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# Sludge Under Suspicion: Explaining Perceptions of Risks from a Relatively "Unknown" Technology


## Abstract

Factors such as knowledge about the technology and trust in technology-generating institutions influenced people's decisions about the acceptability of applying treated sludge on Iowa's agricultural lands.

# Sludge Under Suspicion: Explaining Perceptions of Risks from a Relatively "Unknown" Technology

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Factors such as knowledge about the technology and trust in technology-generating institutions influenced people's decisions about the acceptability of applying treated sludge on Iowa's agricultural lands. Responding to a questionnaire mailed statewide, 700 respondents answered questions about three dimensions of acceptability of this practice: potential for individual use, potential for family use, and attitude toward a ban. Risk message characteristics, respondent's background, knowledge, and attitudes were tested as predictor variables through multiple regression.

The findings provided support for normative/value types of decision making when it comes to less controversial, poorly understood risk topics such as sludge application in farms. Although knowledge of the topic correlated with support for the technology, trust factors were more powerful predictors.

These results suggested that effective risk communication may be more a problem of ensuring trust than it is an issue of explaining risk/benefit analysis in lay terms. History of safe use and industry/regulator integrity were likely to impress the nonexpert far more than improved technical presentations.

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## Statement of the Problem and Rationale

Probably no other issue can frustrate people more than the problems associated with the safe and effective disposal of wastes of all kinds. This topic creates such a wide range of reaction throughout communities, businesses, legislatures, and governmental agencies that one is hard pressed to determine whether public policy is driven by scientific evidence or by shifts in public opinion.

Sludge or biosolids[1] disposal offers one such case. It is an area in which public perceptions of risk differ greatly from that of those who study the field. For instance, Scherer (1993) found that 36% of his New York state sample identified sludge compost as a "serious threat" (p. 14), an assessment with which experts do not agree. Experts contend that sludge composts are generally harmless. The generation of treated sludge and its application on agricultural lands, therefore, is a technology that can still be expected to generate considerable public agitation. Information about it is rare and poorly understood, and the risks associated with it are probabilistic, and uncertain (Wilkins and Patterson, 1987).

Peterson et al. (1994), on the other hand, showed that while a substantial majority was "undecided" (p. 4) about the practice of applying treated sludge, 20-30% viewed the practice favorably, and approximately 5-20% rejected it altogether.

As part of a communication project commissioned by the Iowa Department of Natural Resources (IDNR) to explain new domestic sludge application guidelines to generators and applicators of sewage sludge, and the public, Peterson et al. asked a convenience sample of 66 Iowa farmers about their knowledge and attitudes concerning sludge use. This formative evaluation stage also explored farmers' channel preferences for receiving information on sludge, also known to experts as *biosolids*. These farmers attended Farming 2000 Expo, a two-day annual exhibition, trade show and forum featuring the latest developments in Iowa agriculture, conducted November 1993 at Iowa State University.

Results from this non-probability sample indicated that the generation and use of biosolids was not a topic in which respondents were well versed or highly interested. The majority (43%) of the respondents were somewhat familiar with it; 26% were totally unfamiliar with the term. The interest

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level was not very encouraging either. Fifty-four percent did not care about the topic. Only 4% thought the topic was significant to them.

But despite the fact that they understood little about the technology of biosolids generation and application, 38% either somewhat or strongly agreed that there was a distinct possibility that biosolids pose a threat to their individual health and well being. This perception of risk was carried in their assessments of the technology's impact on the community at large. More than that, they were also able to decide on potential policy initiatives (i.e., a potential ban) on this subject about which they know little or nothing.

The lack of awareness and knowledge about sludge becomes problematic considering that the respondents comprise a highly educated sample — a majority had college degrees. These suggested that even the best of farmers need more information about sludge, how it is generated and how it should be applied. The determinants of opposition to and acceptance of this lesser known practice must also be thoroughly examined.

## Significance of the Study

By explaining audience reactions to this technology, which many perceive as risky, we may be able to:

1. gauge the attitudes of the general public toward the use of treated sludge in Iowa's farmlands,
2. predict the level by which this technology can be accepted,
3. develop ways of enhancing the safe use of sewage sludge in farm areas, and
4. predict public reaction to government initiatives and policy formulations concerning the application of sewage sludge in Iowa's farmlands.

## Theoretical Formulation

Academic approaches to understanding reactions to technologies viewed as risky can be classified into two major subgroups: a technical/rational approach and normative/value approach (Douglas and Wildavsky, 1982; Krimsky and Plough 1988).

Based on economic theories of rational citizens, the technical/rational approach holds that people make risk decisions based on a personal cost benefit analysis informed by scientific and technical data. From this perspective, opposition to a technology that experts define as safe results from not understanding or not knowing the actual "objective" risks (Kasper 1980, p. 11; Otway and Thomas 1982, p. 24). Public opposition often is defined as a problem in effective risk communication (Covello et al., 1987). Effective, in this context, usually means improved methods of presenting technical risk information.

In contrast, cognitive psychologists and decision analysts warn us that the public is not composed of adroit technical decision makers. According to the value/normative approach, people incorporate a number of "qualitative" (p. 23) dimensions in their decisions about risky technologies: catastrophic potential, controllability, scientific uncertainty, equity, and risk to future generations (Slovic et al., 1979). Those stressing normative/value elements argue that the decision maker is not an isolated entity using a restricted range of information. Normative/value proponents emphasize contextual factors, such as social networks, organizational memberships, social class, and cultural understanding evolving from a history of technological successes and failures (Douglas and Wildavsky, 1982). In other words, debates about risky technology involve far more than technical risk estimates: they involve religious, moral, political, and psychological considerations (Otway and von Winterfeldt, 1982).

Intrinsic to the technical/rational and normative/value arguments is the question of which factors have the greatest impact on the risk decision of ordinary citizens. That question is of more than academic interest: it involves issues of resource allocation and the likelihood of success in overcoming or minimizing public opposition to a new technology or a new practice.

Based on these models, it can be hypothesized that the following factors will affect Iowans' attitudes about the acceptability of sludge application in the farms. The above formulations suggest that the following are potential predictors of peoples' attitudes about sludge: information about the technology; knowledge of sludge application and use; trust in science, industry, and government; anti-technology attitudes;

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alienation, knowledge of expert risk assessments, and demographics.

If the technical/rational perspective accounts for public reaction to this technology, it is hypothesized that the following factors can be expected to account for most of the variation in decision to accept or reject it:

- the presence or absence of risk communications that impart scientifically based information about the technology and its outcomes
- knowledge about the technology
- level of education

If the normative/value perspective dominates public reactions, then the following factors are hypothesized to explain the most variations:

- the presence or absence of risk communications
- trust in those who use and regulate that technology
- alienation from modern society
- anti-technology attitudes

## Methodology

In this survey design, the sample (N=700) was a cross section drawn from a random sampling of Iowa residents. Their names were taken from the street address sections of city and suburban directories. All respondents were adults, 18 years and above, who responded to a structured survey questionnaire sent by mail.

The response rate, after the second wave follow-up mailing, was a high 84 percent.

## Dependent variables

In this study, three attitudinal items tap different dimensions of the acceptability of sludge application and use:

1. Potential for individual use. Respondents were asked to assume that they operate farms. This item measured the extent to which individuals intended to apply sewage sludge on their farms or to use them in any farming application. Responses ranged from "definitely will," "probably will," "probably will not," to "definitely will not."

2. Potential for family use. This item gauged the extent to which respondents felt comfortable serving foods from farms that apply to their families. The responses ranged from "totally comfortable," "somewhat uncomfortable," to "very uncomfortable."
3. Attitude toward a ban. If legislation were proposed to ban from the American market all food produced by farmers who treat their farms with sludge, this item sought to reflect respondents' attitudes toward this policy move. The responses ranged from "strongly support," "probably support," "probably oppose," to "strongly oppose" it.

## Independent variables

The independent variables in this study were measured using five scales (three that assessed attitudes and two that measured knowledge), and a number of demographic factors (education, age, income, and having children at home).[2] The scales were as follows:

- Trust. This three item scale gauged trust in government agencies, trust in business and industry in general, and the belief that science knows enough to say that the technology is safe. This stemmed from the recognition that people think that, more often than not, complex technology bears a burden of too much uncertainty, too much greed on the part of its sponsors, and too little effective government control. People often say that even if the scientific and technical plans were flawless, people executing the plan and managing the technology would inevitably create serious mistakes.
- Alienation. This four item scale measured the degree to which the respondent believed that (a) the government protects private over public interest, (b) the wealthy are too powerful, (c) the government has too much to say over people's lives, and that (d) the country would be better off with less big business and a return to individual and family business. This scale indexed perceptions of powerlessness in the face of big government and big business.
- Anti-tech. This two-item scale measured the degree of agreement with statements indicating that "modern technology is so complicated that no one knows what

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is going on" and that "new discoveries always have unforeseen negative outcomes."

- Knowledge of sludge. This ten-item scale assessed knowledge specifically related to sludge: where it comes from; how it is treated or processed; if it contributes substantially as soil fertilizer; whether it leaves unusual substances that contaminate soil and groundwater. This was measured by the number of correct responses to ten close-ended objective questions about the use of sludge in Iowa agriculture.
- Knowledge of risk. This two-item scale dealt with the degree to which the respondent ranked chemical and industrial pollution as well as deforestation as major environmental threats. Correctly ranking them as such indicates agreement with scientific environmental risk assessments.

The distribution of responses to the three dependent variables was ascertained to spot some trends in responses as these three tap different aspects of technology acceptance or rejection. The first dependent variable emphasized the respondent's personal acceptance and potential use, whereas potential for family use focused on "feeling comfortable" feeding food from sludge-treated farms to one's family. People may easily expose themselves to risks, but they may be hesitant to subject loved ones to the same risks. The third variable, however, asked for a judgment of personal support for legislation, a more abstract dimension of acceptance.

Each of these three variables was subject to stepwise regression analysis to determine the amount of attitude variance accounted for by the nine possible antecedents.

## Results and Discussion

The sample met the expectation that few would have much knowledge of sludge. Only one-third reported knowing anything about the process of generating and applying sludge.

Table 1 presents the distribution of responses to the three dependent variables which tap different aspects of acceptance/rejection of sludge generation and use.

The question of personally trying the practice of applying sludge on the farm generated a solid majority (82.3%) willing to try it. The clustering of responses, however, was in the two

**TABLE I:**
*Distribution of Responses (%) to the Three Dependent Variables (N=386)*

| | % | Means | Standard dev. |
|---|---|---|---|
| **Potential for individual use** | | 2.07 | 0.781 |
| Definitely will try | 18.2 | | |
| Probably will try | 64.1 | | |
| Probably won't try | 11.8 | | |
| Definitely won't try | 4.3 | | |
| No answer | 1.6 | | |
| **Potential for family use** | | 2.37 | 0.680 |
| Totally comfortable | 14.3 | | |
| Somewhat comfortable | 45.7 | | |
| Somewhat uncomfortable | 30.3 | | |
| Very uncomfortable | 8.2 | | |
| No answer | 1.5 | | |
| **Attitude toward a ban** | | 2.89 | 0.772 |
| Strongly support | 1.0 | | |
| Probably support | 31.5 | | |
| Probably oppose | 45.5 | | |
| Strongly oppose | 21.0 | | |
| No answer | 1.0 | | |

middle "probably" categories, a pattern which indicated considerable indecision on this issue. The distribution of responses to family use potential, however, seems to take the opposite direction. A small majority said they were willing to serve food from sludge-treated farms to members of their family. But 38.5% reported feeling uncomfortable about it. The range of attitudes toward a ban on sludge use also provided a contrast to potential for individual use on their farms. While 72% indicated they are willing to try sludge on their farms, 31.5% reported they may support a legislative ban.

Three major conclusions can be drawn from this pattern of results. First, the bulk of the responses fall into the middle "probably" response categories which indicated a considerable lack of intensity or attitude commitment. Such attitudes are more ephemeral and easier to change. Second, some respondents were more willing to take risks with personal property but were less willing to impose those risks on others,

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particularly family members. Finally, indices of acceptability may produce different results if they tap different sets of attitudes. The key research question was the possible variation in factors that account for those response distributions.

Tables 2 to 4 present the results of the stepwise regression analysis for each of the dependent variables.

**TABLE 2:**
*Regression Analysis for Individual Use ($R^2$=0.44)*

| Independent variables | Multiple R | $R^2$ | $R^2$ change | Simple R | Beta ($R^2$ change) | F |
|---|---|---|---|---|---|---|
| Trust | 0.599 | 0.358 | 0.358 | 0.599 | 0.534 | 46.02*** |
| Knowledge of sludge | 0.654 | 0.428 | 0.010 | 0.302 | 0.106 | 9.36** |
| Anti-Tech | 0.658 | 0.433 | 0.005 | 0.097 | 0.113 | 10.80** |
| Alienation | 0.662 | 0.438 | 0.005 | 0.183 | 0.095 | 3.68* |

Table 2, outlining the results for potential for individual use, shows that four variables provided at least 1% additional explained variance. Together, they accounted for 44% of the variation. The Trust scale, by itself, accounted for a full 36% of the explained variance. Trust in business and industry in general, government regulators, and science as a provider of valid and useful knowledge were the major predictors of whether the respondents will or will not try sludge on their farms. Having accurate knowledge about the whole process of sludge treatment and use translates into greater acceptance. Anti-tech and Alienation have significant impacts as well: those who express greater anti-tech or alienated attitudes were more likely to reject the practice.

It should be noted here that education correlated highly with alienation. That is, those with lower levels of education felt more alienated from the dominant technical bureaucratic society. Their reaction to this practice that epitomizes big business and government was more likely to be rejection.

The analysis also indicated that accurate information about the process translates into greater acceptance. Those who scored highly on knowledge about sludge also had higher levels of education (r=0.26), more trust (r=0.23), lower alienation (r= 0.20) and anti-tech scores (r= 0.23).

The pattern of results regarding personal acceptability is mixed. The bulk of the explained variance was accounted for by variables, notably trust, representing the normative/value approach. Furthermore, a variable that seemed to index knowledge, education, was entangled with alienation. Knowledge of the practice, however, was significantly related to personal acceptance.

Table 3 presents the results of the regression analysis with potential for family use as the dependent variable. Although only four variables contributed significantly to the overall explained variance, they accounted for over half of it (51%). Trust again explained the bulk of the variance. This means that judgements of the trustworthiness of industry, science and government played a dominant role in deciding sludge use acceptability. The second most important variable was knowledge. Those who scored highly on knowledge were more willing to serve food from sludge-treated farms to their families. Alienation also related predictably with this dependent variable: Higher levels of alienation resulted in less acceptance. Finally, age related to this variable as older people expressed greater willingness to serve food from sludge-treated farms to their families, which may reflect the absence of children in their households.

**TABLE 3:**
*Regression Analysis for Potential for Family Use ($R^2$=0.51)*

| Independent variables | Multiple R | $R^2$ | $R^2$ change | Simple R | Beta ($R^2$ change) | F |
|---|---|---|---|---|---|---|
| Trust | 0.630 | 0.399 | 0.399 | 0.630 | 0.521 | 41.22*** |
| Knowledge of sludge | 0.697 | 0.485 | 0.085 | 0.463 | 0.257 | 23.06** |
| Alienation | 0.713 | 0.508 | 0.022 | 0.266 | -0.116 | 6.18** |
| Age | 0.717 | 0.514 | 0.007 | 0.248 | 0.099 | 2.87* |

*p<.05 **p<.01 ***p<.001

As in personal willingness to try out this technology, the bulk of the variation was accounted for by variables representing a normative/value perspective where trust was the dominant factor.

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Table 4 presents the results of regression analysis with attitude toward banning the practice as the dependent variable, a measure of acceptability-rejection that is much more abstract than the previous two dependent variables. The decision involved outcomes that were several steps removed from personal considerations. Attitudes that closely related to self generally involved greater commitment. Not surprisingly, the total explained variance for this variable was less than half that for the previous two variables (21%). A variable that stems from a rational/technical perspective, knowledge of sludge, accounted for the bulk of explained variance. Those who understood the practice were more likely to oppose a legislative ban. Lack of trust and alienation meant more support for a ban.

**TABLE 4:**
*Regression Analysis for Attitude Toward Banning the Practice ($R^2$=0.21)*

| Independent variables | Multiple R | $R^2$ | $R^2$ change | Simple R | Beta ($R^2$ change) | F |
|---|---|---|---|---|---|---|
| Knowledge of sludge | 0.298 | 0.089 | 0.089 | 0.298 | -0.208 | 19.13** |
| Alienation | 0.436 | 0.190 | 0.006 | 0.158 | 0.037 | 4.42* |
| Trust | 0.443 | 0.196 | 0.006 | 0.182 | -0.106 | 3.87* |
| Age | 0.450 | 0.202 | 0.006 | 0.047 | -0.091 | 1.51 |
| Education | 0.456 | 0.206 | 0.005 | 0.076 | -0.030 | 0.94 |

*p<.05 **p<.01

## Conclusion

Surveys of the acceptability of a technology perceived as risky may produce somewhat different results depending on how the acceptability questions are structured. Structuring the questions so that the focal person is self, family, or a more abstract entity may produce different patterns of results. In this study, significantly fewer people felt comfortable serving food from sludge-treated farms to their families.

Also, some who said they were willing to try the practice in their own farms would support a legislative ban. People may be willing to take personal risks that they would not want their children to take or to impose on a wider public. This lends

credence to attitude theorists who caution that when measuring attitudes to design policy, the questions must always be structured to be as place, time, and activity-specific as possible (Ajzen and Fishbein, 1980).

The findings indicate that technical information on sludge had little impact on acceptability.

The most consistent finding in the regression analysis was the impact of trust on acceptability. Trust in industry, in government regulatory agencies, and in science itself figured prominently on decisions to accept or reject probably because complex technology bears a burden of too much uncertainty and too little government control. Even if the scientific and technical plan were flawless, people perceived those executing the plan and managing the technology as fallible; their mistakes will inevitably create serious problems.

As with other studies of new and poorly understood topics, the bulk of the responses to acceptability items was in the middle, more tentative categories. People simply did not have well-formed, committed attitudes about this issue. Such attitudes were somewhat ephemeral and subject to change based on the perception that others more or less oppose or support the focal issue.

These results suggest that effective risk communication may be more a problem of ensuring trust than it is an issue of explaining risk/benefit analysis in lay terms. Human fallibility and foibles were of the most concern to respondents. History of safe use and industry/regulator integrity are likely to impress the nonexpert far more than improved technical presentations.

## Endnotes

[1]Also known as biosolids, sludge are the nutrient-rich processed organic material derived from wastewater treatment. The variety of substances in the wastewater determines the composition of the solids and can include domestic wastes, industrial discharges, chemicals in the water supply, and stormwater. At the treatment plant, wastewater is first separated into settled solids and liquid effluent. Various processes treat, stabilize, and disinfect the solids, destroying harmful bacteria and reducing odor. Such processes produce a myriad of products. These products can take the form of humus-like

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organic matter, dry powder, pellets, slurry or liquid and bear little resemblance to raw solids from which they were derived.

Processed solids are returned to the environment in a variety of ways: through land application, composting, burning, chemical stabilization, drying and pelletization.

In land application, biosolids are surface-spread or injected directly into the soil. The organic matter increases the soil's ability to store water and provides long-lasting nourishment for crops. Modern composting technologies take the natural process one step further by accelerating the composting cycle under controlled conditions. The resulting composted biosolids are an excellent soil conditioner and organic nutrient source. Sludge can also be burned and the heat used as a source of energy. Chemical stabilization combines wastewater solids with other materials to make biosolids that can be beneficially used as a liming material, low grade fertilizer, cover material for landfills, and back-fill material for land reclamation. In pelletization, wastewater solids are dried and formed into uniform size pellets that can be marketed as a soil conditioner, added to fertilizer blends, or mixed with landfill cover to increase vegetation.

[1]All scales were initially extracted using principal components factor analysis. The requirements that eigen values be at least 1 was applied in viewing factors as significant. Internal reliability was assessed by computing the item-total correlation coefficient, Cronbach's alpha, to each scale that met the factor analysis criteria. An alpha coefficient of 0.60 is the common cutoff point in the attitude literature; the coefficients of the scales in this study range from 0.66 to 0.82. Although scores on some scales (e.g., Trust and Alienation) were somewhat positively related, no relationship was so high as to suggest serious multicollinearity. No two scales were tapping the same factor.

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