USGS

WATER RESOURCES RESEARCH GRANT PROPOSAL

Title: Polymer Effects on Virus and Bacteria Transport in Subsurface

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Focus Categories: WQL, AG, GW

Congressional District: 1st

Descriptors: microorganisms, polyacrylamides, recharge, infiltration, ground water, vadose zone, virus, bacteria.

Critical Regional Water Related Problems

Water management strategies are closely related to management of water resources and water pollution. A water pollution problem which affects all areas with significant rainfall is soil erosion and the subsequent transport of soil and all land-based pollutants (pesticides, nutrients, pathogens, toxin etc.) which enter receiving waters such as coastal waters, estuaries, harbors, streams, rivers, and lakes. This problem is especially relevant to islands, coastal states, and other states in the Southeastern region, which receive heavy rainfall or have a significant acreage under irrigation. A recent management strategy which has alleviated this problem is the application of anionic high molecular weight polymers such as polyacrylamides to soil as means to retain the structure of the soil and to prevent soil erosion and subsequent environmental problems.

This procedure is relatively new (< 6 years) but is now applied to approximately 600,000 acres in the US. This process has been used in furrow irrigated land and at construction sites for temporary erosion control but has potential for use in many other areas such as sprinkler irrigation, sediment detention basins, hillsides, and open land. Application of polymers has clearly shown a reduction in soil loss (95 percent or higher) and a 15-50% increase of water infiltration at these treated sites. Increase of water infiltration has several positive effects such as maintaining soil moisture, soil productivity, and in increasing the groundwater recharge. What is not clear is the effects of the use of polymers on the quality of groundwater if this process allows more of the water and its constituents to flow through the soil and finally to aquifers. Studies must be conducted immediately to evaluate if the use of polymers will allow water pollution constituents such as chemicals, nutrients, pesticides, and microbial pathogens to reach groundwater in aquifer. This question becomes more relevant today because of the increased level of water pollution by animal waste as well as the practice of reusing wastewater for irrigation and the recharge of groundwater supplies. In this regard, a major constituent of wastewater is fecal microorganisms, especially human enteric viruses that are most likely

to be transported through the soil matrix to contaminate groundwater supplies and to cause water-borne diseases in humans.

This study will be conducted in two phases. During phase 1 (i.e., year 1) of this study, we will obtain basic data on the application method, dose, and effectiveness of polymers to stabilize different types of soils. We will then determine the ability of this polymer treated soil to enhance the penetration of chemicals, fluorescent microspheres, and bacteria through leaching experiments on soil columns. If the results of year 1 show that the polymer treatment will enhance the penetration and mobility of pollutants through the soil, phase 2 or year 2 studies will then be conducted to focus on the transport of two different types of fecal bacteria (gram negative rod, gram positive cocci) as well as bacterial viruses which have the same size, shape, and genetic constituents as human pathogen sewage borne viruses. We will also determine bacterial and viral soil sorption and survival characteristics during phase 2 of this study and will enhance a model for the transport of these pollutants with and without the treatment of these polymers.

Nature and Scope of Proposed Research

Agriculture is perceived to be a major non-point source polluter of surface and ground-water supplies. Both chemical (pesticides and nitrate) and fecal (bacteria, protozoa, and virus) pollution have been associated with agricultural land use practices. The proposed research addresses the potential problems (or benefits) associated with the use of high molecular weight polymers (anionic polyacrylamides, PAMs) on soils that have been treated with pathogenic wastes such as wastewater, biosolids (sludge), and manure. Some of the benefits of this research include the demonstration of the impact of soil amendments such as polymers and surface mulching on the transport of chemicals, fluorescent microspheres and spores.

This study will be the first phase of a more detailed study on the transport of bacteria, virus, and other organisms, which will lead to the development of better management practices to reduce surface and ground water pollution. Animal wastes (manure) and composts have traditionally been used for agricultural purposes throughout the world. Disposal of biosolids and secondary-treated effluent from wastewater treatment plants either on agricultural land or on non-agricultural areas (golf course and forested areas) are being actively pursued as a mode of reusing the wastes. Excessive loading of these wastes often leads to serious pollution problems. More recently, high molecular weight polymers have been used in agriculture and construction sites for erosion control. A 15 to 50 percent increase in infiltration has been observed at many locations. An enhanced infiltration in soils treated with wastes that contain pathogenic organisms may lead to a faster movement of microorganisms thus increasing the potential for contamination of ground water. However, no literature is available on the movement of pathogenic organisms such as viruses and bacteria as well as chemicals when they come in contact with soils treated with polymers.

The anionic polymers have a net negative charge (negative charged sites exceed in number than the positive charged sites). The viruses are negatively charged colloidal

particles. Most surficial soils are negatively charged. Further, the polymers are observed to have strong sorption potential for soils. Research is needed to elucidate mechanisms that contribute to the movement of viruses, bacteria, and other chemicals in polymer treated soils. It is time consuming and relatively expensive in the first year to conduct viral assays unless underlying problems with methods are worked out. As the first phase of this project, we propose to conduct mobility studies with chemicals, fluorescent microspheres, and bacterial spores in the first year. We will also examine the mobility of bacteria E. coli in a limited number of tests in the first year. We will submit a more detailed proposal in the second year to study the transport of FRNA coliphage, two types of bacteria (rod and cocci shaped) and their sorption and dieaway rates in systems treated with polymers. Refinements to the mathematical model will be carried out in both the years.

Dr. Ray's specialty lies in environmental hydrology of surface and subsurface environments with emphasis on modeling. He also has a strong background in contaminant transport processes including those for viruses. Dr. El-Swaify's research is focused on soil erosion control, resource conservation, and environment/ecosystem management. Ms. Yoneyama specializes in environmental microbiology with strong analytical background in virology. This collaboration will not only lead to the assessment of the problem, but it will provide the PIs with opportunity for developing management options for reducing ground-water pollution and for the refinement and validation of a virus transport model.

The proposed research will contribute to the training of a M.S.-level student in environmental microbiology. We are quite hopeful of attracting a number of undergraduate students in Civil Engineering and Soil Science, who are working with the PIs, to pursue a graduate degree. This project gives a unique combination of hydrology and environmental microbiology and prepares the students very well for the job market. If this proposal is funded for the first year, a new proposal will be submitted for the next call for RFPs to conduct detailed assessment of virus (FRNA coliphage) transport, sorption, and dieaway rates. This will help the graduate student complete his/her degree. The data will help us prepare additional proposals to agencies such as the U.S. Department of Agriculture, American Water Works Association Research Foundation, and the local agencies.