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Project Summary

Mutagenic Activity and Chemical Characterization for the Palo Alto Wastewater Reclamation and Groundwater Injection Facility

P. L. McCarty, J. Kissel, T. Everhart, R. C. Cooper, and C. Leong

At the Palo Alto Reclamation Plant 0.044 m^3/s (1 mgd) of secondary effluent is reclaimed through a series of wastewater treatment processes including high lime treatment, aerator-fountain spraying, single-stage recarbonation, ozonation, mixed-media filtration, activated-carbon adsorption, final chlorination, and storage. A portion of the reclaimed water is injected into a series of wells to serve as a barrier against the intrusion of sea water from San Francisco Bay.

Mutagenic activity (by the Ames test) was consistently found to be present in the secondary treated municipal wastewater influent to the Reclamation Facility. This activity was not reduced significantly by high lime treatment, air stripping, recarbonation, or ozonation, even though these processes did remove a portion of the overall organic content of the wastewaters and many of the volatile organic compounds. Activated-carbon adsorption was effective in removing mutagenic activity to such a degree that mutagenic activity could not be found in water used for injection or that taken from monitoring wells. Chlorination resulted in an increase in mutagenic activity. A laboratory study demonstrated that this increase in activity would not result if chlorine dioxide rather than chlorine was used for disinfection.

The extracts used for mutagenic analyses contained a broad range of fatty acids, phthalates, aromatic compounds, and several unidentified bromine-containing compounds.

This Project Summary was developed by EPA's Health Effects Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Discussion

Water reclamation and reuse are becoming more important as increasing pollution and water usage reduces the supply of clean water available for beneficial uses. Advanced wastewater treatment processes have been developed to protect receiving waters and to reclaim wastewater for a variety of purposes.

The nature of wastewater is dependent upon the types of industrial and municipal wastes introduced into the sewerage system. Wastewaters may contain a variety of toxic compounds, some of which may not be altered or removed during treatment, and some

may be formed during the treatment process itself.

The direct use of reclaimed wastewaters as part of a municipal drinking water supply is not currently permitted. Before this is allowed, the concern over the potentially harmful effects of contaminants remaining in the water must be alleviated. Although research aimed at the identification and quantification of trace materials in water constitutes an active area of environmental chemistry, little is known about the long-term, or chronic, effects of exposing a population to trace levels of these dissolved impurities over a time period of many years. There is a reasonable probability that many of these compounds are carcinogenic Epidemiological studies do exist which tend to show a degree of correlation between the increased incidence of several forms of cancer and polluted surface waters serving as potable water sources, as well as to chlorinated drinking water.

Several reports document the presence of mutagenic substances in drinking water as well as reclaimed wastewater These investigations relied chiefly upon a bacterial mutagenicity assay, the Ames test, to detect the presence of mutagens. There is some evidence that many compounds which are bacterial mutagens, as determined by the Ames test, are also carcinogenic to animals. Thus, this relatively simple test may provide some indication of the presence of potentially harmful substances in water.

This study on the presence of bacterial mutagens in reclaimed wastewater at Palo Alto, California, was instigated as a result of a previous study evaluating the presence of such mutagens in samples taken from six different California municipal wastewater treatment facilities. For two of the plants, including the one at Palo Alto, it was reported that the mutagenic activity was intensified during the course of the treatment process In the study reported here, the mutagenic activity at the Palo Alto Reclamation Plant was evaluated in more detail on samples taken after various stages of treatment so that their effect in either producing or reducing mutagenic activity could be better evaluated. In addition, chemical analyses were conducted on collective parameters, such as chemical oxygen demand, total organic carbon, and total organic halogens, as well as on a wide range of specific organic compounds, in order to determine if any correlation with mutagenic activity existed

Special studies were conducted on the formation of mutagenically active compounds during the chlorination process, and a comparison was made with an alternative disinfectant, chlorine dioxide. In addition, an evaluation was made of the reduction in mutagenic activity during passage of the reclaimed water through an aquifer following groundwater injection.

Conclusions

Positive mutagenic activity to strains TA98 and TA1535 with S9 activation was consistently measured in the secondary treated wastewater influent to the Reclamation Facility. Chlorination of the secondary treated influent resulted in an increase in mutagenic activity, especially to strain TA1535.

Laboratory disinfection studies confirmed that mutagenic activity of the secondary treated wastewater increased following chlorination, but would not result had chlorine dioxide disinfection been used. Subsequent processes of high lime treatment, stripping, recarbonation, and ozonation had little effect in reducing mutagenic activity, although in combination these processes were effective in removing many volatile organic constituents of health concern.

Activated-carbon adsorption proved very effective in reducing mutagenic activity as well as in reducing the organic content of wastewater as measured by the collective parameters of chemical oxygen demand (COD), total organic carbon (TOC), and total organic halogens (TOX). Because of the effectiveness of activated-carbon adsorption in reducing mutagenic activity, few samples of the reclaimed wastewater used for groundwater injection contained positive mutagenic activity. Positive mutagenic activity was not found in any samples taken from the groundwater monitoring wells.

An average of only about 12 percent of the organic material present in the samples analyzed for mutagenic activity was contained in the XAD-acetone extract concentrates. Fatty acids, phthalates, several aromatic compounds, and several unidentified bromine-containing compounds were present in the XAD-acetone extracts used for mutagenic analysis.

The Palo Alto Reclamation Facility was proven effective in reducing the concentration of a wide range of specific organic compounds and mutagenic activity contained in the secondary treated influent wastewater. Several materials remain in the reclamation plant effluent at low concentration, and mutagenic activity was detected in some samples.

Results and Recommendations

The efficiency of the individual treatment processes for removal (or formation) of a wide range of specific organic compounds and group parameters was measured and are summarized in this report Chlorination results in the production of a significant concentration of non-purgeable, but otherwise unidentified, chlorinated organic compounds, as well as trihalomethanes. Formation or removal of such compounds did not seem to correlate with changes in mutagenic activity Air stripping by the fountain-spray system was most effective in removing volatile organic compounds, while activated carbon was responsible for removals obtained for most other organic materials.

Future work should be directed towards evaluating further the organic material remaining in reclamation plant effluent, as most of this material remains uncharacterized. In addition, the nature of compounds or mixtures of compounds responsible for mutagenic activity should be determined. The use of the Ames mutagenic analysis for judging the health risk of reclaimed wastewater should be further evaluated

P L. McCarty, J. Kissel, and T. Everhart are with the Department of Civil Engineering, Stanford University, Stanford, CA 94305, and R. C. Cooper and C. Leong are with the School of Public Health, University of California, Berkeley, CA 94720.
***Herbert R. Pahren** is the EPA Project Officer (see below).*
The complete report, entitled "Mutagenic Activity and Chemical Characterization for the Palo Alto Wastewater Reclamation and Groundwater Injection Facility," (Order No PB 81-179 590, Cost: $9.50, subject to change) will be available only from:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650

The EPA Project Officer can be contacted at:

Health Effects Research Laboratory
U S. Environmental Protection Agency
Cincinnati, OH 45268

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