SHOULD ENVIRONMENTAL ENGINEERS TRUST RISK ASSESSMENTS?

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Risk assessment is no panacea for making difficult decisions about the priority, extent, and objectives of cleanups of hazardous waste sites. Whenever critics of cleanup programs, such as the federal Superfund program, seek changes, they inevitably focus on using more risk assessment in decision making. Yet for several decades risk assessment has been used without consistent and widely supported results. In particular, risk assessments have been routinely performed for hundreds of Superfund cleanups, where the interests of companies paying for cleanups, government agencies, and community groups representing affected people are usually different and confrontational, because of different priorities and objectives. Ultimately, risk assessment does not do a very good job of satisfying diverse stakeholders about what is or is not a "safe" level of contamination or exposure, either before or after cleanup.

There have been two different applications of risk assessments for Superfund cleanups. First, the government must make the case for taking remedial action. Under the National Contingency Plan regulations, EPA has considerable flexibility, because it can choose to take action ifrisks to public health exceed 1OE-6 and must take action if risks exceed 10E-4. For the vast majority of Superfund decisions, EPA has used the traditional one in a million excess deaths (1OE-6) risk level, but more recently it has placed increasing emphasis on the one in ten thousand (1OE-4) risk level. However, actions by the ten EPA regional offices, which have the maximum discretion in implementing the Superfund program, are often inconsistent.

The second main Superfund application occurs when EPA defends specific numerical cleanup goals or standards that are selected for a site remedial action. There are usually few federal or state numerical standards under other environmental programs, making it necessary to use a risk assessment approach to derive numerical cleanup standards. Here too, EPA can choose to base cleanup standards over the risk range of 10E-6 to 1OE-4.

TECHNICAL ISSUES WITH SUPERFUND RISK ASSESSMENTS

Based on the author's experience with many Superfund sites since the program's inception in 1980, the following technical issues are used to illustrate what have surfaced to be significant problems with relying on risk assessments for hazardous waste cleanup sites.

Indicator chemicals

Over time it has become common practice for parties conducting site studies to define some short list of site contaminants that are used in risk assessments. The inevitable issue is whether such indicator chemicals or chemicals of concern fairly represent the full range of site contaminants and whether estimated risks are

reasonably accurate. What often happens is that attempts are made to minimize the number of chemicals that are included in risk assessments, which seems reasonable on the basis of reducing study costs. However, often one or more of the major site contaminants are not included. Arguments for excluding specific chemicals maybe made on the basis of the small amounts present at a site, an inability to somehow relate the presence of a chemical to the operations originally conducted at the site, or by the argument that other, selected, chemicals are in the same family and represent the one omitted. Upon close scrutiny, however, any such arguments can often be found to be without substance.

For example, at the Brio Refining Superfund site in Houston, styrene was not included in the list of indicator chemicals, even though there was abundant documentation that it had been one of the most prevalent hazardous wastes disposed at the site. No specific argument was given in the risk assessment for excluding it. It was simply ignored. At the Escambia Treating Company Superfund site in Pensacola, even though the highly toxic pesticide dieldrin was found at the site and in the residential area around the site, it was not included in the original risk assessment work. It was argued that there was no relation between the industrial wood treating operations at the site and dieldrin. However, research shows that dieldrin was sometimes used by wood treaters. This fact is mentioned in a fact sheet on dieldrin from the federal Agency for Toxic Substances and Disease Registry.

The central problem is that when some site contaminants are excluded from risk assessments, risks are underestimated. If a site is deemed of sufficient concern to warrant a remedial cleanup under Superfund, then one might say that the problem or threat to public health or environment is significant. But eventually when decisions are made about cleanup standards, the perception of the problem may change. When some toxic chemicals are omitted, cleanup levels may be too high for those chemicals included, and there maybe no action levels for omitted chemicals. In some cases, chemicals that are omitted might influence evaluations of alternative cleanup technologies and ignoring them may lead to inappropriate or ineffective technologies being selected for cleanup.

Exposure scenarios

One of the early decisions in conducting a Superfund risk assessment is deciding what plausible exposure scenarios should be considered. Here the problem is that often some exposure scenarios are excluded. Some examples of arguments for omitting specific exposure routes include:

--Although the groundwater is contaminated, it is not used for drinking purposes. But sometimes such water is used for other purposes, such as washing, irrigation, or recreational uses that do involve reasonable closed exposure routes, through inhalation of volatile chemicals or ingestion of toxic chemicals in water or food. A common scenario is that government agencies are willing to believe that a clay layer separating an upper from a lower aquifer is effective in preventing contaminants in soil or the upper aquifer from contaminating the lower aquifer that serves as a source of drinking water. The problem is that real clay layers often have sufficient interconnected porosity to allow contaminated groundwater to migrate through the clay under various groundwater conditions.

--Although soil is acknowledged to be contaminated at the cleanup site, other than direct ingestion there is no consideration of exposure because of the release of particulate into air followed by inhalation of the contaminants, or because of dermal exposure to the soil.

--Although some surface waterway is known to be contaminated, there is no consideration of how fish may bioaccumulate toxic chemicals and cause exposure through ingestion of the fish.

When relevant, appropriate and plausible exposure pathways are excluded, risks are underestimated.

Future use assumptions

Critics of the Superfund program have often focused on excessive, expensive, and unnecessary cleanups that are caused by unrealistic assumptions about future uses of groundwater or land. Such assumptions generally are that contaminated groundwater will be used for drinking water and that land will be used for residences. These translate into corresponding exposure scenarios that result in more stringent cleanup levels being calculated from risk equations. This author agrees that in significant numbers of cases such inappropriate assumptions have been made. The problem usually is that a site that has been contaminated by industrial or commercial uses is then assumed to be used for residences in the future. However, the opposite situation has also arisen. That is, Superfund sites have been cleaned up on the basis of assumptions that ignore available information about future uses that equate to higher exposure levels and risks. Moreover, many people argue that even though groundwater is not currently being used for drinking water that it is foolish to avoid cleanup, because groundwater supplies should be preserved for potential future drinking water use.

Detection limits and non-detects

A persistent problem is that the site contamination data that are relied on as inputs into risk assessments may not be reliable. The central problem is that findings of non-detectable levels or chemicals are too easily interpreted to mean that the chemicals are not present at the site. However, the analytical method detection limits (or practical quantitation levels) maybe too high. For example, at a number of Superfund sites the methods used for analyzing organic chemicals in groundwater have detection limits that are higher than federal Maximum Contaminant Levels under the Safe Drinking Water Act program. In other words, interpretations that some especially significant toxic chemicals are not present are quite misleading (i. e., false negatives are created). This is, for example, a big problem for testing of dioxins in soil, because there are two approved EPA methods, but one is half the cost of the other and has much too high a method detection level relative to dioxin levels that pose very significant health risks. Some practitioners sometimes assume a value of the detection limit rather than zero or a value halfway between zero and the detection limit, in order to more fairly estimate risks when true zero values are indeterminable.

Cumulative risks

One of the more subtle problems in risk assessments is that often there is no comprehensive calculation of risks based on the full range of both site contaminants and exposure scenarios. For each primary environmental medium, it is appropriate to sum the risks for all significant site contaminants and all relevant exposure scenarios related to that medium, and then to sum risks over all environmental media. The essential problem is that when a risk assessment is incomplete overly high concentration levels can be calculated for contaminants. In some cases a site may not be deemed appropriate for remedial action under Superfund because the levels of risk have been underestimated.

Inappropriate and inconsistent "safe" levels

One of the most contentious issues related to risk assessment applications in the Superfund program is the selection of a particular risk level by the government as acceptable or safe. The National Contingency Plan, the regulatory instrument for the Superfund program, says: "For known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 1OE-4 and 1OE-6 using information on the relationship between dose and response. The 1OE-6 risk level shall be used as the point of departure for determiningg remediation goals for alternatives..." During the early years of the Superfund program, EPA almost always used the one in a million (1OE-6) risk level for establishing cleanup goals. But in more recent years, as both the EPA and responsible parties paying for cleanups placed greater emphasis on lowering cleanup costs, higher risk levels have become more widely used. This has meant that some sites are not cleaned up and that at many others the cleanup standards are much less stringent. Most frequently there are EPA statements along the lines that a site must be cleaned up if the risk is above the 1OE-4 level, without any additional statement that it also has the legal authority to clean up a site if the risk is above the 10E-6 level and that it has done so for hundreds of sites. Interestingly, there is little consistency among the ten EPA regional offices and among similar sites.

In 1995, cleanup decisions were made for two sites with the same principle contaminants of polynuclear aromatic hydrocarbons and presented in terms of benzo(a)pyrene equivalents. At the Southern Maryland Wood Treating site in EPA Region 3 the cleanup goal for surface soil, assuming future residential use, was 0.1 ppm, while for the Southern Shipbuilding site in EPA Region 6, the corresponding cleanup goal was 10 ppm. The lower concentration level corresponded to an acceptable risk level of 10E-6, while the higher level corresponded to the legally allowable 1OE-4 risk level. Oddly, for the Region 6 site the future use of the site for residential purposes was probably more certain than for the Region 3 site.

This risk assessment issue should be viewed in the context of scientific arguments about what levels of exposure to carcinogens are safe. In a recent paper it was reported that nearly 20% of toxicologists agreed with the view that there is no safe level of exposure, while among the general population 50'% believed in this position.(1) This paper also presented very interesting calculations for exposure to one molecule per day of some very toxic chemicals and how that translates to a personal risk level and the risk to the global population. Probably most people living close to Superfund sites who have become strongly concerned about cleanups now believe that even one molecule may be lethal, which in some statistical sense probably is correct. In many civil litigation cases, toxicologists argue for plaintiffs that even a single molecule of a carcinogenic chemical can cause cancer. On the other end of the spectrum is the view that some 25% of people will develop cancer and that environmental risks are insignificant, especially because virtually everyone is exposed to some levels of toxic chemicals in ordinary everyday life. Clearly, regulatory levels of acceptable risk have no relation to person perceptions of safe levels of risks and exposures. Perhaps it is more significant that there is little consistency among cleanup decisions supposedly supported by risk assessments and legal requirements.

Non-cancer chronic health effects

People who see themselves as victims of cleanup sites increasingly are concerned that EPA's risk assessments only consider cancer health effects, while many other health effects are likely from exposures to toxic chemicals. A good example is that at a number of Superfund sites informal and professional health effects studies have found increased levels of birth defects among exposed populations.

DISCUSSION

At cleanup sites, risk assessments have usually become part of the problem facing stakeholders, rather than a clear solution. Like most technical tools, risk assessments, even when standardized (in terms of assumptions, data, and mathematics) to a great extent, are vulnerable to misuse and abuse because of intrinsic limitations and subjective interpretations made by its practitioners. Increasing use of software packages may only mask fundamental issues about trusting and using risk assessments.

A recent study by the General Accounting Office (2) found that 19 of 20 risk assessments (two from each of the ten EPA regional offices) examined in the Superfund program "did not adequately explain the uncertainty and variability in the data used and the assumptions made" and that 7 "did not include proper calculations of the total risk to people who could come into contact with several sources of contamination, thereby understating risk. " GAO also found that when EPA offices did not use guidance numerical values for exposure assumptions the tendency was to use values that would lower risks rather than increase them by a ratio of two to one.

Environmental engineers need to remain cautious and watchful about risk assessments. In addition to a multitude of scientific issues and concerns, there is also an ethical dimension to risk assessment use. No risk assessment application is done in a purely objective fashion, but rather by parties having a particular set of cleanup objectives and priorities that are shaped by economic, bureaucratic or health concerns.

Interestingly, risk assessments for cleanups are almost always done by parties defending specific cleanup decisions, and virtually never by those attacking cleanup decisions. At Superfund sites, most risk assessments are done by environmental contractors working for companies paying for cleanup or government agencies in charge of cleanups. While adhering to necessary and appropriate environmental goals and legal requirements, there is sufficient flexibility and ambiguity to allow bias in favor of achieving minimum cost -- euphemistically called cost-effective -- cleanups.

Most environmental engineers working for government contractors or consulting firms working for companies (responsible parties), therefore, tend to use risk assessments to defend cleanups that members of the affected community and their technical advisors find unsatisfactory. Perhaps the biggest problem is the illusion that risk assessment is like some basic physics equation or principle of mathematics, where any competent practitioner should obtain the same correct answer from applying a standard method. This is definitely not the case for Superfund risk assessments. Environmental engineers need to better understand the longstanding and valid objections to and limits of cleanup risk assessments.

CONCLUSION

The answer to the question posed in the title of this paper is "No." All parties need to see the results of risk assessments as approximate numerical indicators of safe and unsafe conditions, rather than as reliable or accurate quantitative descriptions of actual health risks. Environmental engineers should acknowledge the limited scope of cleanup risk assessments and not confuse results by placing them in a context that emphasizes other common health risks to people. Too many government officials and environmental engineers have increasingly adopted the strategy of the chemical industry, meaning that they downplay the significance of any risk associated with cleanup sites relative to a general societal risk of cancer death of some 25% or other types of everyday risks. With this approach, risks at the 1OE-6 level and even the 1OE-4 level are viewed as unimportant. Such an

approach may seem logical to those directly or indirectly associated with parties primarily concerned about reducing cleanup costs. But from the perspective of people who believe that they have been exposed to risks from hazardous wastes and see themselves as victims, it breeds anger and confrontation. Prevention, elimination or minimization of a specific involuntary chemical risk is a legitimate objective. The enormous challenge to environmental engineers is to keep some balance between economically driven uses of risk assessments and an emphasis on how use of the best environmental technologies can also help reduce costs while minimizing health risks.

References

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