THE USE OF ANTHROPOGENIC TRACERS TO DETERMINE GROUNDWATER AGE AND RESOLVE CONTAMINATE SOURCES

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The determination of groundwater age has at least three applications. First, it can be used to ascertain the rate of degradation of contaminates. Second, dating groundwater can be used to verify mathematical models of groundwater flow that predict travel-time of source water to wells. And third, the dating of groundwater can be used for determining the probable sources of contaminants whose initial applications occurred during a specific time period as is intended by this study. The main objective of this research is to determine the age of groundwater at two particular well fields, in which perchlorate and nitrate have been detected at levels of concern, using the three methods CFC-11:CFC-12 and CFC-113, 3H:He, and 14C. The age of the groundwater, SWAP data, and the known hydraulic conductivities of the sole-source aquifer will then be used to determine if the sources of contamination can be traced to recent events, or if unknown sources of contamination exist that would warrant further investigation. Present results show that the age of groundwater samples at the Peconic site are not old enough to correspond with the date of the a known source of perchlorate contamination and older than calculated travel times.

Perchlorate (ClO_4^-), is an environmental contaminant resulting from leaching from substrates, (Tipton et al. 2003), and into the roots of crops by adsorption (Urbansky 1998). It has been found that anthropogenic sources, including the production and disposal of solid rocket fuels (Hatzinger, et al., 2000) and the use of fertilizers rich in perchlorate, such as Chilean saltpeter are responsible for contamination of the environment. Perchlorate has been detected in public wells on Long Island by the Suffolk County Water Authority and other local water authorities. The United States Environmental Protection Agency (USEPA) established provisional action levels in 1999 of 4-18 µg/L (USEPA, 2004). Values detected on Long Island are presently below the current standard of 18 µg/L, however, this level is under review and new lower standards may be installed.

Nitrate contamination is most common in both agricultural areas and in areas of high population densities (Nolan et al., 1997). Sources of nitrate may include the use of inorganic fertilizers, leaching from septic systems, and airborne deposits from fossil fuel burning (e.g. Puckett, 1994). The USEPA has set the maximum allowable levels of nitrate in drinking water as10mg/L. If the age of the water is significantly old, then it can be assumed that the source of contamination is an inherited one. Modern sources of contamination might be controlled at the source, but inherited ones probably cannot.

Three dating methods using Carbon-14, the ratio of Freon-11(CFC-11) to Freon-12 (CFC-12) (Chlorofluorocarbons), and the ratio of tritium (3H) to helium (He), will be applied to determine the age of the groundwater collected from wells which deliver water from Long Island's sole-source aquifer. The age of a parcel of water implies the length of time since the water was last in contact with the atmosphere (Plummer et al., 1993). Preliminarily results of tritium-helium analysis show that the groundwater from the Peconic site are 28.64 years, with an analytical uncertainty of 0.67 years. Calculated travel times tended to be younger than the age determined by geochemical tracers but this may be because the well has not been active for a long enough to draw in water from younger recharge areas. Based on the data thus far, it appears that there is another unknown source of perchlorate contamination at this public supply well field other than the application of Chilean Saltpeter from the late 1950s. Source Water Assessment Program (SWAP) data from the New York Department of Health was used to compare ages of groundwater to predicted ages. This model takes into account hydraulic conductivity of the aquifer and the type of land use when determining age of the water and the potential for contamination. Using the SWAP

data, we were also able to calculate the apparent age of a sample of water based on the percent contribution of different aged water parcels to the sample.

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References

Hatzinger, P.B., Greene, M.R., Frisch, S., Togna, A.P., Manning, J., and Guarini, W.J., (2000). Biological treatment of perchlorate - contaminated groundwater using fluidized bed reactors. 2nd International Conference on Remediation of Chlorinated and Recalcitrant Compounds.

Nolan, B.T., Ruddy, B.C., Hitt, K.J., and Helsel, D.R. (1997). *Risk of nitrate in groundwaters of the United States - a national perspective.* Environmental Science and Technology, vol. 31, pp. 2229 - 2236.

Plummer, L.N., Michel, R.L., Thurman, E.M., and Glynn, P.D. (1993). *Environmental tracers for age-dating young ground water*. In Regional Groundwater Quality, W.M. Alley, Ed. Van Nostrand Reinhold, New York.

Puckett, L.J. (1994). *Nonpoint and point sources of nitrogen in major watersheds of the United States.* U.S. Geological Survey: Reston, VA; Water Resources Investigation Report 94-4001.

Tipton, D.K., Rolston, D.E., and Scow, K.M., (2003). *Transport and biodegradation of perchlorate in soils.* Journal of Environmental Quality, vol. 32, pp. 40 - 46.

United State Environmental Protection Agency website: www.epa.gov

Urbansky, E.T., (1998). *Perchlorate chemistry: Implications for analysis and remediation.* Bioremediation Journal, vol. 2, pp. 81 - 95.