ASSESSMENT AND CONTROL OF POLLUTION RELEASE FROM WASTE MANAGEMENT: CURRENT AND DEVELOPING US POLICY AND REGULATIONS

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Regulation and control of hazardous waste in the U.S. is administered at the national level by the U.S. Environmental Protection Agency (USEPA, or EPA), with support by the 50 states. The EPA develops national rules and regulations, under the authority of the Resource Conservation and Recovery Act (RCRA). RCRA requires the identification and control of wastes which, if improperly managed, may damage human health or the environment. The hazardous waste regulations establish rules to classify waste as hazardous (or not), and to require the proper storage, transportation, treatment, recycling, and final disposal of hazardous waste. Within the EPA, the national rules are developed by the Office of Solid Waste (OSW), with the help and cooperation of other EPA Offices, in particular the Office of Research and Development (ORD). The public is involved through scientific peer review and comment on the proposed program, and also through the legislature. The 50 states adopt laws and regulations as stringent as the national regulations (or at state discretion, more stringent), and perform dayto-day administration and enforcement of the regulations.

Under the U.S. system, materials must first be identified as a waste to come under the authority of RCRA; hazards from products are regulated under other laws. All discarded materials, including waste waters, contaminated soils and debris, and most recyclables1 are classified as wastes. Once identified as a waste, the generator must apply the regulations to determine whether it is a hazardous waste. If classified as hazardous, handling of the waste is controlled; if it is not a hazardous waste, few national controls apply, and individual states decide what handling is proper.

The hazardous waste management requirements focus to a large degree on risk of groundwater contamination for both classifying waste as hazardous and controlling management and disposal of hazardous waste2. In developing the U.S. system going into the future, the EPA is refining its ability to estimate risks to groundwater and developing models to estimate risk to human health and the ecology through waste constituent release to other environmental media.

La réglementation et le contrôle de déchets dangereux aux USA sont administrés au niveau national par le US Environmental Protection Agency (US EPA), avec l'assistance des 50 états. L'EPA élabore la réglementation sous l'autorité du « Resource Conservation and Recovery Act (RCRA) ». Le RCRA demande l'identification et le contrôle de déchets qui, en cas de mauvaise gestion, peuvent nuire à la santé humaine ou à l'environnement. La réglementation classifie les déchets comme dangereux (ou pas) et rend obligatoire le stockage approprié, le transport, le traitement, le recyclage et l'élimination finale du déchet dangereux. Au sein de l'EPA, les règles nationales sont élaborées par the « Office of Solid Waste (OSW) » avec le soutien et la coopération des autres services de l'EPA, en particulier the « Office or Research and Development (ORD) ».

Le public participe en donnant ses commentaires et points de vue scientifiques sur le programme proposé, ainsi qu'à travers la législation. Les 50 états adoptent les lois et les réglementations et sont chargés de l'administration quotidienne et de l'application de la réglementation.

Dans le système américain, les matériaux doivent d'abord être identifiés comme étant un déchet, afin d'être mis sous l'autorité du RCRA ; les dangers provenant de produits sont réglementés par d'autres lois. Tout matériau abandonné y compris les eaux usées, les sols contaminés et débris, ainsi que la majorité des matériaux recyclables sont classifiés comme déchets. Une fois identifié comme déchet, le producteur doit appliquer la réglementation afin d'établir si c'est un déchet dangereux. Si classifié comme tel, la gestion du déchet est contrôlée. Si ce n'est pas un déchet dangereux, peu de contrôles nationaux sont alors applicables, et les états décident individuellement quelle manipulation est appropriée.

Les obligations de la gestion des déchets dangereux se concentrent essentiellement sur le risque de contamination des nappes phréatiques, tant pour la classification de déchets dangereux que pour le contrôle de leurs gestion et de leurs élimination. En développant le système américain pour l'avenir, l'EPA améliore sa capacité à estimer les risques aux nappes phréatiques et développe des modèles pour estimer l'impact sur la santé humaine et l'écologie à travers le relargage des constituants des déchets vers le milieu environnant.

USEPA CURRENT PROGRAM

Waste Classification

The US regulations use two methods for classifying waste as hazardous: hazardous characteristics and listing of specific wastes as hazardous. Any waste that exhibits a hazardous characteristic (ignitability, corrosivity, reactivity, or toxicity-risk to groundwater) is regulated as a hazardous waste. Any waste that is specifically listed by the EPA is a hazardous waste. Listing decisions are based on examination of particular industrial process and typical waste samples from the process.

Under both of these approaches, wastes estimated to leach toxic metals or organic chemicals at a rate that would contaminate near- by drinking water wells are regulated as hazardous. The EPA uses the toxicity characteristic leaching procedure (TCLP) test to estimate the leaching of metals and organic chemicals from waste in a landfill. Transport of leached chemicals through the groundwater to near-by wells is estimated using mathematical models, and concentrations there compared with national standards for toxic chemicals in drinking water (or cancer risk values using 10-5 risk or toxicity thresholds for non-carcinogenic chemicals). For the toxicity characteristic (TC) regulation, any waste projected to cause a well to exceed the drinking water standard based on the TCLP test and this modeling is classified as hazardous. Also, most listed hazardous wastes were added to the list because of their potential to contaminate groundwater if not properly managed.

Using models to estimate the risks posed by waste is a key aspect of classifying waste as hazardous. The TCLP test is a chemical model of waste leaching in a municipal landfill, which the EPA considers is likely management for an industrial waste that is not regulated. The test conditions (pH 5 buffered acetic acid, and 20 parts leach fluid to 1 part waste) are intended to simulate the conditions likely to occur in the municipal landfill if a small percentage of industrial waste (relative to the garbage) were placed there.

The groundwater transport model used to estimate the chemical concentration that might reach a well (used for the TC regulation and for listings until 1998) is called the EPA Composite Model for Landfills (EPACML). The model is based on hydrogeology principles, and is implemented using distributions of data that describe U.S. landfills, hydrogeology characteristics, and climate. Probabilitybased simulations using these nationally representative data estimate risks from waste; that is, the probability of a waste contaminating a drinking water well located anywhere in the U. S., having generated a particular concentration of toxic chemical in leachate. A protective point (85 or 90%) on this distribution of risk is then chosen for the national regulation. This model has been updated (described below), and the new version is being used for new regulations. However, the EPA has not reissued the older TC and listing regulations based on the new model.

Waste Handling

Once a waste is classified as hazardous, waste handling requirements are imposed. Requirements for waste storage, transport, treatment and final disposal are designed to limit releases to soil and groundwater, and in some cases, to the air. Requirements include design standards for waste storage tanks, containers, and surface impoundments (ponds) to prevent release from leakage or overflow if containers fait, and covers to prevent release of volatile chemicals to the air.

Hazardous Waste Treatment

All waste that is classified as hazardous must be treated before final disposal on the land; it is illegal to place improperly treated waste on the land. This requirement was added to RCRA primarily to protect groundwater. RCRA also prohibits the placement of free liquids in landfills, if they contain hazardous waste. Standards for waste treatment are based on the performance of technologies appropriate for treating different types of waste; the technology considered appropriate for each waste is called the Best Demonstrated Available Technology (BDAT). Most standards are numerical standards, but are based on the performance of appropriate treatment for the waste (either total concentration or leaching concentration from the treated waste). Some treatment standards require the use of the specific BDAT technology, such as combustion. Where a specific treatment is not required, any appropriate treatment can be used to meet the established numerical requirements.

For treating waste containing primarily metals, the standards are numerical, and are expressed as leaching concentration using the TCLP test. That is, the treated waste must not leach metals at a concentration higher than the treatment standard, when tested using the TCLP. No specific treatment method is required, although the BDAT standards for most metals was based on stabilization/solidification (S/S) treatment. Portland cement or a variety of other materials is the most frequent treatment for immobilizing metals. Other treatments that may work include vitrification, macro-encapsulation with resins or plastics, or chemical precipitation3. For wastes that are predominantly organic chemicals or materials, treatment standards are set as total concentration in the treated waste, or for some waste, as a required treatment technology. The treatment for organic chemicals is intended primarily to destroy the toxic chemica14, usually through chemical reaction, biodegradation, or combustion.

Waste containing both metals and organic chemicals must meet the BDAT standards for all regulated constituents. This means that some wastes must be treated by more than one method, or that the ash, sludge, or other residuals f rom combustion or biodegradation treatment may also require treatment to immobilize metals. Devising the appropriate order for treatment is done on a case-specific basis by the treater.

Hazardous Waste Disposal

Once properly treated, characteristic hazardous waste and listed hazardous waste are disposed of differently. Treatment of characteristic hazardous waste is directed at «de-characterizing» the waste, or removing the hazardous characteristic from the waste. It may then be disposed in a non-hazardous waste landfill. Listed waste must be disposed in a hazardous waste landfill, even after treatment. Hazardous waste landfills must obtain an operating permit, and meet specific design requirements, in particular, the requirement for a double liner, with a system to collect leachate from between the two liner layers to prevent it from reaching the groundwater. The leachate itself is then treated and the treatment residuals disposed in the hazardous waste landfill, Once filled, hazardous landfills must be securely closed according to a site-specific plan to minimize future releases from the site. Long-term requirements may include collection, treatment and disposal of leachate and surface runoff, and monitoring of groundwater at the edge of the site.

Delisting

Many listed wastes, after adequate treatment, pose substantially less risk than they do when generated. However, waste «mixtures» and «derived-from» wastes remain regulated to ensure that «sham» treatment or dilution is not used to avoid regulation. Generators may apply to have waste delisted on a case-by-case basis. When a waste is delisted, a set of risk-based leachate concentration values are set that must be met in periodic testing of the waste. Some, but not all delisted wastes, may have the additional requirement for disposal in a particular waste unit type. For delisted wastes without this second condition, disposal is allowed in any type of waste management unit, or the waste may be recycled without regulatory controls.

Evaluation of waste for delisting relies on the TCLP and CML groundwater model, with occasional use of the multiple extraction procedure test (MEP) for stabilized waste, and de-ionized water leaching for cyanides. Risk end-points are drinking water regulatory levels, or cancer risk levels (10-5) or toxicity threshold levels for non- carcinogens. The MEP test consists of a sequential series of 10 acidic extractions of a sample, and is intended to simulate longer-term exposure to acid rain conditions. Evaluation of waste for delisting also accounts for waste volume, attributing higher dilution factors to lower volumes of waste. Several delistings considered or granted in the past year have also considered the risks from surface run-off of waste constituents, and air releases (wind-blown dust), although these have been found to be insignificant risks in the cases considered so far. One recently proposed delisting was based in part on leach testing at neutral and alkaline pHs, in addition to the TCLP's acid.

Recycling

The EPA considers recycled materials to be waste, and regulates them as hazardous, with many exceptions. The EPA's general approach to regulating hazardous waste being recycled is to determine which types of recycling activities and waste closely resemble waste management (and may pose similar risks), and to regulate these. Many other wastes, when recycled, are specifically excluded or exempted from regulation. The result is a program made up of details. For example, recycling such as burning (solvents) for energy recovery or use of slag as road bed material have special requirements. On the other hand, recycling in which materials are returned to a production process without reclaiming them, is exempt. Also, in most cases, the recycling process itself is not regulated, and the final product of the recycling is not regulated (unless the product is paced on the land).

Recycling must be legitimate, and there are informal guidelines to distinguish between legitimate and «sham», or fraudulent recycling. The guidelines focus on the degree to which the recycled material is «commodity-like». The material is compared with non-waste raw materials with regard to: composition; the degree of processing required for the finished product; market value of the material and final product; handling; the economics of recycling; and whether toxic constituents contribute to the product or are simply «along for the ride». Legitimacy determinations are made on a case-specific basis.

Re-use of final wastes is controlled within this context. Again, products made from recycled waste are not regulated, except if the product is to be used on the land. Waste re-use on the land is considered «use constituting disposal». Combustion ash or treatment residuals such as slags from metals recovery operations are often used in cement or road construction materials, and fall in this category. To become unregulated in this use, products must be legitimate commercial products, must meet the waste treatment standards (based on TCLP leaching), and must also undergo chemical change in the course of production so that the recycled hazardous waste becomes inseparable by physical means from the product. The waste constituents must form a chemical bond with the product, such as in cement production and pouring. The requirement for chemical bonding does not apply to fertilizers made from hazardous waste, and neither requirement applies to fertilizer made from electric arc furnace dust used in the fertilizer for its zinc content.

USEPA DEVELOPING PROGRAMS

In the past several years, the EPA has begun to revise and further develop important tools used to support its regulation program. EPA scientists have continued revision and refinement of groundwater fate and transport models, and have made substantial progress in modeling pollutant fate and transport by multiple non-groundwater environmental pathways, including release to the air and runoff to surface water bodies. EPA has also begun using the multi-pathway models to estimate risk to the ecology. Finally, we have begun review of the TCLP test, and may revise, replace or supplement the test itself, or revise how it is used in EPA regulations.

Groundwater Transport and Fate Modeling

Many simplifying assumptions used in the EPACML model meant all chemicals were predicted to have the same degree of dilution and attenuation in concentration as they moved through the groundwater to the drinking water well. EPA's modeling capabilities at that time were more limited, and the CML model provided a protective overestimate of risk.

An updated model, the Composite Model with Transformation Products (CMTP) has been developed in the past several years as a significant refinement of the CML model. CMTP can model hydrolysis, biodegradation, and absorption onto soil. CMTP also does not assume that the source of hazardous constituent input to the groundwater is constant and endless, as the CIVIL model assumed. For metals there is an add-on to the CMTP model, called MINTEQ, which uses groundwater pH, oxidation/reduction conditions, and solubilities of metal sails to estimate which chemical species of a metal will be present in the ground water, and how much will be in solution and able to move with the groundwater flow. EPA scientists have also begun developing multiple-phase flow models, to assess movement of nonmiscible organic contaminants in the groundwater.

Multiple Pathway Transport and Fate Modeling

In 1995 the EPA proposed for public comment a risk evaluation method that considers risks from waste constituent release and transport along multiple environmental pathways. Releases to air and in surface runoff were estimated for waste management from several waste unit types, and environmental transport and risk to potentially exposed persons estimated. Risks to ecosystems were also estimated. In this model, each pathway was modeled separately and independently, using all of the waste constituent chemical of concern in each pathway. Also, the modeling was run backwards; that is, the model was used to estimate a safe concentration in waste by starting with the dose to be avoided, and modeling back to the waste to estimate the maximum safe concentration there. EPA estimated the risks for approximately 200 chemicals in this effort. EPA received many comments and criticisms of the effort, and is presently revising the model. The revised model will address many of the flaws and simplifying assumptions in the 1995 model that led to criticism, including maintaining mass balance for the waste source, partitioning waste constituents to the different release and transport pathways, and integrating the individual pathways into a single model.

Leach Testing

EPA is reviewing the TCLP waste leaching test, and is examining more carefully the leaching of toxic constituents from waste into groundwater under a variety of conditions.

Several concerns have caused this review, but most notably the dramatic failure of the test to predict leaching from highly alkaline stabilized spent aluminum potliners placed in a monofill. Three important conditions of the test differed greatly from the conditions of actual waste disposal.

TCLP uses acetic acid buffered at pH 2.9 for alkaline waste, but the landfill leachate pH was 12-13.

TCLP uses 20 parts leach fluid to 1 part waste (liquid to solid ratio, or US of 20), while the US measured in the landfill was 0.1.

TCLP assumes that 5% industrial waste is co-disposed with municipal solid waste, while the spent potliners were the only waste deposed in this landfill.

The TCLP test failed to predict significant leaching of arsenic, fluoride, and cyanide from the waste (as detected in collected leachate). Both the delisting and treatment requirements were based on TCLP results. The delisting was withdrawn by EPA, and the treatment standards were successfully challenged in the courts before revised by EPA.

The review of leach testing has several goals. The most important is to develop a leach testing procedure that is more accurate for a range of waste types (matrices and constituents) and can account for a broader range of waste disposal conditions, but which can be used nationally and is not site-specific. Use on a national basis is important to avoid a waste classification system under which a waste is declared hazardous in one location but not in another. Simi larly, if a revised test were used for establishing treatment requirements, these would need to be nationally uniform as well. Cost and ease of use are critical too, of course. In addition, good site specific evaluation methods are needed for evaluation of delisting petitions and for assessing the need to clean-up manufacturing sites contaminated by past use and carelessness.

Waste Treatment

Concern about this release of toxic chemicals from a treated waste has also caused EPA to begin examination of long-term stability of treated waste. Developing a better understanding the effectiveness of various treatment methods will support possible revision to the treatment requirements and safer waste management and disposal.

CONCLUSION

These advances in risk assessment begin to provide more precise and accurate estimates of risk from waste in different types of waste disposal units. Improved risk evaluation methods allow better identification of both significant hazards posed by waste and relatively safe waste. Application of these improved methods is coming first in the delisting program, because of its case-specific creation of new regulations. Reviewing and changing existing regulations, such as the Toxicity Characteristic, the BDAT treatment standards, and evaluation of waste re-used in a manner constituting disposal will require both final development of the methods, and significant resources to review such large program areas. Also, the regulated public will need to understand the potential benefit to them from these new methods; the very fact of changing an established program raises significant concerns for them, because it is always difficult to predict the full effects of program changes.

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Références

1. Hazardous waste being recycled are regulated depending on the degree to wich the recycling resembles waste management and disposal, as compared with industrial production. Recycling that resembles waste management is more stringently controlled, and recycling that more resembles industrial production is less controlled. This is done through a series of exclusions or exemptions from the hazardous waste regulations.

2. Other concerns in classifying waste as hazardous and controlling its management are for worker safety in handling igintable reactive or corrosive wastes, and air releases of volatile organic compounds.

3. Mercury is a special case, with recovery for reuse being the goal of treatment. However, with reduced demand, EPA is reviewing and may revise its treatment requirements for mercury, to allow chemical stabilization either throught S/S treatment or amalgamation with zinc. For cyanide wastes, treatment requirements are numerical values based on total CN nd CN amenable to chlorination.

4. USAPE programs that clean-up contamined facilities that are abandoned have used S/S to treat (immobilize) organic chemicals in soil, in some cases, as wall as for immobilizing metals. For newly generated industrial waste, this is an uncommon, but increasing practice, and is a subject of some debate.