

Water Quality Criteria Development and Assessment - Program 53

Program Overview

Program Description

Air emission controls are increasing the quantities of liquid and solid waste streams containing metals and other compounds at a time when discharge limits are becoming more stringent. Waste managers are challenged to manage new, more-complex waste streams while minimizing the associated management costs. Site-specific permitting methodologies and implementation guidance are needed for discharges containing metals and other potential toxics. Rigorous field data and more-comprehensive, risk-based modeling approaches are needed to address health and environmental risks of mercury, selenium, and arsenic in aquatic environments.

The Electric Power Research Institute's (EPRI's) water quality criteria program advances science and technology to mitigate the risks associated with the presence of mercury, other metals, and organic compounds in aquatic environments. The program delivers credible information and analytical tools for incorporating site-specific conditions and new ecological science into regulatory and permitting processes. The program also improves the body of scientific information available for decisions on key regulatory issues such as mercury emission standards and drinking water standards.

Research Value

The scientific information generated by the program can be used by resource agencies in place of assumptions to develop regulations and permit conditions addressing human health and aquatic toxicity. The research addresses new ambient water quality criteria, and revision of existing criteria, to ensure that the risk to human health and the environment is well understood. The program conducts long-term environmental mercury research to characterize ecological effects of emission controls to answer questions such as whether reduced emissions of mercury will result in reduced methylmercury levels in fish and wildlife and how long will it take. Enhancement of the Dynamic Mercury Cycling Model (D-MCM) for total maximum daily load analyses and translation of the mercury fish tissue chronic criterion to a discharge permit is critical to power companies and regulators. The program supports arsenic health research performed under Program 42, Air Toxic Health and Risk Assessment. This research is directed to reducing the scientific uncertainties in the shape of the arsenic dose-response curve at low exposure levels to inform development of a more realistic and scientifically defensible human cancer potency factor for arsenic. The final arsenic potency cancer factor is central to deriving allowable limits for air and water quality criteria, effluent guidelines, soil standards, and drinking water limits, among others. This research presents the power industry with opportunities:

- to participate in or benefit from ongoing cooperative research on mercury sampling and analysis using the D-MCM by EPRI members and other entities, such as the Selenium Inter-Industry Work Group, the U.S. Geological Survey (USGS), and various state agencies
- for future critical research on pressing issues such as effects of increased total dissolved solids (from scrubbers) on water quality criteria and biotic integrity of receiving waters
- for proactive environmental management

Approach

EPRI research is forward looking on specific issues and concerns that are not widely discussed, such as organisms on state or federal threatened or endangered species lists (e.g., freshwater mussels downstream from power plant discharges). From a water quality perspective, program research emphasizes downstream effects of scrubbers and other equipment on discharges. This program delivers

- research on selenium to determine the level of risk for noncompliance with the tissue-based criterion and to develop site-specific criteria protocols for compliance,

- research on mercury to enhance the D-MCM for compliance purposes and to develop site-specific criteria protocols for compliance,
- presentations to states and other stakeholders considering mercury air emissions regulations,
- peer-reviewed literature and other information on arsenic bioaccumulation,
- arsenic health risk estimates to inform development of a more realistic and scientifically defensible human cancer potency factor for arsenic, and
- ammoniated wastewater assessment.

Accomplishments

A substantial volume of peer-reviewed literature, considered by government agencies when developing new regulations, is key to informing development of cost-effective and protective regulations and permits. Assistance to the U.S. Environmental Protection Agency (EPA) in developing new site-specific guidelines for selenium discharges provides for permit flexibility and revision of the arsenic ambient water quality criteria (AWQC). Site-specific applications of program results have resulted in documented savings in compliance costs in the hundreds of thousands of dollars. Program accomplishments include the following:

- EPA's Health & Ecological Criteria Division has committed to work with EPRI on arsenic AWQC research.
- Early results from EPRI's arsenic research provided support for revision of a state's AWQC for arsenic providing regulatory relief for two utilities while still being protective of human health.
- The D-MCM provides understanding of how mercury moves and behaves in lakes and other freshwater bodies; it is used by EPA and states to examine and predict mercury bioaccumulation in aquatic environments.
- Mercury research plays a critical role in increasing understanding of the fate of mercury in the environment, helping address policy and regulatory issues.

Current Year Activities

Program R&D for 2010 will focus on an upgrade of EPRI's D-MCM to improve prediction of the environmental fate and transport of mercury using data from the METALLICUS and other research projects. Specific efforts will include:

- upgrading EPRI's D-MCM starting with the lake version and then expanding into river and estuarine environments to support compliance needs with the new EPA methylmercury fish tissue criterion,
- refining an EPRI-developed approach for generating site-specific selenium water quality criteria,
- improving the scientific basis for estimating arsenic health risk,
- determining potential risk to freshwater mussels from ammonia in discharged wastewater,
- conducting collaborative research with the University of Illinois and USGS on the development of a new analytical method for analysis of methylmercury in water, and
- developing the Biotic Ligand Pulse Exposure Model.

Estimated 2010 Program Funding

\$0.9M

Program Manager

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Summary of Projects

Project Number	Project Title	Description
P53.001	Arsenic Health Risk Estimates	A joint EPRI/EPA cancer risk assessment framework is expected to reduce critical uncertainties regarding arsenic's mode of action and toxicokinetics at low exposure levels. This research will apply new biological information to reduce uncertainties in the cancer health risk assessment for arsenic and will reduce reliance on conservative default assumptions in human health risk estimates.
P53.002	Ammoniated Wastewater Assessment	Many power plants are or will be installing SCR equipment and scrubbers as air quality regulations evolve. There is uncertainty as to how these control technologies might affect wastewater quality and toxicity. The information developed in this project can be used to better inform utilities on the management of SCR and scrubber waste streams, especially if they are to be comanaged in fly ash basins.
P53.003	Aquatic Life Criteria Development	This research builds on a critical assessment of the process by which EPA establishes national ambient aquatic life criteria. That assessment, undertaken with EPA, to develop improved, scientifically based methods included an evaluation of the 1985 EPA report, <i>Guidelines for Deriving National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses</i> .
P53.004	Dynamic Mercury Cycling Model (D-MCM)	The D-MCM will assist dischargers in addressing complex issues associated with mercury regulatory requirements. Research conducted will enhance the applicability of the D-MCM to diverse aquatic ecosystems, ultimately providing a tool to predict ecosystem responses as a function of atmospheric mercury deposition rates.

P53.001 Arsenic Health Risk Estimates (SP0489)

Key Research Question

The planned revision of the arsenic ambient water quality criterion will result in more-stringent limits if the current no-threshold linear default extrapolation for cancer risk is applied. This research will reduce reliance on default assumptions and uncertainties in the scientific basis for human health risk assessment for arsenic, leading to sounder regulatory decisions for wastewater discharges.

Approach

Although recent scientific evidence suggests a nonlinear mode of action for arsenic, a comprehensive risk framework for these observations has yet to be developed. The principal objective of this project is to develop such a framework. Laboratory research to describe kinetics and develop models for arsenic's behavior in the body will be conducted. Laboratory studies also will measure the effect of different arsenic exposure levels on important molecules and genes in animal and human cells. Field studies will measure and compare laboratory results with similar endpoints in exposed humans. Results will be integrated into a new, comprehensive, scientifically based cancer risk framework for arsenic that may then be applied to regulatory revisions for wastewater discharges.

Impact

- EPRI works closely with EPA to develop a human cancer risk framework for arsenic that can accommodate nonlinearity in exposure response.
- Use of new data to develop this framework enhances dependence on science and reduces uncertainties in human health risk assessment for arsenic by reducing reliance on default assumptions in human health risk estimates.
- Program research leads to more scientifically sound regulatory decisions for wastewater discharges.

How to Apply Results

As credible, rigorous scientific results are released in the public domain, members should be proactive in sending key stakeholders the results, making sure that stakeholders understand those results, and suggesting that results be considered as environmental policies are developed. Members should also use this information to communicate with various public groups as necessary. In addition, EPRI will facilitate broader use and awareness of the results by briefing key stakeholders, including EPA and other government agencies; developing materials for the trade press/media; and continuing service on various advisory panels.

2010 Products

Product Title & Description	Planned Completion Date	Product Type
Impact of Interindividual Variability in Response on Nonlinear Risk Assessment Framework: Measured human-to-human differences in response to arsenic exposure will be assessed and incorporated into the new cancer risk assessment framework, in place of reliance on default assumptions concerning these differences.	12/31/10	Peer Literature

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
Refine Risk Framework by Incorporation of Key Biological Interactions Data and Apply to Nonlinear Cancer Risk Estimate: The comprehensive nonlinear risk framework will be refined by incorporation of new data on arsenic's interactions with cellular components, and the refined framework will be applied to a nonlinear cancer risk estimate.	12/31/11	Peer Literature
Application of Computational Systems Biology to Describe Arsenic Toxicity Pathways: Genomic and kinetic information for cellular response pathways will be integrated in a computational framework to identify key biological events in the cancer induction pathway that could give rise to low dose-dependent transitions and thresholds.	12/31/12	Peer Literature

P53.002 Ammoniated Wastewater Assessment (057716)

Key Research Question

Electric utilities are continuing to install selective catalytic reduction (SCR) and selective noncatalytic reduction (SNCR) units to reduce nitrogen oxides for control of ground-level ozone. In some cases, utilities are injecting ammonia to mitigate for sulfur trioxide emissions. Each of these technologies releases ammonia, which may be conveyed to fly ash ponds and landfills. Additionally, many utilities are retrofitting controls for sulfur dioxide on existing units, which will produce solid and liquid discharges, some of which will be placed in landfills.

Approach

- Anticipated increases in ammonia and metals in waste streams may lead to currently unknown synergies and the potential for elevated toxicity of discharges.
- Field studies will be conducted to predict future changes in composition of waste streams and fly ash pond waters.
- Laboratory studies will be conducted to evaluate and predict synergistic toxicity of complex mixtures.
- Laboratory and field studies will provide estimates of potential of discharges for toxicity to current and future threatened species (e.g., freshwater mussels).

Impact

- Improves the understanding of how air emission control technologies affect wastewater quality, thereby reducing risks and costs associated with discharge compliance requirements.
- Identifies potential discharge effects to aquatic life at an early stage so mitigation can be considered.
- Avoids future treatment costs by identifying potential synergisms of ammonium and other constituents before they are actually mixed in waste streams (i.e., identifies necessary segregation and/or treatment of waste streams).

How to Apply Results

EPRI reports on the potential toxicity of ammoniated ash pond wastewaters will provide guidance for ash pond managers and staff responsible for regulatory compliance in determining whether there is a need to manage and treat separate waste streams prior to discharge. Laboratory studies to be conducted during 2009–2011 will provide benchmark data on whole effluent toxicity before new waste streams (primarily wet-scrubber wastewater) become commingled with ash pond waters. These results will be crucial for planning future research that will be necessary for *a priori* evaluations of changes in ash pond discharges.

2010 Products

Product Title & Description	Planned Completion Date	Product Type
Power Plant Effluent Effects on Freshwater Mussels: This research will compare and contrast potential toxicity of fossil power plant effluents containing flue gas desulfurization (FGD) and/or ammoniated waste streams to National Pollutant Discharge Elimination System (NPDES) Whole Effluent Toxicity (WET) organisms and freshwater mussels.	12/31/10	Technical Report

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
Site-Specific Criteria and Toxicity Testing: An updated guidance manual will be prepared for developing site-specific criteria and WET limits for FGD- and ammonia-influenced aqueous discharges.	12/31/11	Technical Report
Aquatic Toxicity of Total Dissolved Solids: Updated WET testing will be performed on ash pond discharges to evaluate the potential toxicity of these discharges as new emission control technologies are added to fossil fuel power plants.	12/31/12	Technical Report

P53.003 Aquatic Life Criteria Development (101916)

Key Research Question

EPA develops national ambient water quality criteria, which are then implemented by the states. Utilities are subject to limits on metals and other substances in their discharge permits based on existing criteria and also on new criteria as those are developed and implemented. There is a need to develop improved, scientifically based methods for the development of water quality criteria to ensure that the criteria reflect the latest science, and, over the long term, to develop modeling approaches that describe more accurately the risk to aquatic life from the release of metals to surface waters. The Biotic Ligand Model (BLM) is such an approach. Use of the BLM will result in metal-related national ambient water quality criteria being implemented on site-specific bases, with the likely result of less-conservative discharge permit limits that are still protective of aquatic life.

Approach

- This research supports critical assessments of the process by which EPA establishes national ambient aquatic life criteria.
- This research will expand the BLM to account for site-specific differences in the magnitude and duration of exposure of target organisms to regulated substances
- Existing criteria will be updated with new information
- Research will provide guidance on the development of site-specific criteria for selenium and methylmercury.

Impact

- Reduction in compliance costs through rigorous, scientifically valid models for deriving site-specific water quality criteria
- Further compliance-cost reductions over the long term through addition of other metals to the BLM
- Assurance that up-to-date scientific knowledge (e.g., metals speciation) is considered in criteria development
- Excellent working relationship with EPA, which ensures to the extent possible that EPA will use research results

How to Apply Results

EPRI disseminates results to members, EPA, and the public through technical reports, peer-reviewed literature, workshops, and meetings. The project is an effort to improve the development of ambient aquatic life criteria at the national level over the long term, streamlining the process and reducing the costs of compliance. Members will also find project results useful in discussions with state water agencies.

2010 Products

Product Title & Description	Planned Completion Date	Product Type
Arsenic Ambient Water Quality Criteria: Bioaccumulation and Speciation Issues: This research, which involves laboratory studies, is directed to determining the accumulation and speciation of arsenic in fresh- and saltwater organisms to support an EPA revision of the arsenic ambient water quality criterion for fish consumption.	12/31/10	Technical Update
Biotic Ligand Pulsed Exposure Model: Peer reviewed paper on the development of the Biotic Ligand Pulsed Exposure Model to support regulatory approval by EPA.	12/31/10	Peer Literature

Product Title & Description	Planned Completion Date	Product Type
Guidance Manual for Developing Selenium Site-Specific Criteria: Guidance manual to assist utilities in developing selenium site-specific criteria as a result of EPA's publication of the selenium fish tissue-based criterion.	12/31/10	Technical Report
Guidance Manual for Developing Methylmercury Site-Specific Criteria: Guidance manual to assist utilities in the development of site-specific methylmercury criteria, as a results of EPA's publication of the methylmercury fish tissue criterion.	12/31/10	Technical Report

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
Arsenic Ambient Water Quality Criteria: Bioaccumulation and Speciation Issues: This research, which involves laboratory experiments, is directed to determining the accumulation and speciation of arsenic in fresh- and saltwater organisms to support an EPA revision of the arsenic ambient water quality criterion for fish consumption.	12/31/11	Technical Report
Nanomaterials - Environmental Effects: Technical resource paper on the emerging use of nanomaterials within power plants and the potential environmental effects when these materials are released to the environment.	12/31/11	Technical Update
Wildlife Mercury Criteria: EPA has developed a tissue-base criterion for mercury to protect human health from the consumption of fish. This paper will explore where this criterion may or may not be protective of wildlife that consume fish (i.e., birds), and if not, what actions might be expected from federal and state governments.	12/31/12	Technical Update
Compilation of Bioaccumulation Models: This deliverable will comprise a compilation of bioaccumulation models, with information on the strengths and weaknesses of each model, settings in which each is appropriate, costs, and other characteristics.	12/31/13	Technical Report

P53.004 Dynamic Mercury Cycling Model (D-MCM) (103348)

Key Research Question

Anticipated mercury air emission controls will reduce mercury emissions and deposition. The degree to which controls will affect the environment and improve public health is still uncertain. To maximize the benefit of these controls, which will cost the industry billions of dollars in compliance costs, it is critical to have a detailed understanding of mercury cycling and be able to simulate its cycling with state-of-the-art models.

Approach

- The Dynamic Mercury Cycling Model (D-MCM) will assist dischargers in addressing complex issues associated with mercury regulatory requirements to protect human health from the consumption of fish. Project research will include environmental mercury research to determine the effect of mercury controls on mercury methylation, bioavailability, and food web transport;
- Collaboration with EPA and USGS to develop long-term monitoring plans for mercury in U.S. watersheds;
- Updating of the D-MCM to permit the translation of the methylmercury fish tissue chronic criterion to a water permit;

- Exploration of linking the D-MCM to EPRI's Watershed Analysis Risk Management Framework (WARMF), a whole-watershed transport model; and
- Workshops for EPRI members to help them become proficient in using the D-MCM.

Impact

- Site-specific application of the D-MCM may help reduce compliance costs at individual facilities through an improved understanding of mercury dynamics in the new environment.
- Biogeochemical processes that convert inorganic mercury to its toxic form can be better managed.

How to Apply Results

Although discharges of mercury and methylmercury in aqueous waste streams from power plants are currently regulated at some power plants under National Pollutant Discharge Elimination System (NPDES) permits, in the future, more power plants likely will be regulated as a result of the recent publication of EPA's *Guidance for Implementing the January 2001 Methylmercury Water Quality Criterion*. The D-MCM will serve to predict fish responses to changes in discharge limits. The model can be used by utility personnel responsible for regulatory compliance to evaluate scenarios and develop discharge limits that are sufficiently protective of human health and aquatic life. The model also can be used by regulators, stakeholders, and academicians. The software will operate on modern PCs, and EPRI will hold workshops for members on its use. EPRI will provide product support only to EPRI members.

2010 Products

Product Title & Description	Planned Completion Date	Product Type
Dynamic Mercury Cycling Model V3.0 (D-MCM): EPRI will hold a workshop for utility members, EPA, and state staff to explain and demonstrate D-MCM V3.0 for addressing mercury permit limits and Total Maximum Daily Load (TMDL) calculations.	10/20/10	Workshop, Training, or Conference
Dynamic Mercury Cycling Model V4.0 (D-MCM): This update will be a major revision of the model to incorporate river systems for translating the methylmercury fish tissue criterion to a water discharge permit in these types of systems.	12/31/10	Technical Update
Controls on Fluxes of Mercury into Aquatic Food Webs: Continued reporting on laboratory and field research will be conducted under the METAALICUS project delineating ecosystem level response to mercury loading. Results will be used to update the D-MCM.	12/31/10	Peer Literature
WARMF Dynamic Mercury Cycling Model (WARMF D-MCM): This report will describe how the D-MCM can be linked to WARMF, a whole-watershed transport model, to conduct whole-watershed studies on the transport of mercury to receiving waters and then model the fate and transport of mercury in receiving waters.	12/31/10	Technical Update

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
Dynamic Mercury Cycling Model V4.0 (D-MCM): This update will be a major revision of the model to incorporate river systems for translating the methylmercury fish tissue criterion for mercury discharge permit limits and TMDLs in these types of systems.	02/25/11	Software
Dynamic Mercury Cycling Model V4.0 (D-MCM): EPRI will hold a workshop for members, EPA, and state staff to explain and demonstrate the D-MCM V4.0 for addressing mercury permit limits and TMDLs.	10/26/11	Workshop, Training, or Conference
Controls on Fluxes of Mercury into Aquatic Food Webs: Continued reporting on laboratory and field research will be conducted under the METAALICUS project delineating ecosystem-level response to mercury loading. Results will be used to update the D-MCM.	12/31/11	Peer Literature
Dynamic Mercury Cycling Model V5.0 (D-MCM): This update will be a major revision of the D-MCM to estuarine systems to translate the methylmercury fish tissue criterion to a water discharge permit.	12/31/12	Technical Update
Controls on Fluxes of Mercury into Aquatic Food Webs	12/31/12	Peer Literature
Dynamic Mercury Cycling Model V5.0 (D-MCM): This update will be a major revision of the D-MCM to estuarine systems to translate the methylmercury fish tissue criterion for addressing mercury permit limits and TMDLs in this type of system.	02/28/13	Software
Dynamic Mercury Cycling Model V 5.0 (D-MCM): EPRI will hold a workshop for members, EPA, and state staff to explain and demonstrate the D-MCM V5.0 for addressing mercury permit limits and TMDLs.	10/23/13	Workshop, Training, or Conference
Controls on Fluxes of Mercury into Aquatic Food Webs: Final report on laboratory and field research conducted under the METAALICUS project delineating ecosystem-level response to mercury loading.	12/31/13	Technical Report