Land-application of biosolids: Concerns and consequences when assumptions are not met

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Introduction

While microbial risk assessments are often performed for scenarios under normal operating conditions, little attention has been paid to the consequences of deviations from good operating procedures. Such deviations can have significant influence on various aspects of a microbial risk assessment.

Methodology

In this study, we explore plausible deviations from standard good practice assumptions, which we term "failure scenarios." Land-applied biosolids was used as a convenient and safe area to test our methodology, which might have generated sensitive information if applied in a homeland security domain. The methodology developed to identify scenarios of concern is a two-step process: generation of failure scenarios and ranking. This process was consistent with risk ranking literature that requires two groups: categories and attributes.

First, we reviewed the biosolids land application process and identified potential failures at each step of the process. A workshop was conducted with an expert panel, consisting of federal and state regulators, academics, biosolids generators, and biosolids land appliers, to review candidate scenarios and propose additional plausible failure scenarios. An effort was made to include scenarios that address the five priority pathways of human exposure to microbial risk from land application.

In addition to aiding in the development of scenarios, the panel helped develop six attributes for rating each scenario. These attributes were created to gain insight into how to best manage biosolids land application programs, and they were believed to address key attributes of risk management without significant overlap in any of the ratings . While we wanted to study the outcomes of the failure scenarios, we also needed to explore how controllable management would be.

Next, professionals with extensive experience in biosolids production and application, including biosolids regulators, researchers, biosolids utility workers, and private consultants, were surveyed to characterize these scenarios along six different attributes: severity, frequency, incentive to ignore control measures, gaps in existing control processes, public concern, and overall concern

This sort of expert elicitation through ranking and surveys has been performed in other industries, including nanotechnology and hazardous waste management. The generation of failure scenarios has previously been used in software development. However, the combination of these two approaches used in this study, generation of failure scenarios and their risk-relevant rating, is a novel approach to the field of risk management.

Acknowledgments

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Results

The experts rated intentional dumping (unpermitted disposal) as the most severe of the failure scenarios, lack of worker protection as the most frequent, and application of Class A biosolids that have failed to meet treatment standards as the scenario for which incentives to ignore control measures are highest. Failure of public access restrictions to application sites was the scenario for which existing controls were judged the weakest, and application too close to wells was ranked highest for public concern and of highest overall concern.

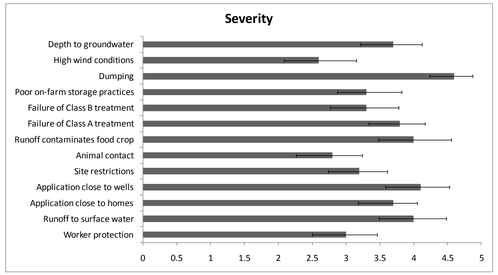

Figure 1. Mean scores and 95% confidence intervals for severity of each scenario. Ratings ranged from 1 (not severe) to 5 (extremely severe).

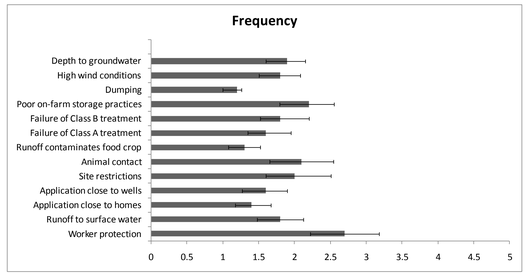

Figure 2. Mean scores for frequency of each scenario. Ratings ranged from 1 (never) to 5 (often).

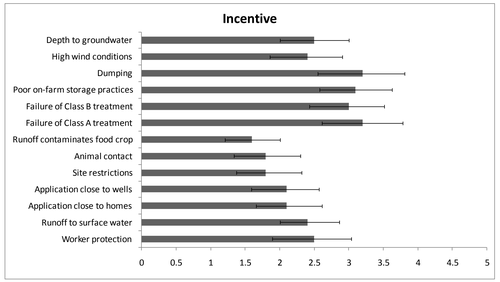

Figure 3. Mean scores and 95% confidence intervals for incentives to ignore control measures or discount good management practices with each scenario. Ratings ranged from 1 (no incentive) to 5 (high incentive).

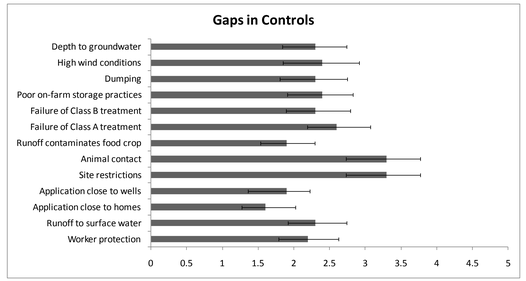

Figure 4. Mean scores and 95% confidence intervals for gaps in existing control processes. Ratings ranged from 1 (many gaps/almost no control) to 5 (no gaps).

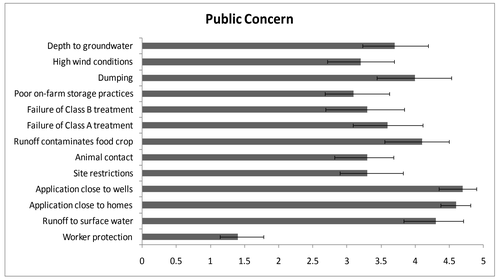

Figure 5. Mean scores and 95% confidence intervals for public concern with each scenario. This criterion measured the experts' beliefs about the degree of public concern. Ratings ranged from 1 (not concerned) to 5 (extremely concerned).

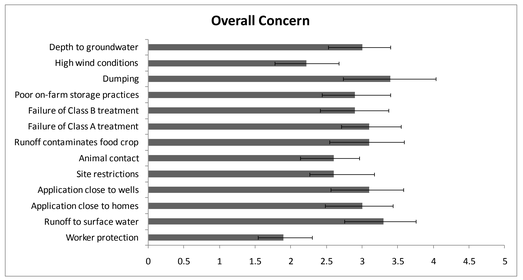

Figure 6. Mean scores and 95% confidence intervals for overall concern with each scenario. Ratings ranged from 1 (not concerned) to 5 (extremely concerned).

Scenario	Criteria Mean(SD)					
	Severity	Frequency	Incentive	Gaps in Controls	Public Concern	Overall Concern
Worker protection rules not followed*	3.0(1.21)	2.7(1.15)	2.5(1.39)	2.2(1.10)	1.4(0.84)	1.9(0.91)
Runoff to surface water*, **	4.0(1.27)	1.8(0.93)	2.4(1.23)	2.3(1.10)	4.3(1.12)	3.3(1.23)
Application too close to homes**	3.7(1.19)	1.4(0.65)	2.1(1.26)	1.6(0.96)	4.6(0.61)	3.0(1.22)
Application too close to drinking water wells (public or household wells)*, **	4.1(1.22)	1.6(0.91)	2.1(1.25)	1.9(1.11)	4.7(0.72)	3.1(1.34)
Public access site restrictions not followed*	3.2(1.15)	2.0(1.17)	1.8(1.35)	3.3(1.26)	3.3(1.26)	2.6(1.19)
Animals (i.e. pets, livestock) come in contact with biosolids*	2.8(1.26)	2.1(1.13)	1.8(1.19)	3.3(1.38)	3.3(1.14)	2.6(1.07)
Runoff contaminates food crop*	4.0(1.38)	1.3(0.57)	1.6(1.11)	1.9(0.98)	4.1(1.30)	3.1(1.44)
Failure of Class A treatment*	3.8(1.02)	1.6(0.77)	3.2(1.41)	2.6(1.12)	3.6(1.34)	3.1(1.08)
Failure of Class B treatment*	3.3(1.39)	1.8(0.94)	3.0(1.45)	2.3(1.21)	2.2(1.52)	2.9(1.20)
Poor on-farm storage practices*	3.3(1.24)	2.2(0.96)	3.1(1.37)	2.4(1.22)	3.1(1.21)	2.0(1.54)
Dumping to surface water or vacant land*	4.6(0.79)	1.1(0.33)	3.2(1.67)	2.3(1.22)	4.0(1.46)	3.4(1.58)
High wind conditions during application or before incorporation*	2.6(1.35)	1.8(0.72)	2.4(1.36)	2.4(1.37)	3.2(1.23)	3.0(1.10)
Inadequate depth to groundwater*	3.7(1.20)	1.9(0.76)	2.5(1.40)	2.3(1.24)	3.7(1.29)	3.0(1.14)

Table 1. Mean scores and standard deviation for scenarios and criteria. Ratings ranged from 1 (no concern / low priority) to 5 (high concern / high priority). Scenarios marked with an asterisk (*) were said to have actually occurred by at least one person. Scenarios marked with two asterisks(**) indicate statistically significant differences between mean scores for "public concern" and "overall concern" (p<.001).

Conclusions

While conducting the surveys, numerous participants mentioned that the scenarios we included had happened, which helped confirm that the scenarios we chose are concrete examples and are important to focus on. This confirmation, along with the significant correlations between all of the attributes and "overall concern" validates the methodology that was used in creating the failure scenarios used in the survey.

The findings of this study have relevance for public-focused risk communications and stakeholder engagement . Public judgment on the acceptability of technologies is multi-faceted and heavily focused on the acceptability of perceived health and safety risks.

The results highlight areas for improving management plans and reducing risks. The methods developed to identify scenarios of concern for the biosolids industry can be applied to other areas of risk identification and risk management. Through expert elicitation, the generation of failure scenarios, and ranking of these scenarios, management practices and policies can be focused on the most pressing issues.

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For further information

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