Regulating Copper in San Francisco Bay:
Importance of Appropriate Use of Aquatic Chemistry and Toxicology

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Regulation of Copper and Other Heavy Metals in Urban Area Street and Highway Stormwater Runoff

Need for Biogeochemistry and Aquatic Toxicology to Develop Technically Valid, Cost-Effective Regulation of Heavy Metals

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Figure 10. Dissolved copper (Cu) concentrations in water in parts per billion (ppb) at 24 RMP stations sampled in February, April, and August of 1995.

Figure 11. Near-total copper (Cu) concentrations in water in parts per billion (ppb) at 24 RMP stations sampled in February, April, and August of 1995.
Near-Total Copper, μg/L

Rivers

Northern Estuary

Central Bay

South Bay

Figures 64 and 65. Plots of average chromium and copper concentrations (parts per billion, ppb) in water in each Estuary reach from 1989–1995.
Water Quality Criteria for Copper in Marine Waters

National Toxics Rule - December 1992
National Cu Criteria For:
Salt water
  1 Hour Average  2.9 μg/L
  4 Day Average  2.9 μg/L

SFRWQCB Site-Specific Objective 1995
  Total Copper Objective  4.9 μg/L/hr average
  Based on Water Effect Ratio

US EPA 1995 National Toxics Rule
  Convert Salt Water 1 Hr Average Total Copper to Dissolved Copper Multiplied by 0.83
  San Francisco Bay Dissolved Copper Site-Specific Objective is 4.1 μg/L

San Francisco Bay Waters in 1995 Showed Exceedances of the Total and Dissolved Copper Site-Specific Objectives
Figure 3.6. Chart showing results of aquatic bioassays at selected RMP stations.
Figure 27. Chart showing results of water bioassay testing at selected RMP stations.
Clean Water Act Requirements

Exceedance of Water Quality Standard for More than Once in Three Years

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Water Quality Limited

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Waste Load Allocation

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Total Maximum Daily Loads

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Phased Approach

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If the Phase 1 Load Reductions Do Not Result in Achieving Site-Specific Water Quality Objective So There Is No More than One Exceedance of Any Magnitude Every Three Years, Establish New TMDLs for Phase 2

Mass Loading Limits for Copper by 2003

Stormwater Runoff 20%
Riverine Inputs to Bay 25%
Municipal and Industrial Wastewaters 25%

(SFRWQCB, 1993)

Not Based on Copper Load Bay Concentration Response Relationship
Copper Regulatory Issues

Copper of Concern Because of Potential Toxicity to Aquatic Life

National Criterion Based Principally on Copper Toxicity to Mytilus edulis Larvae

San Francisco Bay Water with “Excessive” Copper Non-Toxic to Mytilus edulis Larvae

Where Is the Water Quality Problem?
  “Administrative” Exceedance - Not Related to Water Quality Use Impairment
  Over-Regulation

Copper in San Francisco Bay Water in Non-Toxic, Non-Available Form

Figure 4. Copper (Cu) concentrations in sediment in parts per million, dry weight (ppm) at 24 RMP stations sampled in February and August of 1995.
San Francisco Bay Sediment Copper Issues

San Francisco Bay Sediments, In General, Do Not Contain Elevated Concentrations of Copper
Average Copper in California Soils – 50 mg/kg

San Francisco Bay Shallow Sediments Stirred into the Water Column with Each Storm
Will Not Achieve Water Quality Standards with Only One Exceedance Every Three Years,
Even if All Copper Inputs to the Bay Terminated

Phased Approach for Copper Control for San Francisco Bay Technically Invalid and Could
Result in Expenditures in Excess of $1 Billion to Try to Meet Regulatory Requirements,
Ultimately Failing to Achieve Them

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Toxicity of San Francisco Bay Sediments Not Related to Copper Content

- Exceedance of Copper Water Quality Objective is Not Causing Discernible Water
  Quality Impairment in Bay Waters and Sediments
We need your support to form the Brake Pad Partnership.

In the 1980's, the U.S. Environmental Protection Agency and state agencies across the nation began to address water pollution from copper and other toxic metals as a top priority. Initially these efforts focused primarily on point sources, such as industrial operations and publicly owned waste water treatment facilities. As a result significant reductions in pollutants from individual point sources were achieved and, in some cases, water quality improved substantially. However, many major water bodies continue to fall far below water quality objectives. To realize further significant gains in water quality, regulatory agencies, industry, and environmental organizations are broadening their attention to water pollution from nonpoint sources.

Copper pollution is a nationally significant problem occurring in major water bodies such as: the Chesapeake Bay, the Delaware Estuary, New York-New Jersey Harbor, and the San Diego Bay. Recent studies on the San Francisco Bay demonstrate the relative importance of nonpoint sources, and automotive brake pads, in particular, to controlling copper levels. Controlling copper levels in brake pads could potentially reduce copper flowing to surface waters around the nation.

Common Ground for the Environment is requesting your support and participation in convening a national Brake Pad Partnership. The goal of the Partnership is to identify and implement a voluntary, business solution to reduce the levels of copper entering water bodies from brake pads.

A partnership presents the opportunity to address the issue of copper from brake pads in a manner that can benefit industry, government, and environmental concerns. Benefits include:

- Moving beyond traditional command and control regulation toward a cooperative, voluntary solution;
- Anticipating environmental concerns through a proactive approach that directly incorporates market, economic, and technical issues;
- Meeting or creating market preferences in lieu of regulatory requirements.

Common Ground is prepared to bring together stakeholders in this process to:

- Better define and understand the environmental problem;
- Identify the best means of approaching that problem, and
- Develop a voluntary business solution to that problem.

If you have any questions regarding this effort, or would like to send a letter of support, please contact Greg Schwartz, Common Ground for the Environment, at Sustainable Conservation; 415-338-0380.
Solving the Copper Problem: The Brake Pad Partnership

Kelly D. Moran, Ph.D., City of Palo Alto

Heated copper levels are a priority concern for stormwater runoff. Copper is how to aquatic life in very low concentrations (parts per billion). Runoff copper levels typically exceed both acute and chronic water quality criteria for both fresh water and saltwater. See Figure 1. The National Water Quality Inventory and the Regional Water Quality Control Council have found significant amounts of copper in urban runoff from car washes and vehicle service facilities, and in storm water from stormwater systems. Much of this copper, which constitutes 5% of the wastewater treatment plants, copper will not normally be from brake pads. 

**FIGURE 1**
Annual Stormwater Runoff Test Copper Concentrations in Two California Urban Areas

Urban runoff program found that copper was one of the biggest concerns for urban stormwater runoff. 

**FIGURE 2**

Copper Concentrations in Urban Stormwater Runoff

Some, but not all, brake pads contain copper and other heavy metals. Copper content can vary from manufacturer to manufacturer and even among pads made by the same manufacturer. The range of copper content in a group of 20 brake pads analyzed by the Santa Clara Valley Waterboard Source Pollution Control Program was from 0.016% to 2.05%.

Braking, which forces pads against a metal disc mounted on the wheel of a car or truck (see Figure 3), releases the dust from wear of the pad material into the environment. Once brake disc dust comes off a car, it can fall on streets or blown through the air by other vehicles. The dust can be absorbed into the soil or washed into surface water bodies. In most cases, storm drains flow directly to surface water bodies without wastewater treatment.

Preventing pollution by eliminating the use of copper in brake pads would be substantially more effective than attempting to control the pollution once it appears in the environment. From sampling, this study is not particularly effective at collecting fine particulate matter on the relatively coarse filter paper. Similarly, other operations and structural controls, while costly, have not been demonstrated.
FIGURE 1
Average Storm Water Runoff Total Copper Concentrations in Two California Counties

FIGURE 2
Urban Storm Water Copper Sources

FIGURE 4
South Bay Copper Sources
Auto Brake Pad Copper Substitution Issues

Based on Current Information, Auto Brake Pad Copper Substitution is a Mis-Directed Effort
Where is the Real Water Quality Use Impairment Due to Copper Exceedance of Water Quality Objectives?
  Administrative
  Will Disappear If Independent Applicability Policy Terminated

Substitute for Copper Could Cause Real Water Quality Problems
  Alternatives Not Properly Evaluated for Public Health and Environmental Impacts

Should Focus Water Pollution Control Resources on Finding Real, Significant Water Quality Use Impairment—i.e. Organophosphorus Pesticides
  Search for Problems Due to Copper in Auto Brake Pads
  If Found, Implement Control After Proper Evaluation of Alternative Materials

Pollution Prevention

Removal of Copper from Auto Brake Pads Advocated As a “Pollution Prevention” Activity
Pollution Is an Impairment of the Designated Beneficial Uses of a Waterbody
  No Pollution Found for Copper Currently Present in San Francisco Bay Water and Sediments

Pollution Prevention Should Be Based On Pollution Control and Not Chemical Constituent Control
  Requires Comprehensive Investigation of Aquatic Chemistry and Toxicology of Potential Pollutants
Automobile Brake Pad Copper: 
Is There a Real Water Quality Problem? 
*An Example of an Inappropriate Approach for Developing a Stormwater Runoff Source Control BMP* 

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With the implementation of the US EPA national NPDES urban stormwater runoff water quality management program in 1990, stormwater managers in urban areas in many parts of the US have begun to monitor urban area and highway stormwater runoff for a variety of chemical constituents and pathogenic organism indicators. These studies are confirming the findings of similar types of monitoring efforts that were conducted in the 1960’s as well as the US EPA’s National Urban Runoff Program (NURP) studies conducted in the late 1970’s and early 1980’s that urban stormwater runoff contains elevated concentrations of a variety of chemical constituents that are of potential concern because of toxicity to aquatic life.

It has been known since the 1960’s that several heavy metals, such as copper, lead, zinc and cadmium, are present in urban area street and highway runoff at concentrations that exceed US EPA water quality criteria/state standards in the runoff waters. These exceedances, therefore, could be considered "water quality impairments" under current federal and state regulatory requirements where the exceedance of a water quality standard in ambient waters for an NPDES permitted discharge is labeled, albeit inappropriately, a “use impairment” that requires control.

In the early 1990’s, the state of California Water Resources Control Board and its regional water quality control boards worked with major urban stormwater dischargers (with populations greater than 100,000) to develop early, compared to most of the rest of the country, stormwater runoff NPDES permits. This situation has led to the development of data from a number of stormwater runoff monitoring programs. These programs have demonstrated that copper and several other chemical constituents are present in urban and highway stormwater runoff at concentrations above water quality standards in the South San Francisco Bay area. The Bay has been found to contain both total and dissolved copper concentrations above the site specific copper standard (called "objective" in California) developed by the San Francisco Bay Regional Water Quality Control Board. This situation has led to the Bay being classified as "water quality limited" and has, in accord with current regulations, caused the regulatory agencies to develop the wastewater allocation for copper and Total Maximum Daily Loads (TMDL’s) for the various sources of copper to the Bay.
Validity of US EPA Water Quality Criteria to Estimate Toxic Concentrations of Chemical

Criteria Assume Worst-Case Conditions - 100% Toxic/Available Forms and Chronic - Extended Periods of Exposure
  Only Small Part of the Total Copper Toxic

Aqueous Chemistry and Toxicology of Copper in Marine Waters Such That Worst-Case Assumptions Over-Estimate Actual Toxicity

Water Effect Ratio Adjustment

Measure Toxicity of Copper in Standard Lab Water and in Bay Water, Use Ratio to Adjust Water Quality Objective

Water Effect Ratio = Site Water LC50 / Lab Water LC50

Only Considers Short-Term Equilibration, Does Not Consider Total and Dissolved Slow Equilibration

Underestimates Water and Specific Chemical Form Impacts
Relationship between Analytical Chemistry and Water Quality

Poor Relationship Between Analytically Measured Concentrations and Water Quality Impacts

Purpose of Water Pollution Control
   Protect and Where Degraded, Enhance Designated Beneficial Uses of Waterbody for Aquatic Life-Related Beneficial Uses

Cannot Use Chemical Analysis to Predict Toxicity
   Must Use Bioassays - Toxicity Test as Primary Regulatory Tool

Need Research on Chemical Species Toxicity Test Results
Urban Stormwater Runoff Water Quality Impacts
New Regulatory Area


Urban Area Streets and Highway Stormwater Runoff Contains Several Heavy Metals Such as Cu, Pb, Cr, Zn, Hg and As at Excessive Concentrations Compared to US EPA Water Quality Criteria

If Urban Stormwater Runoff Regulated to the Same Degree as Domestic Wastewaters—No Exceedance of Water Quality Standard Outside of Mixing Zone, Will Cost Urban Dwellers $1 to $2 per Person per Day

Must More Reliably Evaluate Real Water Quality Impacts of Stormwater Runoff-Associated Constituents

Rarely Are the Heavy Metals In Stormwater Runoff from Urban Area Streets in a Toxic-Available Form
Independent Applicability Policy

US EPA Adopted Independent Applicability Policy in Early 1990s
No Public Review

Requires Attainment of Chemically-Based Water Quality Criteria/Standards Even If Biological Assessments - Toxicity and/or Organism Assemblages Show No Impacts Due to the Chemical Present in Excess of Criterion/Standard

Leads to Administrative Exceedances of Criterion/Standard Without Adverse Impacts on Beneficial Uses of Water
- Technically Invalid and Wasteful of Public Funds
- Focuses on Chemicals Rather than Chemical Impacts
  Ignores Purpose of Water Quality Management
  Protection of Beneficial Uses

US EPA Announced Proposed Rulemaking
Possible Change Independent Applicability Policy

Appropriate Use of Numeric Chemical Concentration-Based Water Quality Criteria

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INTRODUCTION

Increasing attention is being given to the cost-effectiveness of chemical contaminant control programs established to reduce toxicity to aquatic life in the watershed and sediment, and excessive bioaccumulation of contaminants in aquatic life. Evaluation and control of chemical contaminants has generally focused on either the effects of the contaminant(s) on aquatic organisms (biological effects-based approaches), or on concentrations of individual chemical contaminants with extrapolations to their impact on aquatic organisms (chemical concentration-based approaches).

Owing to their comparative simplicity and widespread acceptance, chemical concentration-based state water quality standards based on or equivalent to US EPA numeric water quality criteria are being increasingly relied upon as independently applicable regulatory tools for the assessment, protection, and/or enhancement of designated beneficial uses of aquatic systems. However, the present-day use of such criteria and standards largely ignores the complex environmental chemistry and toxicology of contaminants, the worst-case or near-worst-case foundation of those criteria, and the fact that there is a large body of contaminants for which numeric concentration criteria do not exist. Each of these factors diminishes the reliability of the extrapolation of chemical concentrations to impacts on aquatic organisms/beneficial uses of water, and tends to make them more stringent than necessary to protect designated beneficial uses of waters. That notwithstanding, the US EPA has adopted the policy of Independent Applicability for chemical concentration criteria in which chemical-specific concentration values are applied independent of biological effects-based approaches for regulating “water quality”. They are presented as independently reliable even when they indicate an “effect” that is not supported by biological effects-based approaches, such as toxicity testing and actual measurements of bioaccumulation evaluated on a site-specific basis.

For more recent information and writings on this topic, visit our website at www.gfredlee.com; click on the Surface Water Quality Info.

Suggested Regulatory Approach

Do Not Regulate Based on Worst-Case Criteria/Standards Where Exceedances Require Establishing TMDLs

Use Exceedance of Criterion as an Indicator of Potential Water Quality Problems

If Exceedance of Water Quality Criteria Found for Potentially Toxic Chemicals, Allow Discharger/Source Option of Complying With the National Chemical Criteria or Demonstrating Lack of Biological Impact-Toxicity
Problems With Conventional Water Quality Monitoring of Stormwater Runoff

Conventional Monitoring of Runoff/Discharge Water for Suite of Chemical Parameters Produces Little Useful Information on Water Quality Impacts
Focus on Exceedance of Water Quality Criteria

Urbonas & Torno, ASCE Stormwater NPDES Related Monitoring Needs (1994) Conference Summary,
“Very little meaningful monitoring is being directed toward measuring the actual effect of stormwater discharges on the short- or long-term health of the environment. Furthermore, there is no consensus on how this monitoring should be done.”

Roesner in Same Conference Discussion,
“....the course we are taking with the NPDES stormwater permitting program is going to cost municipalities a lot of money, but is not going to result in any significant improvement in the quality of our urban receiving water systems.”

Factors that Must Be Considered in Translating Runoff Concentrations to Potential Aquatic Life Water Quality Impacts

Stormwater runoff
• Need information:
  o measured concentration of constituent during runoff event - concentration time profile
  o discharge of the runoff waters during runoff event - hydrograph
  o analytical chemistry of the method used for analyses - what chemical species are measured

Receiving waters
• Physical factors - need information:
  o Currents, tides - transport-advection
  o Mixing-dispersion

• Biological factors - need information:
  o Duration of organism exposure to toxicant
  o Organism movement - locomotion
    - Diel migration
  o Sensitivity to toxicants
  o Organism assemblages - resident populations relative to habitat characteristics

Chemical factors - need information:
• Aquatic chemistry
  o Kinetics and thermodynamics of reactions
Additive, synergistic and antagonistic reactions and impacts

- Toxic and non-toxic, non-available forms
- Background concentrations of constituents of concern

Evaluation Monitoring As An Alternative to Conventional Water Quality Monitoring and Management

Need Alternative Monitoring/Evaluation Approach to Determine if Real Water Quality Use Impairments Are Occurring in Receiving Waters for Urban Stormwater Runoff Metals and Many Other Constituents in Urban Area and Highway Stormwater Runoff in Particulate, Non-Toxic Forms

Episodic, Short-Term Exposures Occur with Stormwater Runoff Events

Rare that Real, Significant Water Quality Use Impairments Will Occur from Urban Area and Highway Stormwater Runoff-Associated Constituents

Evaluation Monitoring

Find a Real Water Quality Use Impairment in Receiving Waters for Stormwater Runoff that is Due to Stormwater Runoff-Associated Constituents

Rather Than Measuring Suite of Potentially Toxic Chemicals, Measure Toxicity in Runoff Waters and Receiving Waters

- If Significant Toxicity Found, Determine Its Cause through TIEs
- Determine Sources of Toxic Constituents through Forensic Studies
- Develop Control Programs for Toxic Constituents at Source

Technically Valid, Cost-Effective Approach
Evaluation Monitoring as an Alternative to Conventional Stormwater Runoff Monitoring and BMP Development

G. Fred Lee & Associates

There is growing agreement (Etzenhaus and Toney 1994, Hamner 1993, Lee and Jones-Lee 1994, 1994) that conventional stormwater runoff monitoring for the detection of chemical in the water runoff is more effective than the direct monitoring of water quality parameters directly at the location of the runoff as a means to assess stormwater quality. The conventional approach involves a series of water quality monitoring events at selected sites, followed by a laboratory analysis to determine the concentrations of specific pollutants. This approach is time-consuming, labor-intensive, and requires a significant investment in equipment and personnel. In contrast, the evaluation monitoring approach involves the use of a network of monitoring stations that are strategically located to provide continuous monitoring of water quality parameters. This approach is more cost-effective and can provide real-time data on water quality, enabling more effective decision-making and BMP development.

Evaluation Monitoring involves the collection of water quality data from a network of stations, followed by an analysis to determine the concentrations of specific pollutants. This approach is more effective than the conventional monitoring approach because it provides real-time data on water quality, enabling more effective decision-making and BMP development.

In conclusion, evaluation monitoring is a more effective approach for monitoring and BMP development, providing real-time data on water quality and enabling more effective decision-making and BMP development.
Assessing Water Quality Impacts of Stormwater Runoff

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Abstract

Current "water quality" monitoring of non-point source runoff typically involves periodically measuring a laundry list of chemicals in the runoff waters. This approach, while satisfying regulatory requirements, provides little to no useful information on the impact of the chemicals in the runoff on the real water quality - designated beneficial uses of the receiving waters for the runoff. There is need to focus water quality monitoring on investigating the receiving waters in order to assess whether the chemicals in the runoff are adversely affecting beneficial uses. This paper presents an evaluation monitoring approach for monitoring receiving waters that determines whether the runoff is a significant cause of water quality - use impairments. For each type of use impairment, such as aquatic life toxicity, excessive bioaccumulation of hazardous chemicals, excessive fertilization, etc., highly focused site-specific studies are conducted to determine the use impairment that is likely occurring due to a stormwater runoff event(s) and the specific cause of this impairment.

Introduction

There is growing recognition that domestic and industrial wastewater and stormwater runoff "water quality" monitoring involving the measurement of a suite of chemical "pollutant" parameters in discharge/runoff waters is largely a waste of money. For stormwater runoff, such programs generate more data of the type that have been available since the 1960's on the chemical characteristics of urban area, highway and street runoff. It has been known since that time that runoff from these areas contains a variety of regulated chemical constituents and

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Possibility of Copper-Caused, Non-Detected, Subtle Water Quality Impacts

While No Identified Water Quality Problems - Use Impairments Have Been Found – No One Can State With Certainty that No Subtle Problems Will Be Found in the Future

Evaluation Monitoring Requires that Funds Be Made Available to Search for Subtle Water Quality Use Impairments

Prioritize Water Quality Use Impairments - Focus on Most Important Problems
With Limited Financial Resources Available for Water Pollution Control, Focus the Funds Available on the Most Significant, Readily Discernible Water Quality Use Impairments Search for More Subtle Problems

Conclusions

- Traditional Regulatory Approaches for Heavy Metals Such as Copper Fail to Reliably Incorporate Aquatic Chemistry of Regulated Constituents into Regulatory Approach
- Leads to Over-Regulation and Waste of Public and Private Funds in Unnecessary Waste Treatment Facilities/Control Programs
- Need to Shift Regulatory Approach from Control of Chemicals to Managing Water Quality of Concern to the Public
- Use Toxicity Tests to Determine if Toxicity Present. If Present, Determine Cause and Sources
- Urban Stormwater Runoff New Regulatory Area Where There Is Need to Integrate Use of Aquatic Chemistry and Toxicology to Define Real Water Quality Problems