IJC 2009-2011 PRIORITY: EFFECTIVENESS OF WASTEWATER TREATMENT PLANTS FOR REMOVAL OF CHEMICALS OF EMERGING CONCERN

Update for Great Lakes Science Binational Toxics Strategy Forum

June 15, 2011

Charge from Commission

The IJC Multi-board Work Group on Chemicals of Emerging Concern (CEC) is conducting an assessment of the performance of WWTPs for removal of CECs

- To provide the Parties with a sampling of the information which might be derived if a more fulsome evaluation was undertaken, the performance of a subset of the WWTPs in the Great Lakes basin will be examined
- A literature review of the effectiveness of CEC removal technologies is expected to provide an opportunity to consider an array of potential WWTP upgrades

Assessment of the WWTP Performance: Outline of Approach

1. Develop inventory of facilities
2. Detailed survey of operating parameters for selected facilities
3. Literature search of the effectiveness of CEC removal technologies
4. Government/WERF reports on field studies of the performance of full scale facilities
5. Expert consultation
6. Draft report for review

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Expert Consultation – Findings

- There are a total of 1,448 municipal WWTPs which discharge 18 billion liters per day or 4.8 billion gallons per day of treated effluent to the Great Lakes Basin
- Based on data from Environment Canada/OMOE, 95% of the wastewater flow in Ontario receives secondary treatment or better
  - A very small fraction (~1%) of the plants in Canada do not practice secondary treatment (primary and community septic tanks).
  - Lagoons provide a low rate of secondary treatment and while they may constitute 37% of the facilities, they process only a small fraction of the total flow (3.1%).
- Based on the US Clean Water Needs Survey, 4% and 95% of the wastewater flow into the basin meets the performance standards for secondary and advanced treatment, respectively
- Although there are differences in how the two countries define such systems, collectively the combined group of secondary, advanced and tertiary plants treat 98 percent of the total wastewater flow, indicating a relatively high level of treatment of discharges to the Great Lakes Basin

Expert Consultation – Findings

- There are many flows into the Great Lakes basin that were not included in the analysis
  - These include wastewater by-pass events, combined sewer overflows, industrial discharges, millions of private septic systems, and agricultural runoff, some of which are not treated
- Combined sewer overflows may represent a relatively small percentage of annual sewage flow into the basin, but they may be responsible for substantial releases of organic contaminants to the environment especially during high precipitation or sever storm events
- Biosolids from WWTPs are often applied to agricultural land in the basin
- Concern has been raised that this practice has the potential to contaminate surface waters and groundwater with various organic, inorganic, and microbiological contaminants

Expert Consultation – Findings

- Detailed operating conditions were evaluated for a spectrum of facilities which discharge into the Great Lakes basin
- Of the 25 plants responding to the survey:
  - 17 use activated sludge or advanced treatment technologies
  - 4 use fixed film technologies
  - 2 are lagoon based systems
  - 2 are primary treatment plants
  - Wastewater flow rates for the facilities ranged from less than 10 to greater than 50 million gallons per day.
- Because the survey was not intended to be a statistical representation of the plants in the Great Lakes basin, extrapolation to other facilities in the basin cannot be made
- Effective removal of the wide variety of CECs is dependent on both the nature of the substance, and the design and operation of the WWTP

Expert Consultation – Findings

- Examination of the performance data collected from the survey suggests that some plants that are operated very well while others are not
  - Facilities designed for primary treatment are unlikely to adequately reduce the concentrations of biodegradable CECs
  - Some very large cities are serviced by WWTPs designed for organic (BOD) removal only
- Many of the facilities are operated at high solids residence times and were effective in both organic (BOD) and nutrient (ammonia) removal
  - Such facilities are likely to show effective reductions of biodegradable CECs
- Conventional parameters (BOD, ammonia) provide useful surrogates for assessing removal efficiencies for biodegradable CECs
- Different indicators are required for substances that are poorly or non-biodegradable, or have a propensity to adsorb to biomass

Expert Consultation – Findings

- Although municipal WWTPs were not designed to remove CECs, results of the present study as well as government and WERF reports suggests that conventionally designed plants that are well operated are capable of achieving effective reductions of a variety of substances
- While the weight of evidence suggests that at least half of the 42 of the CECs examined in the present study are likely to be removed in municipal WWTPs, a purely statistically analysis is limited in terms of reaching definitive conclusions about the extent to which treatment facilities, as currently operated in the Great Lakes Basin, are able to remove which various CECs
- None of the statistical or visual analyses have examined the impact of operating conditions on plant performance
- There is insufficient granularity and reproducibility in the various datasets to be able to discern the impact of operating conditions such as temperature, loading rate, solids and hydraulic residence times, etc.
  - It is likely that much of the variability in the reported data could be explained by differences in operating conditions at the various facilities.

Expert Consultation – Findings

- While much has been learned about the presence of CECs in wastewaters during the past few years, the inability to provide definitive answers on the effectiveness of wastewater treatment questions is not surprising given the
  - number of and range in molecular complexity of the various CEC compounds
  - range of different technologies employed by municipal WWTPs within the Great Lakes Basin
  - range of different conditions under which they are operated
- There is a lack of publicly available environmental fate information for many CECs
  - Approximately 250 of the 300 compounds identified in the literature search lacked information on biodegradability, which is a major impediment to the development of simulation models for predicting the removal efficiency (extent and reliability) of WWTPs

Expert Consultation – Recommendations

- Investigate the contribution of combined sewer/storm sewer overflows, by-passes, and industrial discharges to loadings of CECs to the Great Lakes in the next priority cycle
  - Combined sewer/storm sewer overflows may contribute substantially to loadings of CECs to the basin
- Primary treatment facilities should be encouraged to move toward upgrading to secondary treatment, perhaps with advanced treatment technologies
- Secondary treatment plants should consider enhancements to enable biological nutrient removal processes and other process optimization in order to improve reduction of biodegradable CECs
- The utility of advanced oxidation processes for advanced treatment of contaminants needs to be further explored

Expert Consultation – Recommendations

- Improvements to WWTPs should be evaluated in the context of sustainability and the triple bottom line
  - There is a need to balance benefits of updating treatment technology with costs, which include both capital and operational costs, as well as environmental impacts such as increased power requirements and emissions of greenhouse gasses (CO_2) as well as NOx and SOx emissions due to increases in energy requirements to operate equipment
- Sampling and analysis to determine the effectiveness of wastewater treatment in removal of CECs should be conducted and done in conjunction with surrogate indicators (i.e. ammonia, BOD)
  - There is a need to standardized methodologies, including validated protocols, for the analysis of wastewater contaminants
  - There is also a need to increase capacity in contract analytical laboratories

Expert Consultation – Recommendations

- A list of indicator compounds should be developed in order for plants to assess their treatment process regarding effectiveness in removal of CECs
  - A list of criteria may be needed to define "indicator compounds" which could be used as surrogates (i.e., in addition to the conventional parameters of ammonia removal, BOD removal)
  - Water Environment Research Foundation is currently addressing this need
- Biosolids from WWTPs are often used as amendments to agricultural soils. The role of biosolids as a source of CECs to the environment should be examined.
  - Government agencies are currently addressing this issue.
- CECs that are difficult to treat using current technologies should form the basis of a list of compounds that require the development of a risk assessment/risk management strategy, which includes consideration of both ecological and human health.

Expert Consultation – Recommendations

- Biological effects monitoring of wastewater effluents should be recommended
  - For example, bioassays of wastewater effluents could be used in combination with chemical analysis
  - Compounds need to be sorted according to those that are highly consequential in small concentrations (i.e. estrogens) versus those that are not (i.e. caffeine)
- There needs to be an increase in public education regarding the use of pharmaceuticals and personal care products and their entrance into the environment and the wastewater treatment process
  - This public education would also include manufacturers in terms of promoting green chemistry