USGS

WATER RESOURCES RESEARCH GRANT PROPOSAL

PREFERENTIAL FLOW AND ORGANIC ENHANCEMENT OF METALS TRANSPORT TO GROUNDWATER FROM LAND-APPLIED BIOSOLIDS IN THE NORTHEASTERN U.S.

2. Focus Categories ST (Solute Transport)

TS (Toxic Substances)

MOD (Models)

3. Key Words Contaminant transport, sludge, biosolids, heavy metals, leaching, phosphorus, surfactants, nonylphenols, pollutants, preferential flow, facilitated transport groundwater, water quality, modeling,

4.Duration September 1, 1998 to August 31, 2001

5. Federal Funds Requested $ 89,900

6. Non-Federal Funds Match $235,948

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8. Congressional District 26

9. Statement of Critical Regional Water Problems

Application of municipal wastewater sludges (biosolids) to land is being widely promoted as a cost-effective management alternative. Agricultural land, forest land, and land reclamation sites are increasingly being used for land application. In addition to beneficial components such as organic matter and nutrients, sludges also contain trace metals (such as Cd, Cu, Hg, Ni, Pb and Zn) which in groundwater or agricultural products may present a human toxicity risk. Current USEPA regulations governing sludge application assume little or no mobility of sludge-applied metals to groundwater (USEPA, 1993). We have observed substantial movement of sludge-applied metals via preferential flow paths, facilitated by complexation with soluble organics. Moreover,

many field studies are unable to account for a substantial fraction of sludge-applied trace metals when the receiving soil is examined several years after application. Losses from the soil profile via leaching is a potential mechanism for the apparent losses. Relatively few studies report water quality data, and results can be complicated by instrumental detection limits and by the potential for sampler interactions (such as substantial metal adsorption by ceramic cup lysimeters as reported by Wenzel et al. 1997).

Our ongoing experiments have shown heavy metal leaching through soils in experimental and field systems. The presence of preferential flow paths (soil fractures, shrink-swell cracks, worm holes, etc. that exist under field conditions) and soluble humic organics (which complex with metals) both served to greatly increase the leaching of metals in undisturbed soil columns (Camobreco et al.1996). In contrast, conventionally-prepared homogenized soil columns (which are completely unlike field conditions) immobilized all applied metals, whether in water alone or with soluble organics. Preferential flow and facilitated transport factored significantly in metal mobility recently observed in an old sludge application site (Richards et al. 1998). Unfortunately, much of present conventional wisdom about metal immobility is based on homogenized soil columns and is thus overly optimistic about the soil immobilization of sludge-applied metals. Similarly, conventional simulation models (including those used for the USEPA assessment of groundwater contamination risk during Part 503 rule development) do not account for either preferential flow or facilitated transport. These phenomena may increase the risk of leaching of sludge-applied metals to groundwater, especially in the Northeast where soils are relatively shallow and leaching rates are high, and may thus present an unforseen long-term environmental risk. Rates of nutrient mineralization from land-applied sludges are also poorly defined, and overapplication may result in groundwater contamination. A more recent concern with land-applied sludge is the presence of surfactants and metabolites thought to act as endocrine disruptors, and for which there is little field data, especially regarding leaching potential. Emerging national and international water quality standards for these surfactants are on the order of 1 µg/L (Renner 1997)

10. Statement of Results and Benefits

There is a sense among many soil scientists and others that the USEPA Part 503 sludge land-application standards may not be sufficiently protective in the Northeast US, and that cumulative sludge applications in the Northeast US should be lower than the Part 503 standards would allow, at least until more long-term research is available. Some have advised using the Northeast recommendation levels found in Baker et al. (1985) as interim cumulative application limits, equivalent to approximately 10% of the allowable Part 503 metals loadings (e.g. Harrison et al. 1997). Concerns include potential human, animal and crop toxicity. The recent convening of the NEC-100 Northeast regional ad hoc technical committee to review and discuss sludge application issues specific to the Northeast underscores these concerns. The need for reliable field data on the fate of sludge-applied metals in typical Northeastern soils has been identified as a key parameter, especially in view of our findings of potential metal mobility in leachates. There is also little US field data on the presence and impacts of surfactants and their

metabolites in land-applied sludges (Rubin, 1998), which may contain these compounds at up to part-per-thousand levels (Giger et al. 1984) but for which no sludge quality standards exist.

The proposed work will allow us to obtain a better understanding of metal movement in the soil. The concept that metals are moving as organic complexes through preferential flow paths is relatively new and needs further investigation. We will expand and verify our current observations by continuing to examine an extensive existing soil column study for longer-term metal mobility. At well-documented field sites we will examine soil profiles, soil water, tile outflow and/or groundwater to determine if metals and nutrients are leaching. The proposed project will also afford the opportunity to screen sludge, soil, and water samples obtained for the presence, persistence and mobility of surfactants and their metabolites (in this case primarily 4-nonylphenol, which can act as a potent endocrine disrupter). The results of the study will contribute to our understanding of the potential risks to water quality posed by land application of sludges, and will contribute to the base of knowledge needed to define land application practices that are protective of water quality in the Northeast.