Assessing Water Quality Significance of N & P Compound Concentrations in Agricultural Runoff

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CA Central Valley Regional Water Quality Control Board Requires Irrigated Agriculture Monitor Ag Discharges/Runoff for Nutrients (N&P) for Potential Water Quality Impacts

Discussion of Issues & Approach for Using Aquatic Plant Nutrient Concentration Data to Evaluate Potential Water Quality Impacts

Invited Paper presented at Agrochemical Division, American Chemical Society National Meeting, San Francisco, CA, September (2006)

Regulating Biostimulating Substances

- CVRWQCB Requires:

  "Water shall not contain biostimulatory substances which promote aquatic growths in concentrations that cause nuisance or adversely affect beneficial uses."

- Basin Plan Provides No Guidance How to Evaluate "Excessive" Biostimulatory Substances
- Uncertainty Regarding Interpretation of Aquatic Plant Nutrient Data to Assess Water Quality Problems
  - Nutrients, Themselves, Not Problematic
  - Only of Concern if/as Become Manifested as Excessive Amounts of Aquatic Plant Material That Impact Use
  - Some Aquatic Plant Material Essential for Maintaining Healthy System

Few Algae:

High Water Quality

The Culprits:

Plate C. Polluted water algae

Excessive Algae:

Poor Water Quality

Excessive Fertilization (Eutrophication) The Problem

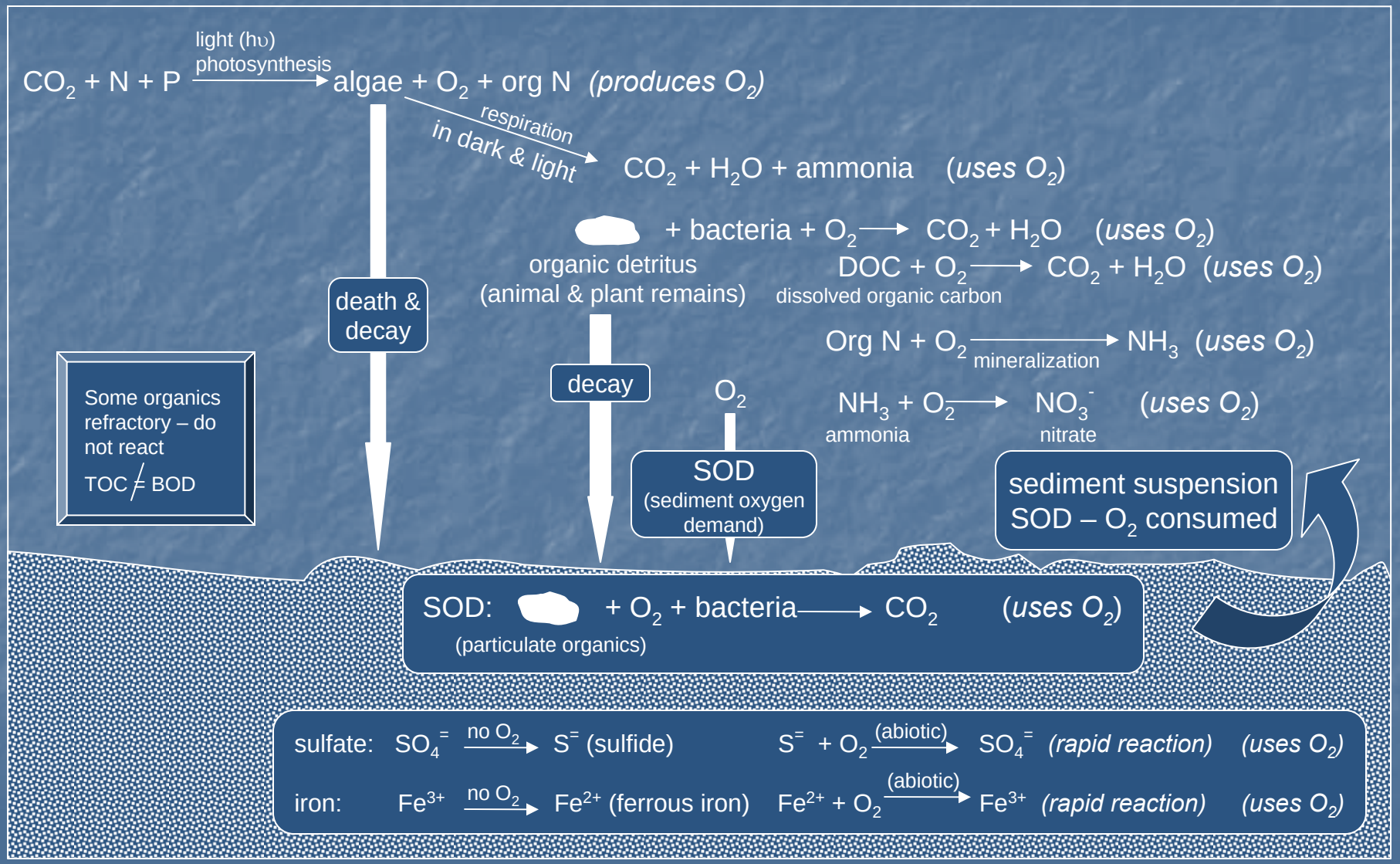
- Excessive Growths of Aquatic Plants
  - Algae: Plankton (Suspended) & Attached
  - Water Weeds: Macrophytes, Floating & Attached
- Impacts
  - Impair Domestic Water Supplies
    - Tastes & Odors, Shortened Filter Runs
    - Increase Trihalomethane Precursors (TOC)
      - THM's (Chloroform) Carcinogens
  - Cause Violations of Water Quality Standards
    - pH & Dissolved Oxygen
    - Diel Photosynthesis & Respiration

      1P $\rightarrow$ Algae $\rightarrow$ 276 O Consumed

      Gulf of Mexico Anoxia

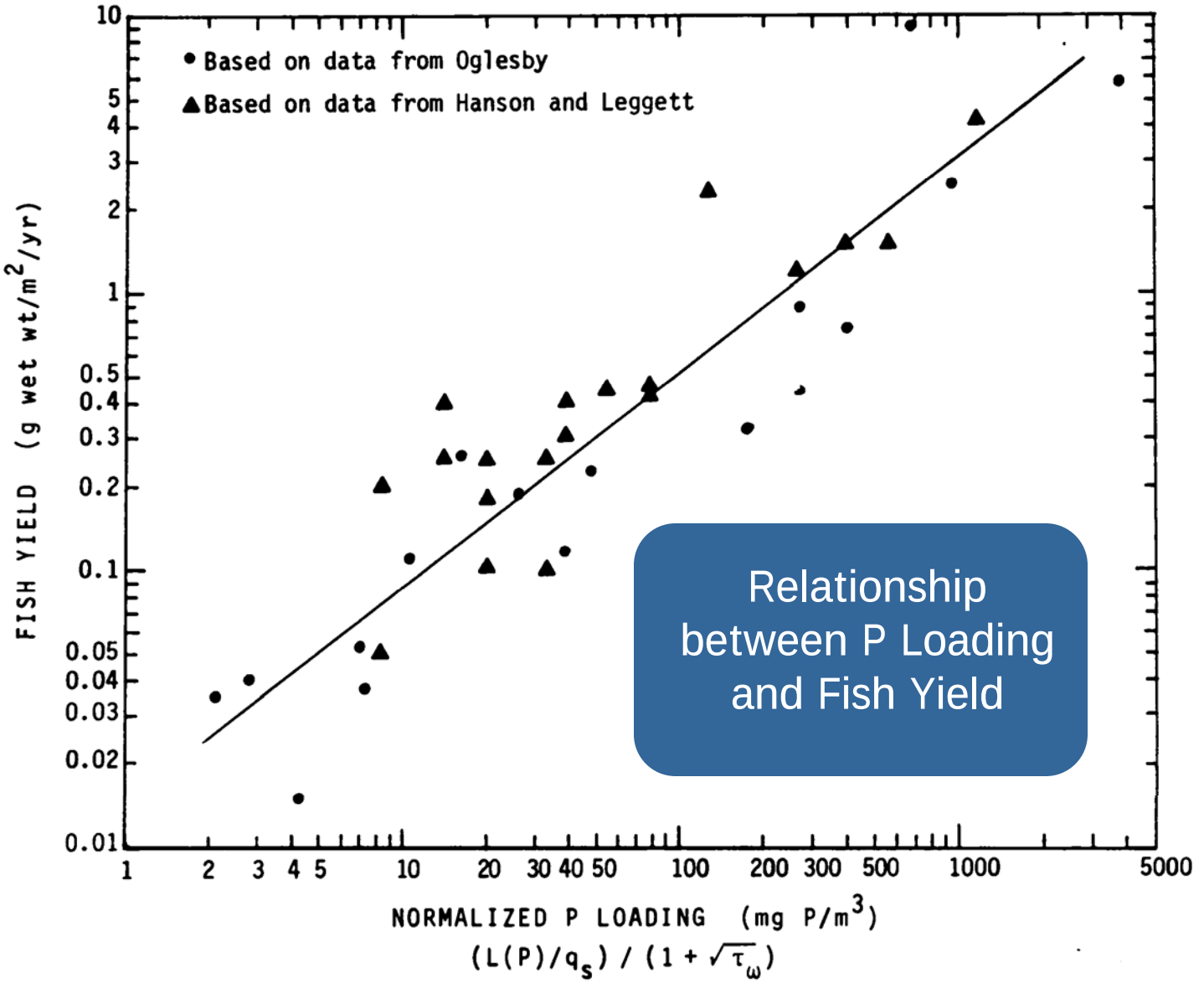
      SJR DWSC

Algae & Organic Detritus as Sources of Oxygen Demand



Excessive Fertilization (Eutrophication) The Problem (cont'd)

- Impacts (cont'd)
  - Toxic Algae
    - Fish Kills (*Pfiesteria*)
    - Kill Livestock & Wildlife (Blue-Green Toxins)
  - Impairment of Recreation
    - Swimming, Boating, Fishing, Aesthetics (e.g., Odors, Scum)
  - Loss of Shallow Water Vegetation Habitat
    - Algal Turbidity Reduces Light Penetration Needed for Emergent Plants
  - Impacts on Fisheries
    - Increase Amount of Fish Produced
    - Lead to Loss of Cold Water Fisheries if Resulting Oxygen Demand in Hypolimnion Is Sufficient to Deplete Oxygen
    - Increase in Less-Desirable, Rough Fish Such as Carp
  - Excessive Fertilization Is One of Most Important Causes of Water Quality Impairment



Relationship between P Loading and Fish Yield

Nutrients of Concern

- Total Phosphorus
- Soluble Ortho Phosphate
- Ammonia
- Nitrate
- Nitrite
- Organic Nitrogen

Algal Stoichiometry

$$106\ CO_2 + 16\ N + 1\ P + \text{trace elements} \xrightarrow{h\nu} \text{Algae} + O_2$$

Chemical-Specific, Numeric Water Quality Criteria for N & P

- Many Chemicals (e.g., Cu, Zn, Pb) Regulated Based on Numeric Water Quality Criteria – Required by Clean Water Act
  - Easily Implemented – Measure Concentration & Compare
  - Based on Worst-Case Assumptions about Aquatic Life Toxicity
  - Need to Be Adjusted for Site-Specific Conditions
- Why Not Develop Numeric WQC for Nutrients ?

Nutrient Criteria

EPA United States Environmental Protection Agency

Federal Register
Environmental Documents

Related Material

- Other Related Documents

[Federal Register: January 9, 2001 (Volume 66, Number 6)]
[Notices]
[Page 1671-1674]
From the Federal Register Online via GPO Access [wais.access.gpo.gov]
[DOCID:fr09ja01-62]

ENVIRONMENTAL PROTECTION AGENCY

[OW-FRL-6931-1]

Nutrient Criteria Development; Notice of Ecoregional Nutrient Criteria

AGENCY: Environmental Protection Agency (EPA).

ACTION: Notice of Ecoregional Nutrient Criteria for Lakes and Reservoirs, Rivers and Streams, and Wetlands.

SUMMARY: The Environmental Protection Agency (EPA) is publishing seventeen Ecoregional Nutrient Criteria Documents for lakes and reservoirs, rivers and streams and wetlands within specific geographic regions (ecoregions) of the United States. These recommended section 304(a) water quality criteria for nutrients were developed with the aim of reducing and preventing eutrophication on a National scale. Each document presents recommended criteria for causal parameters (total phosphorus and total nitrogen) and response variables (chlorophyll a and some form of turbidity). This information is intended to serve as a starting point for States, authorized Tribes and others to develop more refined nutrient criteria, as appropriate, using EPA waterbody-specific technical guidance manuals and other scientifically defensible approaches. EPA will work with States and authorized Tribes as they adopt water quality criteria for nutrients into their water quality standards. EPA expects States and authorized Tribes to adopt or revise EPA ecoregional nutrient criteria published in 2000 into State or Tribal water quality standards by 2004.

Under the Clean Water Act, States, Territories, and authorized Tribes adopt into their water quality standards water quality criteria to protect designated uses. The criteria recommendations presented in these documents are guidance that States, territories, and authorized Tribes may use as a starting point for developing their own criteria as part of their water quality standards. EPA strongly encourages States, Territories and authorized Tribes to refine these recommendations based on the key elements of nutrient criteria development (historical information, reference conditions, models, consideration of downstream

United States
Environmental Protection
Agency

Office of Water
4304

EPA-822-B-00-002
July 2000

Nutrient Criteria Technical Guidance Manual

Rivers and Streams

Nutrient Criteria

- Nutrient Dischargers Face Nutrient (N&P) Criteria That Could Regulate Nutrient Releases
  - Nutrient Concentrations above Criteria Concentrations Could Lead to Listing of Waterbodies as 303(d) “Impaired”
  - Will Likely Require Greater Control of Nutrients in Runoff/Discharges
- Nutrient Dischargers Should Become Involved in RTAG Efforts to Establish Appropriate Criteria
- US EPA Proposed Two Approaches for Criteria
  - National Default Criteria Values
  - Site-Specific Criteria

Chemical-Specific, Numeric Water Quality Criteria for N & P

- Why Not Develop Numeric WQC for Nutrients?
  - US EPA Tried – Developed Generic Numeric Criteria for N & P
    - Technically Invalid Approach
    - Do Not Consider Variety of Factors That Influence How Nutrients Develop into Aquatic Plants That Impact Water Quality

Cannot Reliably Regulate Nutrient-Related Water Quality Impacts Based on Generic Numeric, Chemical-Specific Concentration Limits for N & P Compounds

Requires Site-Specific Evaluation of Nutrient Concentrations, Loads, Waterbody Characteristics, Aquatic Plants Types, etc.

Site-Specific, Nutrient-Related Water Quality Impact Issues
◄ *Must Consider* ►

- Types of Aquatic Plants of Water Quality Concern
  - Planktonic Algae, Attached Algae, Emergent (Rooted) Macrophytes (e.g., Cattails, Egeria), Floating Macrophytes (Water Hyacinth, Duck Weed)
  - Each Type Has Own Nutrient Requirements & Impacts on Water Quality/Beneficial Uses
  - Public Perception of Aquatic Plant Impacts on Water Quality
  - Need Nutrients to Support Base of Food Web for Waterbody Aquatic Resources

Site-Specific, Nutrient-Related Water Quality Impact Issues
◄ *Must Consider* ►

- Type of Waterbody
  - Lake/Reservoir, Stream, River, Estuary, Marine Water
- Waterbody Physical/Hydrological Characteristics
  - Depth, Surface Area, Hydraulic Residence Time (Lake/Reservoir), Velocity (Stream/River)
- Nutrient Availability
  - Not All Forms Available to Support Plant Growth, Especially P

Issues That Need Consideration in Developing Appropriate Nutrient Control Program

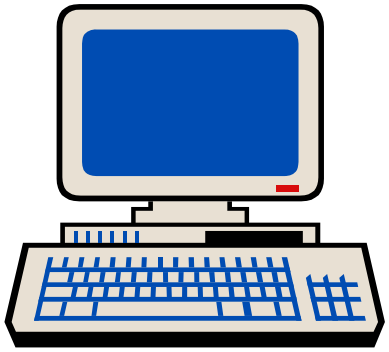
- What Is the Nutrient-Caused Water Quality Problem(s)?
- When Does the Water Quality Problem Occur?
  - Summer? Fall?
- Which Nutrient Loads Cause or Contribute to Excessive Fertilization of Waterbody (i.e., Cause Water Quality – Use–Impairment)?
  - Annual Load; Seasonal Loads
- What Is the Hydraulic Residence Time (Filling Time) of the Waterbody?
- When & Where Do the Nutrients That Cause Water Quality Problems, Enter the Waterbody?
- How Will the Magnitude of the Nutrient–Caused Water Quality Problems Change with Given Change in Nutrient Load?
- What Will Be Cost of Nutrient Control to Achieve Desired Water Quality?
  - Who Will Pay These Costs?

Interpretation of Significance of Measured Nutrient Concentrations

- No Simple Approach for Interpretation of Nutrient Concentration Data Relative to Excessive Biostimulation of Aquatic Plants
- Requires Site-Specific Evaluation of Impacts of Nutrients on Excessive Growths of Aquatic Plants That Cause Impairment of Beneficial Uses
- Must Consider Impacts on All Downstream Waterbodies as Well

Further Information

Consult Website of
Drs. G. Fred Lee and Anne Jones-Lee



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Many of the above-listed papers and reports are available from Dr. Lee’s web site

Assessing Water Quality Significance of N & P Compound Concentrations in Agricultural Runoff

◄ *Abstract* ►

Excessive growth of aquatic plants causes significant water quality/beneficial-use problems, including low dissolved oxygen, impairment of domestic water supplies' water quality, impairment of recreation, etc. The growth of aquatic plants to excessive levels is driven by nitrogen and phosphorus compounds from a variety of sources, including agricultural stormwater runoff, tail water and subsurface drain water discharges. Because of the significance of those sources, many water quality monitoring programs include the suite of nitrogen and phosphorus compounds that serve as aquatic plant nutrients. To this end, statements such as, *"Water shall not contain biostimulatory substances which promote aquatic growths in concentrations that cause nuisance or adversely affect beneficial uses"* are in some regulations. However, guidance is not provided on how to evaluate "excessive" biostimulatory substances. The nutrients, themselves, are not problematic; they are only of concern as they become manifested in excessive amounts of aquatic plant material, some of which is essential for maintaining a healthy ecosystem. This paper discusses the issues that need to be considered in determining excessive concentrations of nutrients in agricultural runoff.