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Investigations Related to a "Treatment-Based" Regulatory Approach to Address Unregulated Contaminants in Drinking Water

The New Jersey Department of Environmental Protection (Department) is focusing on new approaches to address the occurrence of unregulated contaminants found in drinking water throughout the State. These chemicals may be present individually or as mixtures, they are present at low concentrations, and little if any toxicity information is available for most of them. Discussions on possible new approaches for addressing their occurrence began in the 1990s when synthetic organic contaminants were discovered in a water system supplied by groundwater. Subsequently, many additional studies in the State have been conducted, and the Department is currently investigating the possibility of a "treatment technique" approach to regulating mixtures of organic chemicals in drinking water, as summarized below.

Background Information

Research studies have found that many unregulated industrial, household, and commercial chemicals are present in raw waters used as drinking water sources, and that some of these chemicals survive the drinking water treatment process and appear in finished drinking water. Work on this issue by the Department began in the 1990's in response to community concerns about a possible link between childhood cancer and drinking water contaminants. Department chemists, in collaboration with EPA chemists, evaluated unregulated (tentatively identified) contaminants in the drinking water. Since then and continuing to the present time, studies conducted in New Jersey by Department scientists in cooperation with the Environmental and Occupational Health Sciences Institute (EOHSI) of New Jersey, the US Geological Survey (USGS), and the federal Centers for Disease Control and Prevention (CDC) have shown that source water and finished drinking water samples analyzed by advanced analytical methods contain low levels of household, commercial, and industrial compounds. Current analytical methods used for regulatory purposes are not capable of detecting these compounds. In addition to the contaminants detected, thousands of other chemicals have the potential to reach source waters used for drinking water. A study conducted in New Jersey by the Department of Health and Senior Services (NJDHSS) with the Agency for Toxic Substances and Disease Registry

(ATSDR) reported statistical associations between certain drinking water sources and specific childhood cancer in a community (NJDHSS 2003).

The chemical-specific approach currently used for regulating chemicals in drinking water, while useful for the development of drinking water standards for contaminants first detected in the 1980's and early 1990's, may not represent the optimum approach for addressing low level contamination with multiple chemicals today.

One approach under consideration is the development of a "treatment technique" (e.g., granular activated carbon) drinking water standard in lieu of a chemical-specific "maximum contaminant level" for currently unregulated organic contaminants in drinking water. In order to develop a maximum contaminant level, a ground water quality standard or an interim ground water quality standard, toxicity information appropriate for the development of a chronic risk assessment is necessary. For many contaminants detected in the NJDEP-EOHSI and USGS- NJDEP-CDC studies, even the most basic toxicity information is lacking. This treatment technique option asserts that given the lack of necessary health information available for many of the contaminants detected, the current methods of addressing unregulated compounds cannot be applied to most of these contaminants. This strategy represents a proactive approach to protecting public health in the absence of definitive scientific information on the human health effects of the contaminants being detected. Rather than wait for health-effect studies to be completed, this option proposes the use of water treatment as a protective measure.

Toward this end, New Jersey is piloting several research projects to generate much-needed information before determining how or if to proceed with the treatment-based approach. Two water systems that use groundwater as their water source were selected for "Demonstration Projects" to evaluate the effectiveness of activated carbon to remove unregulated organic chemicals from their drinking water. The other projects are investigating how effective existing advanced drinking water treatment techniques already in place at surface water plants are at removing unregulated organic chemicals. These are discussed under the section titled, "On-going Projects."

Previous Projects

- **NJDEP-DSRT/EOHSI "TIC" study (1997-2003)**

NJDEP worked with analytical chemists at the Environmental and Occupational Health Sciences Institute (EOHSI) to analyze raw and finished drinking water for the presence of synthetic organic contaminants, indicated as Tentatively Identified Compounds (TICs). The study, which focused on ground water systems near hazardous waste sites, showed that both raw and finished drinking water at vulnerable areas contain a number of TICs at low levels (at or below one part per billion). Over the course of the four year study, approximately 600 tentatively identified organic compounds were detected in 199 water samples collected (including five bottled waters that are sold in NJ). Given the number of TICs found in the study, the Department initiated a study with UMDNJ to determine what, if any, toxicity information existed on them.

- **Human Health Impacts of Non-Regulated Compounds in Drinking Water**

This project evaluated the health effects information available on the TICs identified in the above study. Most were present below 1 ug/L. Toxicology data of any type was only available for 22% of the 524 chemicals evaluated. For many of these 22%, only acute toxicity information was available, and such acute data are not suitable for development of chronic health-based drinking water levels. Information which could be used to develop chronic drinking water concentrations was available for only a small fraction of the TICs. The results of this study suggest that chemical-by-chemical health risk assessment is not a feasible approach for addressing the many unregulated contaminants found at low concentrations in drinking water.

- **UMDNJ /NJDEP-DSRT/USGS/CDC cooperative project (1999-2000)**

NJDEP/USGS cooperative: A water-treatment plant was sampled as part of this project. Forty-five waste-water related organic chemicals were detected in samples of source water and 34 were detected in samples of settled sludge and (or) filter-backwash sediments. The number of waste-water compounds increased during conditions of low flow in the river. The average percent removal of these was: 53% of the chemicals removed by granular activated carbon filtration; 32% removed by disinfection; and 15% by clarification. This treatment plant is located in the heavily populated highly urbanized drainage basin which includes more than 50 wastewater facilities that discharge effluent to the two streams from which the plant withdraws its raw-water.

The Department had the opportunity to utilize the best analytical capability in the nation to assess the efficiency of removal of these newly identified organic contaminants at several of the drinking water purveyor locations in the state. For the past several years, the NJDEP has worked with water systems to evaluate the levels of chemical contamination contained in the raw and finished drinking water supplies before and after advanced water treatment, including carbon treatment. By identifying the removal efficiency of the state of the art treatment operations of treatment units, the Department can apply that knowledge most efficiently to solve the contamination challenges faced by the other water systems throughout the state.

- **Interested Party Review (2004)**

The Department considered the treatment-based approach after numerous internal and external discussions, including the Drinking Water Quality Institute. The Department developed a list of potential options to consider for addressing unregulated contaminants in drinking water and published these options in the NJ Register as an Interested Party Review (IPR). The options under consideration were:

1. Chemical-specific regulation of drinking water contaminants.
2. Intensive Site Remediation investigation of unregulated contaminant occurrence in ground water.
3. Regulation of classes of chemicals, by health end-point.
4. Regulation of classes of chemicals, by chemical property
5. Installation of water treatment technology to reduce levels of regulated and unregulated synthetic organic chemicals

The water treatment technology approach represents the likely outcome of the other four options. The best available technology for removing most synthetic organic contaminants from drinking water is granular activated carbon (GAC). However, other treatment techniques may be appropriate depending upon the quality of the source water. For instance, ozone and ozone followed by hydrogen peroxide oxidation has been shown to be effective at reducing levels of synthetic organic chemicals in drinking water.

Almost all comments received in response to the IPR concerned the type of treatment selected: respondents indicated that advanced treatment techniques other than granular activated carbon had been shown in preliminary experiments to reduce levels of unregulated organic contaminants to below detectable levels and that these other techniques should be studied as well. The Department agreed with the comments and initiated a literature review of best treatment options for ground water sources and for surface water sources. The purpose of the literature review was to compare the best treatment techniques under different source water conditions to determine the optimum treatments for removing unregulated organic chemicals.

- **Literature Review**

    - Groundwater Systems:

A comprehensive literature review conducted by Black & Veatch (2007) for the Department determined that while carbon filters are the best options for removal of synthetic organic chemicals from ground water, no one treatment technique can remove all of the organic chemicals that have been detected in NJ ground waters. The estimated capital cost to install granular activated carbon treatment for a 1 million gallon per day system ranged from $0.8 to $1.2 million. Annual operating costs were estimated to range from $50,000 to $100,000. Although GAC was identified as the most applicable technology for NJ ground water systems, both air stripping and oxidation might be preferred in certain circumstances in order to reduce the frequency at which the carbon must be replaced thereby reducing annual operating and maintenance costs.

    - Surface Water Systems

The Black & Veatch report for surface water systems (2007) concluded that no one treatment technique can remove all of the unregulated organic compounds that have been detected in NJ surface waters. In addition, it is unlikely that all of the unregulated organic compounds could be removed from a given location even using a combination of processes. Further, by-products of oxidation and biological activity are likely to be generated during treatment, creating other organic chemicals while the original organic chemicals in the surface water are removed to a certain extent. Although GAC may be the most applicable technology generally, oxidation might be used in conjunction with GAC to reduce the frequency at which the carbon must be replaced. The estimated capital and operating costs for these techniques for a 50 million gallon per day surface water plant could range from $1.4 million for packed activated carbon to $9 million for ozone/hydrogen peroxide to $30 million for ozone with GAC and ultraviolet treatment. However, many of these treatment processes may already be present at the drinking water plant to remove other contaminants from drinking water.

ON-GOING PROJECTS

- **Demonstration Projects (2007-present)**

Based on the literature review on ground water systems prepared for the Department by Black & Veatch, the best available technology for removing a broad number of synthetic organic chemicals from NJ groundwater was granular activated carbon. To further explore the efficacy of using water treatment to address multiple contaminants in drinking water, the Department funded the construction of full-scale GAC units to remove these unregulated chemicals at two water systems that serve groundwater. Past studies have indicated that groundwater systems are also vulnerable to contamination by industrial and household chemicals, the type of chemicals that are reducible by carbon treatment. Both advanced and conventional chemical analyses conducted during operation will be used to determine optimal ways to measure compliance for such a regulatory approach.

Two groundwater systems were selected for full-scale projects. These systems were selected because they both contained high numbers of unregulated synthetic contaminants in raw and finished drinking water when they were sampled in previous studies, and a remedial treatment strategy (air-stripping) is currently in use at these facilities to address contamination by regulated chemicals. In order to monitor unregulated contaminants at these facilities, advanced analysis for unregulated organic chemicals will be conducted by chemists at EOHSI as well as by NJDHSS laboratories. Some split samples will be sent to USGS labs in Denver as well.

- **Tailored Collaboration (2009 – present)**

NJDEP is collaborating with Black & Veatch and with five surface water utilities throughout the state to conduct comprehensive studies on the occurrence and removal of unregulated contaminants in drinking water using conventional and advanced water treatment at surface water systems. This is part of the "tailored collaboration" program through the Water Research Foundation. The US Geological Survey is leading and training the sampling teams at the water systems for sample collection. Water samples will be sent to the USGS Denver laboratory for analysis. NJDEP is funding the analytical portion of the project. Sampling is expected to begin April 2010.

The overall objective of this project is to investigate the effectiveness of conventional and advanced water treatment processes for the removal of unregulated organic chemicals (UOCs) such as pharmaceuticals and personal care products and industrial and household use organic chemicals from surface water systems. Specifically, this research is designed to answer several questions including: 1) What UOCs are removed by conventional water treatment processes? 2) What additional UOCs are removed with advanced processes such as GAC and ozone? 3) What per cent removal can be achieved with conventional and conventional plus advanced processes? 4) What process design parameters and operating conditions are associated with these removals? 5) How effective are current analytical methods in quantifying low levels of UOCs? 6) Is it

plausible for NJ to consider a "treatment-based" regulatory approach for managing UOCs in drinking water in the state?

The processes that will be evaluated during this study include clarification (conventional settling, solids contactors, upflow clarification, and ballasted flocculation), filtration, packed tower air stripping, GAC adsorption/filtration, GAC adsorption, and ozone. There will be four sampling events at each treatment plant, during the spring, summer, fall and winter. The results will be presented in a report along with an interpretation of the results with respect to treatment process, water quality and design and operating conditions.

The results of this proposed project will be of value to the water industry for several reasons. First, these studies will provide state and federal agencies with information on removals of UOCs under full-scale treatment conditions and will provide a basis for considering the impacts of possible regulation of these contaminants, as well as provide utilities with treatability information for assessing their treatment processes and for future planning. Secondly, these studies will also provide Water Research Foundation and USEPA Research Group with additional information on which to base future research work and add to the current knowledge base relative to the removal of UOCs during drinking water treatment. These study results will also provide valuable information to use in developing public health protection strategies for UOCs in drinking water. Finally, these studies will provide information to validate analytical methods for low level detection of UOCs.

- **Settlement of Environmental Penalty (SEP) (2007-present)**

The primary objectives of this study are to document the occurrence and concentration of synthetic organic contaminants in raw and finished water supplies water treatment facilities that are supplied by surface waters and to identify the primary physical and chemical processes that govern the fate of synthetic organic contaminants through select water treatment facilities. Specific objectives are to:

1. determine the occurrence and concentration of synthetic organic contaminants in coupled raw- and finished-water samples from four water treatment facilities that are supplied by surface waters,
2. at a select water treatment facility, identify the physical and (or) chemical unit processes by which synthetic organic contaminants are most effectively removed from raw-water supplies, assess sludge from sedimentation tanks and activated carbon from filter systems as potential sinks for the removal of synthetic organic contaminants from source waters, identify the synthetic organic contaminants that persist through water treatment and determine their occurrence and concentrations at select locations throughout the distribution system.

USGS has completed all the sampling and the Denver Lab has completed the analysis. Mid-way through the sampling and analysis, it was determined that the organic wastewater related compounds (the focus of the USGS methods) were not being detected. Therefore, the focus of the analytical component of the project shifted from organic wastewater contaminants to non-point source related contaminants like pesticides. The source waters for the water system are in watersheds where nonpoint source contamination is more prevalent than wastewater discharges.

The results from the water samples collected after the shift in analytical focus are currently being evaluated.

- **Wastewater Study (2009-present)**

NJDEP is pursuing the possibility of controlling the release of unregulated organic chemicals at their source for the purpose of protecting human health and wildlife. The NJDEP is funding two projects focusing on characterizing the occurrence and removal capacities of unregulated organic chemicals in wastewater. One project is a literature assessment investigating the sources of the unregulated organic contaminants in waterways and examining existing and available wastewater treatment methodologies for removing these contaminants. Another study focuses on sampling wastewater and sludge from selected publicly owned treatment works in the state for organic contaminants. Ultimately the Department plans to conduct advanced wastewater treatment studies, similar to that conducted in coordination with an MUA (Metcalf & Eddy 2006), which demonstrated that the technology to remove these contaminants exists, despite the current high costs of installation and maintenance. Further work is needed to examine the true feasibility of installing full-scale wastewater treatment at facilities in New Jersey. These two studies began in the fall 2009 and will continue through 2012.

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