TOSC Review of *Pall Life Sciences*

"Work Plan for the Testing of In-situ Oxidation using Hydrogen Peroxide for the Treatment of 1,4-Dioxane at the Pall Life Sciences Facility."

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For: Technical Outreach Services for Communities (TOSC) Program
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Conducted at the request of the Scio Residents for Safe Water, the City of Ann Arbor, the Michigan Department of Environmental Quality and other Ann Arbor-area citizens

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Pursuant to the request of Scio Residents for Safe Water, the City of Ann Arbor, the Michigan Department of Environmental Quality and other Ann Arbor-area citizens, the Michigan State University Technical Outreach Services for Communities (TOSC) Program provides the following recommendations. The recommendations address community concerns over the proposal by Pall Life Sciences, Inc. (PLS) to inject hydrogen peroxide into the groundwater to destroy 1,4-dioxane. The recommendations were written by Dr. Susan Masten, Ph.D., PE, and Professor of Environmental Engineering at Michigan State University. (Dr. Masten also presented these comments, in summary form, at the public meeting held March 24, 2004, in Ann Arbor.) They specifically address the PLS proposal titled “Work Plan for the Testing of In-situ Oxidation using Hydrogen Peroxide for the Treatment of 1,4-Dioxane at the Pall Life Sciences Facility.” PLS has begun to install wells in the Maple Village area to conduct the injection. It is TOSC’s opinion that MDEQ would be acting imprudently to allow the injection of hydrogen peroxide to began before PLS’ performed additional testing, as outlined below.

Questions about TOSC’s comments should be directed to Kirk Riley, TOSC Program Manager, by phone (517.355.7493) or e-mail (rileyki@egr.msu.edu). For additional information on the TOSC Program and the PLS TOSC project, visit www.tosc.msu.edu/gelman.

Recommendations

Before PLS begins pumping hydrogen peroxide into the Aquifer E plume, several experiments should be conducted. As part of the drilling process, aquifer material should be collected. Both batch and column experiments should be conducted using extracted groundwater from the Unit E aquifer. As background, the aquifer material to which TOSC refers is the geological material present in the Unit E aquifer. Batch experiments are performed in a closed vessel for a specific time period. Chemical reagents are added to the contaminated soil and the concentration of 1,4-dioxane is monitored with respect to time. Column experiments are performed by packing the geological material into a glass column and passing the chemical reagents through the column. The concentration of 1,4-dioxane in the flow from the column (effluent) is monitored. The concentration of 1,4-dioxane in the treated soil is determined after completion of the experiment.

Bench-scale experiments

The batch experiments should be designed in such a way as to determine:

1) The percentage of hydrogen peroxide and the rate at which the reagent solution can be safely added to the aquifer material without excessive heat and gas generation. TOSC is concerned that heat and gas could build up to excessive levels, perhaps even explosive levels.
2) The rate of oxidation of 1,4-dioxane with the addition of the proposed mass (and addition rate) of hydrogen peroxide. This needs to be accomplished on a “per” dosage level, i.e., the mass of 1,4-dioxane that is oxidized for each volume of

hydrogen peroxide that is added so that the oxidation process can be scaled from the bench to full-scale in the aquifer.

3) The byproducts formed during the oxidation. Possible byproducts that should be tested for include 2-hydroxyethylglycoaldehyde hemiacetal, 2-hydroxyethylglycoaldehyde, 2-hydroxyethylglycolic acid lactone, 2-hydroxyethylglycolic acid, 1,2-ethanediol monoformate ester (O=CH-O-CH_2CH_2OH), 1,2-ethanediol diformate ester (O=CH-O-CH_2CH_2O-CH=O), methoxyacetic acid (CH_3OCH_2COOH), Glycolic acid ($HOCH_2COOH$), glyoxal (OHCCHO), glyoxylic acid (OHCCOOH), oxalic acid (HOOCCOOH), formaldehyde (HCHO), and formic acid (HCOOH). Specific quantities of each byproduct should be reported to MDEQ. In addition, there are several byproducts that would retain the basic 1,4-dioxane structure but be either esters or alcohols. These should also be quantified. It is important to determine the byproducts that are formed and their concentrations so that one can determine the overall effectiveness of the process and to assess the toxicity and fate of the chemical oxidation by-products, along with the completion of the reactions.

Column experiments

The column experiments should be designed based on the results of the batch experiments. Based on these results and using concentrations and rates at which hydrogen peroxide can be safely added, a column experiment should be designed and operated.

1) Hydrogen peroxide should be added at the proposed field concentration and at an appropriate rate scaled[1] from the proposed field operation. The addition of the hydrogen peroxide to the column should be videotaped and made available to the public and the MDEQ. It is important to monitor heat and gas production in the column as the release of gasses could be hindered in a packed column situation as compared to that in a batch reactor. Videotaping will allow the community and MDEQ personnel to observe the rate of gas generation and how the gas moves in the aquifer material. While this is not a perfect simulation of what will occur in the confined aquifer (since it is not under pressure and is unconfined), it provides the best "estimate" of what we can expect using relatively simple and inexpensive laboratory experiment.
2) The column should allow for sampling of hydrogen peroxide at measured depths to determine the extent to which hydrogen peroxide migrates in the aquifer material and, therefore, to allow PLS to estimate a radius of influence. (Radius of influence refers to the area over which the hydrogen peroxide comes into contact with dioxane-contaminated water). In order to determine the effectiveness of *in situ* hydrogen peroxide injection, it is important to determine how far hydrogen peroxide will move away from the well and out into the aquifer. 1,4-Dioxane

[1] To accomplish this I suggest that the surface area of the screened interval in the injection well be calculated. In addition, the surface area of the column (which should be at least 5 cm in diameter and 50 cm long) should also be calculated. The flow rate at which hydrogen peroxide is to be added at full scale should be divided by the surface area to calculate a surface overflow rate. This same surface overflow rate should be used to determine the hydrogen peroxide flow rate to be employed for the column experiments.

should also be monitored with depth to determine if it is being oxidized or simply pushed along the column by the pumped fluid.

4) The byproducts formed, including 1,2-ethanediol monoformate ester (O=CH-O-CH_2CH_2OH), 1,2-ethanediol diformate ester (O=CH-O-CH_2CH_2O-CH=O), methoxyacetic acid (CH_3OCH_2COOH), glycolic acid ($HOCH_2COOH$), glyoxal (OHCCHO), glyoxylic acid (OHCCOOH), oxalic acid (HOOCCOOH), formaldehyde (HCHO), formic acid (HCOOH.) should be quantified. It is important to determine the byproducts that are formed and their concentrations so that one can determine the overall effectiveness of the process and to assess the toxicity and fate of the chemical oxidation by-products, along with the completion of the reactions. In addition, by measuring the oxidation by-products PLS will determine the extent to which the injection of hydrogen peroxide results in the oxidation of 1,4-dioxane and its byproducts or if the injection of hydrogen peroxide simply forces the migration of the 1,4-dioxane away from the injection well. In the later case, 1,4-dioxane should be conserved and no byproducts would be found.