WASHINGTON STATE DEPARTMENT OF ECOLOGY

Sources of Treatability Data

Dangerous waste regulations require that certain dangerous wastes must be treatable in the publicly owned treatment works (POTW) where they will be received if they are to be considered for a discharge permit or authorization. The permit authority (Department of Ecology and delegated POTWs) will decide the treatability of such wastes based, in part, on data provided by the applicant.

The exclusion specifies that treatability must be determined for the waste before mixing it with domestic sewage. This is important since concentration can influence treatability. In addition, pollution prevention and source reduction techniques, pretreatment standards, and additional treatments required by Ecology must be applied to the waste before determining its treatability.

This document reviews the data sources used to support treatability determinations. It is meant as a guide for permit writers, sewer authorities, applicants, and consultants who may assist applicants.

Overview of Treatability Information

Treatability determinations for discharge of toxics to POTWs have two main components: determining the **fate** of toxics in a POTW, and evaluating their potential for biological **inhibition**.

Fate determinations estimate the biodegradation of the compound of interest and its distribution into the air, effluent, and biological solids of the POTW. Applicants can derive fate data from testing or from scientific literature and reference manuals. They can also extrapolate fate data based on certain chemical characteristics, or by using computer models to combine chemical information with the characteristics of a specific treatment plant.

Fate information must be used in conjunction with **inhibition** data. A toxic compound present at a concentration that inhibits the biological action of a POTW's micro-organisms will impair sewage treatment capacity. Inhibition data appears in scientific literature and reference manuals, or can be derived through testing.

Chemical Characteristics Data

Chemical characteristics can give clues to the treatability of a compound. Characteristics such as volatility, solubility, molecular weight, density, biodegration rate constants and sorption coefficients affect the treatability of toxics entering a sewage treatment system. Many printed volumes of chemical data are available, as well as computerized databases. This information is best combined with a knowledge of treatment system parameters such as aeration rates, detention times and solids concentration, among others.

Computerized fate models usually contain their own databases of chemical characteristics, and they have the advantage of

combining this information with actual operational parameters for the specific POTW under consideration (see Computerized Fate Models on page).

The Annotated Reference List on page lists several handbooks with chemical data useful for deciding treatability. Electronic sources of chemical characteristics and removal efficiency data are also given.

Literature

Scientific and professional journals contain papers and articles on the treatability of specific compounds and waste streams. Searches for this information can be conducted through university libraries, such as the Washington State Library (360-704-5221), EPA's Region 10 library (206-553-1289), the Department of Ecology library (360-407-6152), and the METRO library (206-263-3051).

Several EPA manuals have been used as sources of treatability information, including generalized removal efficiencies, chemical characteristics and inhibition concentrations. The annotated references on page 5 list EPA publications containing treatability data. These publications can also be obtained through the libraries mentioned above.

Some reported data show inconsistencies resulting from factors such as variable treatment processes and operational parameters; scale of the treatment process; antagonistic/synergistic effects; degree of acclimation at the POTW receiving the waste; differing influent concentrations; and inconsistent sampling, handling, and analytical techniques. These factors make it difficult to group data from different POTWs, or to assume the applicability of data to any other POTW.

Bench-Scale Testing

Bench-scale testing provides laboratory information on the potential biodegradation and/or inhibitory effects of toxic compounds or complex waste streams. No standards or widely-established protocols exist for bench-scale testing of biodegradation or inhibition. Several popular methods are given below. Tests normally required are the Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD). Whole effluent Toxicity testing (WET), respirometry and photo-luminescence tests are also used to a lesser extent. More experimental and less commonly used methods are available, but should only be used with the approval of and in conjunction with the water quality permit writer. All of the techniques (except the WET protocol) share a potential problem of not accurately reflecting the treatability of the wastewater in an actual POTW.

Theoretical Oxygen Demand (TOD)

TOD of a specific compound is calculated based on the complete oxidation of the chemical to CO2 and water. This calculation is usually done before the discharge has occurred, with the goal of understanding if the POTW has the capacity to oxidize these compounds in the wastewater.

5-Day Biological Oxygen Demand (BOD)

One simple method of evaluating inhibition due to an industrial waste adds incremental volumes of the waste to dilution water seeded with sewage sludge and analyzes it for 5-day BOD. If the waste is inhibitory to the POTW bacteria, higher concentrations of the waste will result in less oxygen depletion and lower BOD. If relatively biodegradable, larger volumes of the waste should produce

proportionately higher oxygen depletion. The technique can estimate the concentration at which the waste becomes inhibitory. The major disadvantages are the five-day waiting period and the questionable correlation between degradation in a BOD bottle as compared with a full-scale biological reactor.

Chemical Oxygen Demand (COD)

Some researchers use COD as a yard stick to compare degradation test results. The COD test is often used in conjunction with the BOD test and the ratio of these numbers indicates the overall treatability of the substance. The closer the BOD is to the COD, the more easily the waste stream can be treated.

Whole Effluent Toxicity (WET) Testing Protocols

This methodology has gained wider acceptance as a failsafe method of confirming that non-domestic discharges are not causing toxic effects at the POTW. One way to use these protocols is to do a WET test after beginning to receive the waste stream at a POTW. The effluent can then be evaluated for increased toxicity resulting from the waste stream. The downside of this method is the chance for chemical upset and excess toxicity at the POTW. Alternatively, a small amount of the proposed waste stream may be used in a dilution series to determine at what concentration the proposed waste stream is toxic to aquatic life. If toxicity affects are observed at low concentrations, the waste may be too toxic to accept. A third way to use WET testing is to simulate treatment with a bench scale batch treatment setup and then test the toxicity of the effluent. Testing protocols should be established in coordination with a representative of Ecology's Water Quality Program to ensure mutual agreement.

Respirometry

Respirometry can also measure the oxygen uptake of POTW bacteria. Adding a compound that causes the bacteria to increase their use of oxygen is interpreted to mean that the compound is biodegraded. Some researchers define inhibition as conditions where the oxygen uptake of microorganisms, with addition of the test compound, is less than the oxygen uptake without adding the test compound. They define toxicity as the condition of no oxygen uptake, an indicator of little biological activity.

Photo-luminescence (Microtox)

This method uses photo-luminescent marine microorganisms whose light output decreases proportionally to their level of toxic shock when fed varying concentrations of waste. The method can evaluate the toxicity of influent to the POTW, and it can measure toxicity reduction through the treatment process. This method may be more sensitive than respirometry at low concentrations. One disadvantage for measuring plant interference is that it does not use POTW organisms. Test time is 5-15 minutes.

Fate Models

Computerized fate models estimate the effects of biodegradation, sorption onto solids, and volatilization on substances entering a treatment system. Most fate models provide data on percent distribution, mass loading, and concentration of the substance in the effluent, solids and air from the POTW. The models vary in the size of their chemical database, the number and types of their unit processes, the sources of their data and other features.

The following is a brief review of the most prominent computerized fate models currently available:

■ TOXCHEM+ Version 3

Toxchem+ Version 3 (January 2001) allows pollutant fate to be modeled in activated sludge, fixed film, lagoon, closed tanks, industrial pretreatment systems and other types of treatment processes. It includes a database of 156 substances (including metals most commonly of concern) backed by extensive bench-, pilot, and full scale testing. The model allows dynamic (non-steady state) modeling of slug charges and has the ability to perform a sensitivity analysis to estimate effect of parameter variations. By entering effluent, sludge and air permit levels, the model can be "back-solved" to determine headworks loadings. Also, the software has the ability to group and run multiple contaminants. Toxchem+ is available from Enviromega. Pricing and availability information can be found on their Web site at http://www.enviromega. com or by phone (905) 689-4410, fax (905) 689-7040.

■ AQUATOX Release 2.0

AQUATOX Release 2.0 (April 2004), is a simulation model for aquatic systems. It does not model a pollutant's fate through a treatment system, but rather its fate after release into the environment. The AQUATOX fate model is best used in conjunction with other models that do track the pollutant's fate through a treatment system. AQUATOX can predict the fate of various pollutants (such as nutrients and organic chemicals) and their effects on the ecosystem, including fish, invertebrates, and aquatic plants. This assessment can help predict the pollutant's maximum effluent concentration that it would be safe to allow, and make ecological risk assessments for aquatic ecosystems. AQUATOX Release 2.0 is available free of charge on the Internet at http://www.Epa.gov/ost/models/aquatox/.

■ WATER9

WATER9 (February 2001), a wastewater treatment model, is a Windows-based computer program for estimating air emission and treatment effectiveness for pollutants discharged to wastewater treatment facilities. It includes a database of common organic compounds and can produce a report of constituent fates. WATER9 updates WATER8, Chem9, and Chemdat8. WATER9's model units can be assembled in modular fashion to project pollutant fates for facilities containing complex collection systems and treatment configurations. Emission estimates are based on the compound properties and concentrations. Additional compounds can be modeled by entering certain properties of the compound. The EPA document, *Air Emissions Models for Waste and Wastewater*, includes the equations used in WATER9. The Air Emissions Model Hotline at (919) 541-5610 provides support for this program. WATER9 can be downloaded from http://www.epa.gov/ttn/chief/software/water/.

■ BASTE 4.0

BASTE 4.0 (Bay Area Sewage Treatment Emissions), estimates losses of organic compounds from wastewater treatment processes due to volatilization, sorption and biodegration. Its primary uses are to model air toxics emissions and odors for wastewater treatment plant liquid processes. Its database contains 526 volatile organics, and the user may select individual compounds or grouped compound lists including EPA's HAPs, AMSAs list of the VOCs most commonly found in wastewater influent, and odor generating

compounds. It does not model metals. BASTE has been authorized by EPA for estimating VOC emissions from POTWs. BASTE is available from CH2MHILL at (510) 587-7545.

Computer Databases

The following are computerized databases providing treatability data. Refer to the section on Computerized Fate Models for additional information.

USEPA Chemical/Toxicological Internet Resources — Over two dozen Internet databases and sources of on-line chemical characteristics and toxicity information are listed at this USEPA Web site at *http://www.epa.gov/esd/trc/ pubs/chemical.htm*.

PBT Profiler — In 2003, USEPA launched a program called PBT Profiler, which is useful for determining toxicity and persistence for organic chemicals. The program models a chemical's toxicity and fate in the environment, but doesn't look at the fate of a pollutant through a specific treatment process. PBT profiler can be found at *http://www.pbtprofiler.net/*.

CHEM-BANK — Chem-bank provides eight complete databases on one compact disk. It includes RTECS, HSDB, IRIS, OHMTADS, CHRIS, TSCA, Emergency Response Guide and the NIOSH Pocket Guide. It is available from Croner (a UK company). Contact sales staff in the UK at 020-8217-1630 or by e-mail *customerservices@croner.cch.co.uk*.

NRMRL Treatability Database — This database is available only on disc from the USEPA National Risk Management Research Laboratory. It provides chemical characteristic and removal data with references. For a free copy contact Ms. Marilyn Joos at (513) 569-7720. For technical questions, call Glenn Shaul (513) 569-7408.

The Environmental Fate Database (EFDB) Available in on-line and PC versions, this database contains chemical characteristics and biodegradation data for thousands of compounds. EFDB is useful for determining biodegradability of specific pollutants through treatment processes, and is especially useful in identifying persistent chemical classes. It is available from Syracuse Research Corporation at *http://www.syrres.com/esc/efdb.htm*.

Registry of Toxic Effects of Chemical Substances (RTECS) — RTECS is a commercially available database giving toxicity and chemical characteristics for over 155,000 chemicals. Vendors of RTECS are listed at *http://www.cdc.gov/niosh/vendors.html*.

TOXNET — A free on-line service from the National Library of Medicine, it provides access to 10 databases, including HSDB, IRIS, and TRI. It is available on the Internet from Specialized Information Services, at *http://toxnet.nlm.nih.gov/*.

Annotated Reference List

Clement Associates, Inc., ***Chemical, Physical, and Biological Properties of Compounds Present at Hazardous Waste Sites: Final Report, September 27, 1985.*** Chemical and physical data useful for determining the fate of toxic compounds.

Howard, Philip H. et al, ***Handbook of Environmental Fate and Exposure Data for Organic Chemicals***, Lewis Publishers, Inc., 1989. Tables of chemical characteristics affecting the fate of toxics in a POTW.

Industrial Technology Division, Office of Water Regulations and Standards, Office of Water, ***CERCLA Site Discharges to POTWs Guidance Manual***, Document #EPA/540/ G-90/005, August 1990. Reported threshold concentrations for biological inhibition by organic and inorganic compounds. Examines inhibition in activated sludge, nitrification and anaerobic digestion.

Industrial Technology Division, Office of Water Regulations and Standards, Office of Water, ***CERCLA Site Discharges to POTWs Treatability Manual***, Document #EPA/540 /2-90/007, August 1990. Mean, minimum and maximum percent removals for activated sludge, trickling filter and aerated lagoons, based on a literature search.

Pajak, Andrew et al, ***Effect of Hazardous Material Spills on Biological Treatment Processes***, Document #EPA-600/2-77-239, December 1977. Compilation of literature data on biological inhibition and removals in biological treatment processes.

Mackay, Donald et al, Illustrated ***Handbook of Physical-Chemical Properties and Environmental Fate for Organic Chemicals***, Lewis Publishers, 1993. Five volume series. Excellent resource for physical-chemical characteristics affecting the fate of organic chemicals.

Schnoor, Jerald et al, ***Processes, Coefficients, and Models for Simulating Toxic Organics and Heavy Metals in Surface Waters***, Document #EPA/600/3-87/015, June 1987. Excellent resource for chemical characteristics.

USEPA, ***Fate of Priority Pollutants in Publicly Owned Treatment Works: Final Report, Volume I***, Document #EPA 440/1-82/303, September 1982. Minimum and median percent removals of priority pollutants, based on a field study of selected POTWs.

USEPA, ***Guidance Manual for Preventing Interference at POTWs***, September 1987. Includes data on inhibition by metals and some inorganic compounds for activated sludge, nitrification and anaerobic digestion. Inhibition ranges are estimated for several broad classes of organics.

USEPA, ***Guidance Manual on the Development and Implementation of Local Discharge Limitations Under the Pretreatment Program***, Revised 2004. Generalized priority pollutant removal efficiencies from primary, tertiary, activated sludge and trickling filters. Priority pollutant inhibition threshold levels for activated sludge, nitrification and anaerobic digestion.

USEPA, ***Report to Congress on the Discharge of Hazardous Wastes to Publicly Owned Treatment Works***, Document #EPA/530-SW-86-004. Contains RREL removal estimates and extensive inhibition data.

Verschueren, Karel, ***Handbook of Environmental Data on Organic Chemicals***, New York, Van Nostrand Reinhold, 1983. Tables of chemical characteristic affecting the fate of toxics in a POTW.

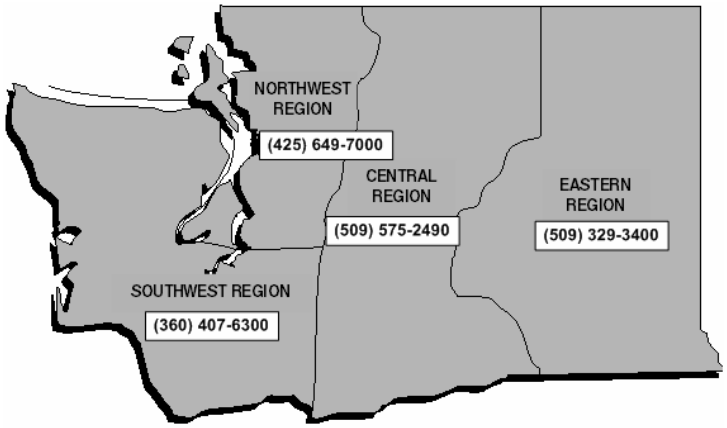
For a copy of this document, please contact:

Department of Ecology
Publication Distribution Center
PO Box 47600
Olympia, WA 98504-7600

Please include your street address for UPS delivery.

Or access it from Ecology's Web site at *http://www.ecy.wa.gov/pubs.shtm*

The Hazardous Waste and Toxics Reduction Program is responsible for the management and reduction of hazardous waste and toxic substances in Washington State. We are available to answer your questions. Contact your nearest regional office and ask for a Toxics Reduction Specialist for information on reducing or recycling hazardous waste. And if you are uncertain about your responsibilities as a hazardous waste generator, ask for a Hazardous Waste Specialist.



If you need this information in an alternate format, please call the Hazardous Waste and Toxics Reduction Program at 360-407-6700. If you are a person with a speech or hearing impairment, call 711, or 800-833-6388 for TTY.