprehensive understanding of risks. Humans can incur low-level (and sometimes high-level) exposures to many chemicals, pathogens, and heavy metals through biosolids, so the possibilities of cumulative and interactive exposures and effects raise concerns, particularly for vulnerable subpopulations. Yet most risk assessments examine single chemical risks to single organ systems in the "average individual." In essence, they push for a number—crumpling information to achieve a point estimate—at the expense of a broader, more nuanced understanding of risk. Some limitations of quantitative risk assessment in characterizing complex risks associated with biosolids include:

- Risk assessment tends to limit the amount of information and disciplines used in examining environmental and health hazards. This may inhibit a holistic understanding of complex systems and interactions. In the case of biosolids, which are a complex mixture of chemicals and organic matter, the makeup of which varies widely, a narrow examination of each component is inappropriate. Without detailed understanding of the way every permutation of biosolids mixtures behaves, it is impossible to truly "assess" risk. Attempting to quantify the little we do understand, and calling that a true reflection of risk, is not an accurate characterization of risk or a good use of science. Evaluation of biosolids requires a broader understanding of the situation, incorporating a variety of disciplines and approaches. The recent National Research Council report on land application of biosolids indicated that the EPA has not updated its standards and policies on biosolids in concordance with developments in science and risk assessment (3). However, it is hard to imagine that the EPA, or anyone, for that matter, could ever accurately test for all potentially harmful materials that may occur in biosolids, even if using cutting-edge techniques.
- Risk assessments are based on numerous assumptions about exposures, human behavior, chemical effects, and chemical fate that may or may not be explicit. While these assumptions are often scientifically based, many times they are based on politics or uncertain information. Two risk assessments conducted by groups of scientists in regular contact and using the same data set can differ by orders of magnitude (4).
- Risk assessments can be expensive and time-consuming, tying up limited resources. Given the contentious nature of such analyses, debates over nuances (e.g., specific models) can stave off regulation for long periods of time.[1] This is certainly a potential problem with biosolids, which are already the subject of much debate.
- Risk assessment processes often exclude those potentially harmed by environmental degradation. Risk assessments traditionally do not include public perceptions, priorities, or needs. As risk assessments become more complex, they increasingly exclude public participation, as only those with advanced training in modeling, toxicology, and quantitative analysis have the ability to understand and evaluate the nuances of the analyses and methods. Decisions made regarding biosolids could affect a wide spectrum of human activity, including manufacturing, food and agriculture, wastewater treatment, recreation, and much more. People involved in all aspects of the creation and disposal of biosolids must be involved in the decision-making surrounding it.

Uncertainties are inherent in most risk assessments, but because they complicate decision-making, they are often played down or ignored, or only addressed

[1] An example is the OHSA methylene chloride standard, which took almost 11 years to finalize, partly due to on-going debates over pharmokinetic and mechanistic models

in outcome variables of analyses. Uncertainty is inevitable because humans operate in complex, unpredictable, and uncertain systems that are difficult to control and may produce consequences that are unpredictable, irreversible, and very costly. Uncertainties are also introduced into analyses as a result of our assumptions, our disciplinary perspectives and backgrounds, and the questions asked or not asked in an analysis. There are numerous types of uncertainty that should be addressed in a risk assessment of biosolids. They include simple parameter uncertainties (variability, all sources of exposure, etc.); uncertainties in models used to bridge gaps in knowledge; broader, "systemic" uncertainties; and "political uncertainties" when risks are not studied, uncertainties are ignored, or uncertainties are created to make it more difficult to reach causal judgments and policy action.

There are also two types of more profound uncertainties—*indeterminacy and ignorance*—that are generally not considered in decision-making on biosolids. The condition of indeterminacy reflects the lack of direct causal linkages in open-ended systems with multiple influences. Ignorance is the state of not knowing what we do not know. Unfortunately, uncertainties or limitations in our scientific tools to quantify or demonstrate risks are often misinterpreted as evidence of safety. But not knowing whether something is dangerous is not the same as knowing it is safe. Our scientific understanding of risk of toxic substances, particularly of complex mixtures, is limited and subject to much debate. The classic epidemiological question is whether we have evidence of lack of harm, or lack of evidence of harm. We often see this problem in analyzing environmental health risks; we lack the data to know if an effect exists, and we may never have good data. If we continue to follow the path of risk assessment, demanding ever more specific data on an ever expanding universe of health threats related to biosolids, we will never be able to act effectively to protect human health.

The current paradigm of regulatory action is a pollution control, or end-of-pipe, tertiary prevention approach, that is tied in with the risk assessment approach. Pollution control means starting with the belief that some contamination, some exposure, and some risk are inevitable. Tertiary prevention entails identifying (through quantitative risk assessment) and maintaining acceptable "safe" levels of exposure that correspond to an agency pre-defined "acceptable" level of risk, and assume that a population or individual has a certain "assimilative" capacity, that is they can break down toxic contamination rendering it harmless. Controlling substance levels requires expensive end-of-pipe technologies, which are often ineffective, transfer pollution from one media to another, and have no useful value in production—they are simply expensive add-ons. It also requires expensive monitoring equipment to ensure that contaminant levels do not exceed "acceptable" levels. This approach leads to disjointed, ineffective, media-by-media policies that limit, but do not prevent, pollution.

## TOXICS USE REDUCTION AND PREVENTION

The set of questions listed above, however, can potentially shift the focus to pollution *prevention* rather than control. Pollution prevention (known in Europe as Cleaner Production) focuses on primary prevention, integrated multimedia solutions, and reduction of contaminants of source. Clean Production and pollution prevention involve changes to production systems and products to reduce pollution at the source (in the production process or product development stage). This includes reducing the raw material, energy, and natural resource inputs (dematerialization) as well as reducing the quantity and harmful characteristics of toxic substances used (detoxification) in production systems and products [5, 6]. A central aspect of clean production is understanding the "service" that a production system or product provides and seeking out safer alternatives to provide that same service (e.g., chlorinated solvents provide the service of degreasing). Many European countries and the European Union are now debating policies that would force the substitution of hazardous chemicals and fill in gaps in our knowledge of toxicity. Pollution prevention is very consistent with sound, profit-oriented decision-making. It is iterative; it is pro-active; it frames the problem widely enough to actually capture the root causes. Pollution prevention releases science from the myopic restrictions of risk assessment, and encourages thoughtful evaluation of alternatives.

A sound approach to primary prevention demands a new approach to environmental science and technology assessment, going far beyond risk assessment. It requires a careful, interdisciplinary examination of all the available information on hazards and options, incorporating qualitative and quantitative data and recognition of uncertainty. It also requires identification and analysis of a wide range of alternatives, their impacts, and their tradeoffs.

A preventive approach also requires that all affected parties be involved throughout the decision-making process, because those at the ground level often know a great deal about how to change processes and products. People with hands-on experience are particularly effective in situations involving lots of uncertainty and complex systems, where both the problem and the solution are poorly defined. Pollution prevention in the workplace requires the involvement of the workers who run facilities on an every day basis. They know how changes will affect the production process, the product, and their own health.

The Massachusetts Toxics Use Reduction Program is a great success story in pollution prevention. The Massachusetts Toxics Use Reduction Act, passed in 1989, requires manufacturers to report their chemical usage over a threshold, and to develop a Toxics Use Reduction Plan, analyzing the services provided at their facility by toxic chemicals used and evaluating options to reduce usage. Toxics use reduction (TUR) is defined as "in-plant changes in production processes, raw materials, or raw materials that reduce, avoid or eliminate the use of toxic or hazardous substances or the generation of hazardous byproducts, reducing risk equitably to the health of workers, consumers or the environment. One action should not lead to a risk to another element (consumers, workers, the environment)." The centerpiece of a TUR approach is focusing on solutions, opportunities, and innovation, rather than the inevitable acceptable levels of risk from a narrow range of options. With new information, new technologies, and new science, come opportunities to further reduce use of toxic substances and the generation of waste. The Massachusetts TURA has produced impressive results; in its first 10 years, toxic chemical emissions were reduced by nearly 80 percent, toxic chemical waste by nearly 60 percent and toxic chemical use by nearly 40 percent while saving Massachusetts industry some $15 million (not accounting for health, safety, and environmental benefits).

There are as many approaches to toxics use reduction as there are creative problem-solvers, but there are some common methods. One is input substitution, such as substituting aqueous solutions for chlorinated solvents as a cleaning mechanism. Product reformulation focuses on designing new products that use less hazardous substances. Redesign or modification of the production system reduce both waste and the need for toxic substances. Modernization of equipment frequently helps reduce waste and increase efficiency. Improved operations and maintenance, such as mending leaky pipes, often can be implemented with minimal intervention and little cost. Lastly, recycling, reuse and extended use of toxics in a closed loop can help extend waste reduction. The concept of a closed loop is critical to TUR, preventing materials from escaping into the workplace and the environment. Evaluation, in the form of continuous monitoring and improvement, follows naturally from alternatives assessment, moving the search for safer alternatives process continuously forward.

## APPLYING THE POLLUTION PREVENTION APPROACH TO BIOSOLIDS

Toxics use reduction and pollution prevention need not apply only to individual firms. Pollution prevention can be implemented at a societal level, and must be in the case of biosolids. We need to first identify the sources of contaminants in biosolids. If we do not know where they come from and how they behave through production, use, and disposal, we cannot control them. There is a saying in pollution prevention that "what can't be measured, can't be managed." The inventory starts with *point sources,* such as industrial facilities, household and small business dumping. For example, prescription and non-prescription pharmaceuticals are found in the environment [7], probably emanating from point sources such as excretion and medical or agricultural dumping. *Non-point sources* include street effluents, air deposition of contaminants, agriculture, gardening, lawn-care, and much more. Many products, such as cosmetics, floor finishers, and home use pesticides also release toxic substances that can make their way into biosolids. Finally, by-products of chemical use such as dioxins and polycyclic aromatic hydrocarbons make their way into water systems and sludge. Once we know where these contaminants are coming from, and how they get into the sludge, we can begin to think about preventing that contamination at the source. Characterizing material flows by determining what sources are contributing to municipal solid waste can help us identify the kinds of pollution prevention measures we need to take. We do not need to know the exact concentrations and chemical makeup of every contaminant that enters the waste system; we *do* need to know what the sources are so we can evaluate the types of risk that may be associated with that source, and the ways we can prevent those risks.

Once we identify the sources of contaminants in sludge, we need to develop pro-active, forward-looking policies to prevent that contamination. They have been described in greater detail elsewhere [5, 8]. Such policies include: product labeling and right to know; mandatory pollution prevention planning for facilities and products releasing toxic substances into the environment, green chemistry, extended producer responsibility (take back); mandatory environmental and health impact statements; integrated pest management (and pesticide use reduction); and integrated product policy. As demonstrated by the Massachusetts TURA results, these policies have the potential to substantially reduce the amount of toxics entering municipal solid waste systems. The goal of such policies is to infuse primary prevention in all aspects of product and process design, policy, and decisions themselves. Because biosolids involve such a wide variety of inputs and outlets, primary prevention of biosolids contamination requires work across a broad realm of activities. Every source that contributes to solid waste must be included in primary prevention.

## FINAL THOUGHTS

Given the disparate and widely distributed sources of contaminants in biosolids and the amount of uncertainty in information about health and environmental effects, we need a new approach to this and other environmental dilemmas. We need to move from the acceptable risk assessment/pollution control approach to a primary prevention approach. This approach is embodied in the concept of the precautionary principle, which is gaining momentum at the state and local level in the United States. A more precautionary approach to the risks of contaminants in biosolids would include: acting based on early warnings, even though the magnitude and nature of risk are not fully understood; creating and choosing the safest alternatives to meet our needs, driving innovation in safer and clearer technologies and products; placing greater responsibility on those creating risks to fully study them, and take preventive actions; and developing interdisciplinary scientific methods for comparing alternatives and identifying early warnings. A more democratic, participatory process for making tough decisions about technologies and products under uncertainty is also necessary. A variety of more participatory modes of decision-making are emerging in Europe and the United States, and these must be integrated into policy [9].

Central to applying primary prevention to the risks of contaminants in sludge is the establishment of broad, long-term goals for chemicals and health. Goal-setting focuses not on what futures are likely to happen but rather with how desirable futures can be obtained [10]. Short and long-term goals are routinely established in public health (such as for immunization). During recent years, several Scandinavian countries have established such goals for environmental health, including a goal of ceasing emissions of hazardous substances to the environment within one generation (by 2020). These countries are currently developing a series of broad chemicals policies to achieve these goals in a continuous, step-wise fashion. Biosolids contamination presents a challenge for goal-setting. If we can clean up our biosolids using pollution prevention, we will reap many other health and environmental benefits, because of the broad changes required across many sectors of society. Here in the United States, where long-term social planning is viewed as a relic of communism, we need to aggressively follow the lead of the Scandinavian nations in moving policy debates from the question of how much contamination humans and ecosystems can take before obvious damage occurs (and it is too late) to the question of how can we use human ingenuity to prevent damage to health and ecosystems while maintaining a vibrant economy. This is the challenge for the future.

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