

Remedial Techniques for Improving Water Quality in Lakes, Rivers, and Water Supplies

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Purpose

Improve Water Quality of Rivers and Lakes in Korea



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Background

- ◆ Poor water quality
- ◆ Taste and Odour Problems
- ◆ Potential Health Problems
- ◆ Recreational Impairment



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Eutrophication

- ◆ Major cause of water quality problems is excessive phosphorus

Sources of phosphorus include:

- Rain
- Point and non-point sources
 - Agricultural runoff
 - Industrial Runoff
 - Urban Runoff
- Sediments

Controlling Nutrients

Key to improving water quality

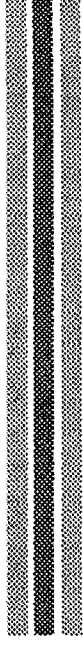
- ◆ Best Management Practices must be instituted prior to any remedial action
 - Rain
 - Point and non-point sources
 - Agricultural runoff
 - Industrial Runoff
 - Urban Runoff



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Controlling Nutrients (Cont'd)

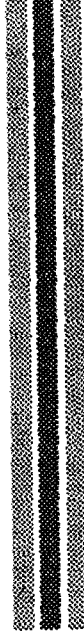
Sediments

Under certain chemical/physical conditions the sediments can supply up to 90% of the phosphorus load to lakes

- ◆ Required Conditions:
 - low sediment redox
 - no oxygen in overlying water
 - low cation binding capacity in sediments
 - pathway for transport of P rich water to the surface

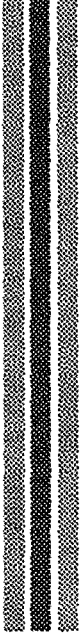
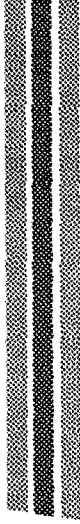
Control Sediment Phosphorus Release

- ◆ Remove sediments (dredging)
- ◆ Cover sediments (capping)
- ◆ Alter the *in situ* characteristics to inhibit sediment release of phosphorus
 - Add oxygen to the sediments/water column
 - Increase the cation binding capacity of the sediments
 - Increase the redox of the sediments



Dredging

- ◆ Remove the nutrients
 - Complete removal may not be possible
- ◆ Sediment Resuspension
 - Contaminant Dispersal
- ◆ May require secondary treatment
 - Oxidise the sediments (sulfides)
 - Other Contaminants
- ◆ Sediment disposal issues



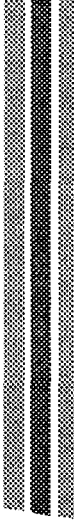
Sediment Capping

Cover sediments with a clean cap

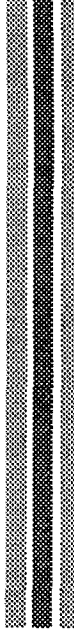
- ◆ Require “lots” of clean material
- ◆ Require specific physical characteristics
- ◆ Require specific hardware



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Add Oxygen to Sediments

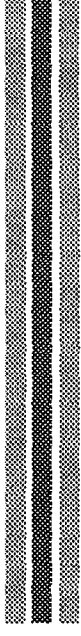
- ◆ Impractical to add oxygen to sediments
 - sediment resuspension
 - relatively low solubility
 - extremely high oxygen demand
 - high cost



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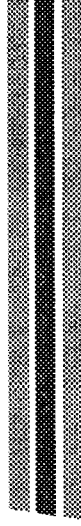
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Addition of Flocculants

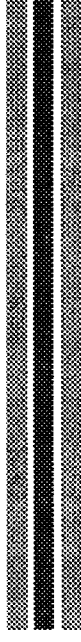
- ◆ Target water column nutrients/algae
- ◆ Alter the cation binding capacity of sediments
- ◆ May produce short-term problems in water quality (pH)
- ◆ Very good for small bodies of water



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Add Oxygen to the Water

- ◆ May require certain physical conditions
 - Water depth
 - Velocity of inflows
 - Infrastructure
- ◆ Traditional Hypolimnetic Aeration
 - pumping air
- ◆ Liquid Oxygen Injection
 - Hypolimnetic bubbles
 - Sidestream pumping



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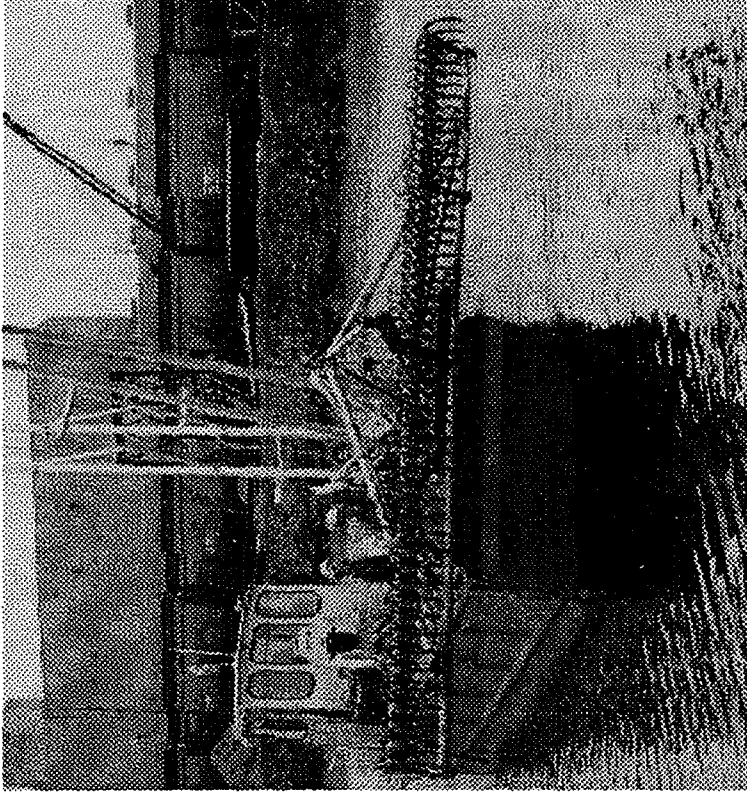
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In Situ Sediment Treatment

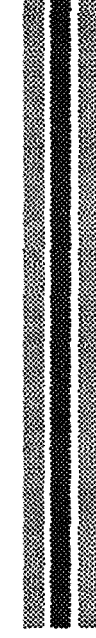
- ◆ Developed by Environment Canada,
→ licensed to Limnofix Inc.
- ◆ Addition of Oxidants & Amendments to alter the bio-chemical-physical nature of the sediments



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In Situ Sediment Treatment Technology

- ◆ Chemical and physical alteration of the sediments by the addition of specific chemicals.

- ◆ Technology includes:
 - Materials handling system
 - Injector system
 - Injection chemicals
 - Oxidants
 - Nutrient amendments
 - Flocculants



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In Situ Sediment Treatment

Objectives

- ◆ **Sediment oxidation**
 - Nutrient inactivation
 - Sulphide control/detoxification

- ◆ **Bioremediation**
 - Accumulated organic deposits
 - Hydrocarbons, PAHs



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Highlights

***In Situ* sediment treatment is:**

- cost effective
- robust technology
 - eutrophication control
 - bioremediation enhancement
 - odour control
- easily implemented



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In Situ Treatment Applications

- ◆ Lakes and storage reservoirs
 - Eliminate sediment nutrient release
 - Odour control

- ◆ Harbours and waterways
 - Decontamination
 - Pre and post dredging

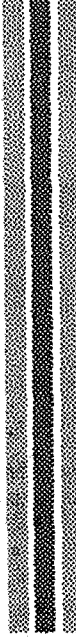
- ◆ Industrial lagoons
 - Sludge treatment and stabilization



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In Situ Sediment Treatment

Advantages:

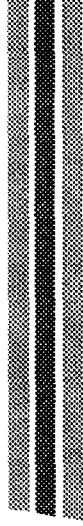
- ◆ Many amendments can be added to the sediments
- ◆ Low cost
- ◆ No dredging
- ◆ No disposal
- ◆ Low treatment impact on non-target parameters

Lake & River Rehabilitation Procedure

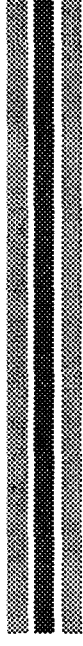
- ◆ **Phased Tiered Approach**
- ◆ **Keep project team members involved in ALL aspects of the project**
- ◆ **Allows for ongoing modification of scope of project**
- ◆ **Extremely cost-effective**



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Phase 1

- ◆ Problem Definition
 - Data Review
 - Data collection
 - Hydrology
 - Loadings
 - Manifestation of Problem
 - spatial
 - temporal

- ◆ Preliminary Evaluation of Remedial Alternatives

Phase 2

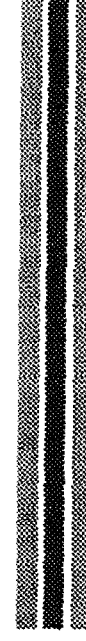
- ◆ Fill in Data Gaps
- ◆ Detailed Screening of Remedial Alternatives
 - Cost effectiveness
 - Acceptance by regulators
 - Complimentary with existing planning requirements
- ◆ Identification of Remedial Alternatives
- ◆ Bench-Scale /Computer Test of Alternatives



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Phase 3

- ◆ Perform Pilot-Scale remediation test(s) of Alternative(s)
- ◆ Audit Remediation Test(s)
- ◆ Identify the most suitable technology



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Phase 4

- ◆ Full-scale Implementation of Remedial Technology(ies)
- ◆ Monitoring of Remedial Activities



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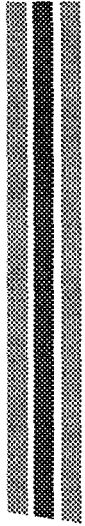
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Schedule

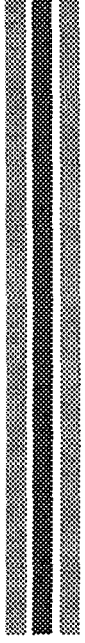
- Phase 1: 3 months
- Phase 2: 3-4 months
- Phase 3: 4 months
- Phase 4: 3-5 months (site specific)



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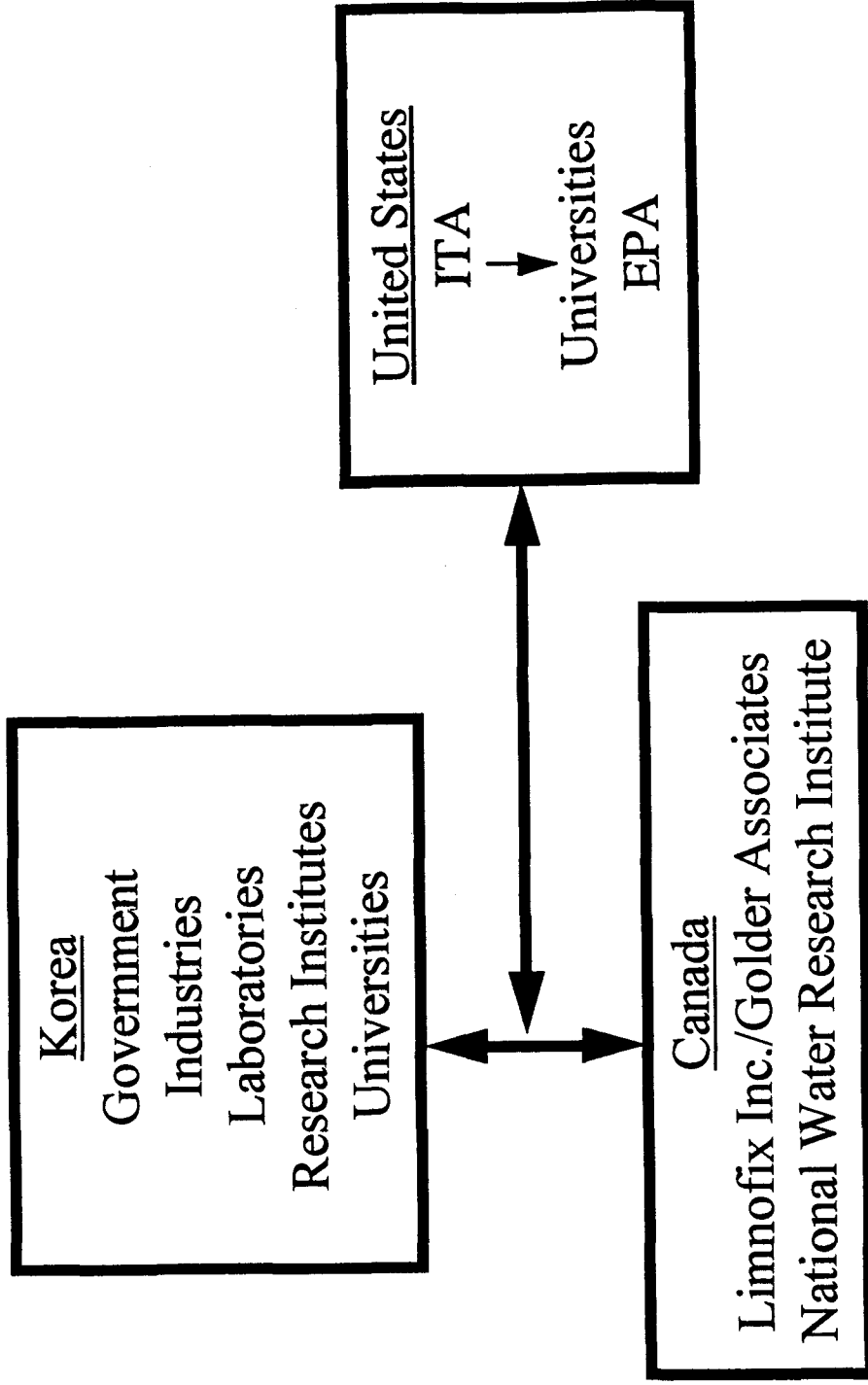


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Working Together to Clean Rivers and Lakes in Korea



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Paldang Lake Characteristics

- ◆ Highly Eutrophic
- ◆ Excess phosphorus: (62 - 121 $\mu\text{g/L}$)
- ◆ Very green (algae): (19 to 90 $\mu\text{g/L}$)
- ◆ Low visibility (Secchi disk depth): (0.75-1.1 m)
- ◆ Softwater: (22.5 to 73 mg/L CaCO_3)
- ◆ Reduced sediments (-200 to -300 mV)
- ◆ High sediment phosphorus release rates
3.6 to 6.1 $\text{mg P/m}^2/\text{day}$

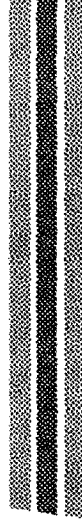


Lake Biwa

- ◆ Drinking water supply for Osaka
 - sediment controlled water quality problems
 - Taste and odour
 - Nutrients
 - Algae
- ◆ Bench & Pilot-scale treatments completed



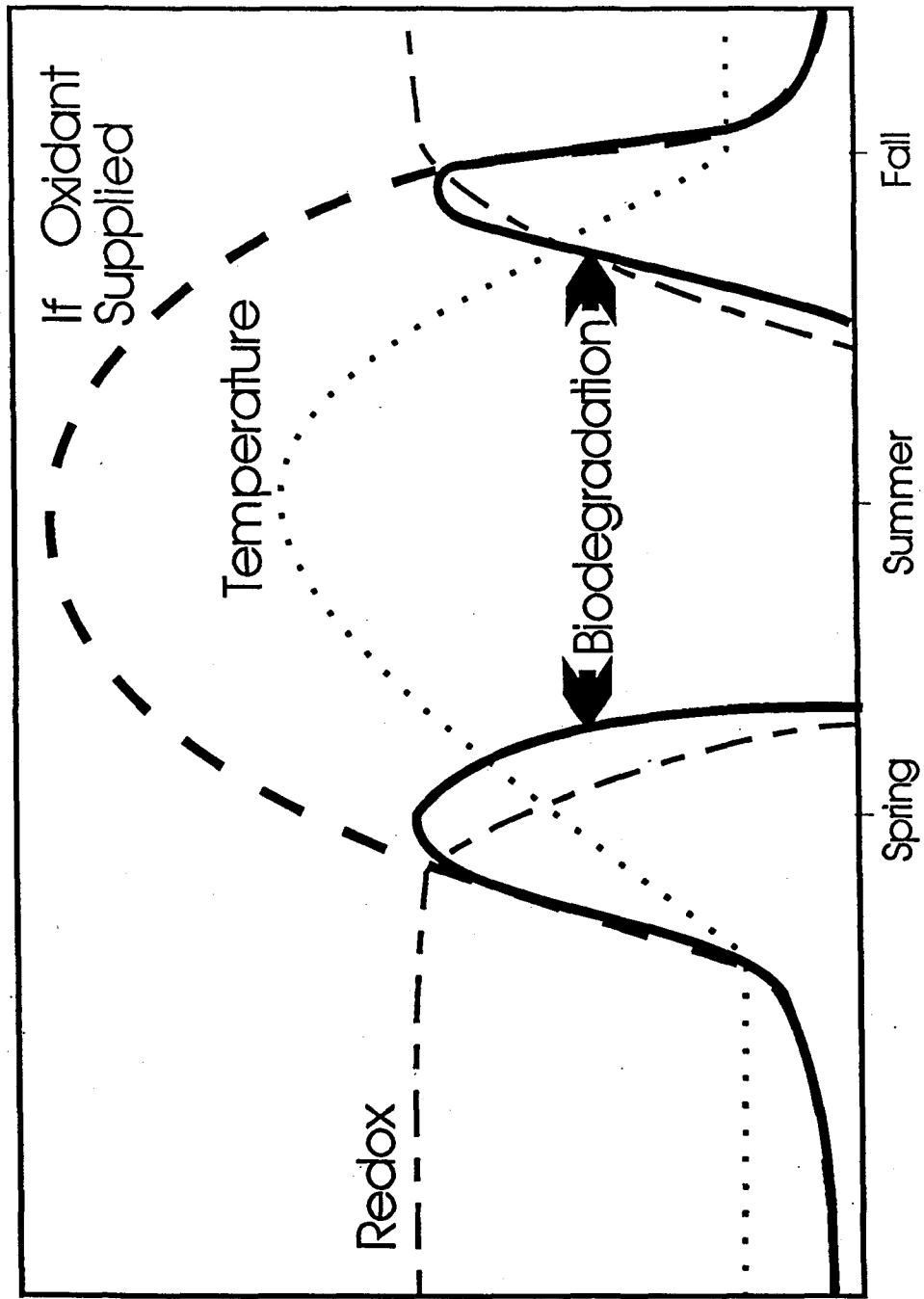
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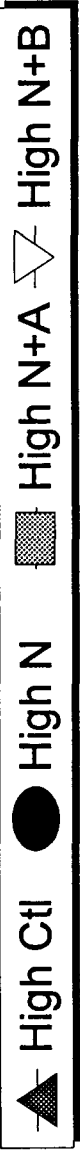
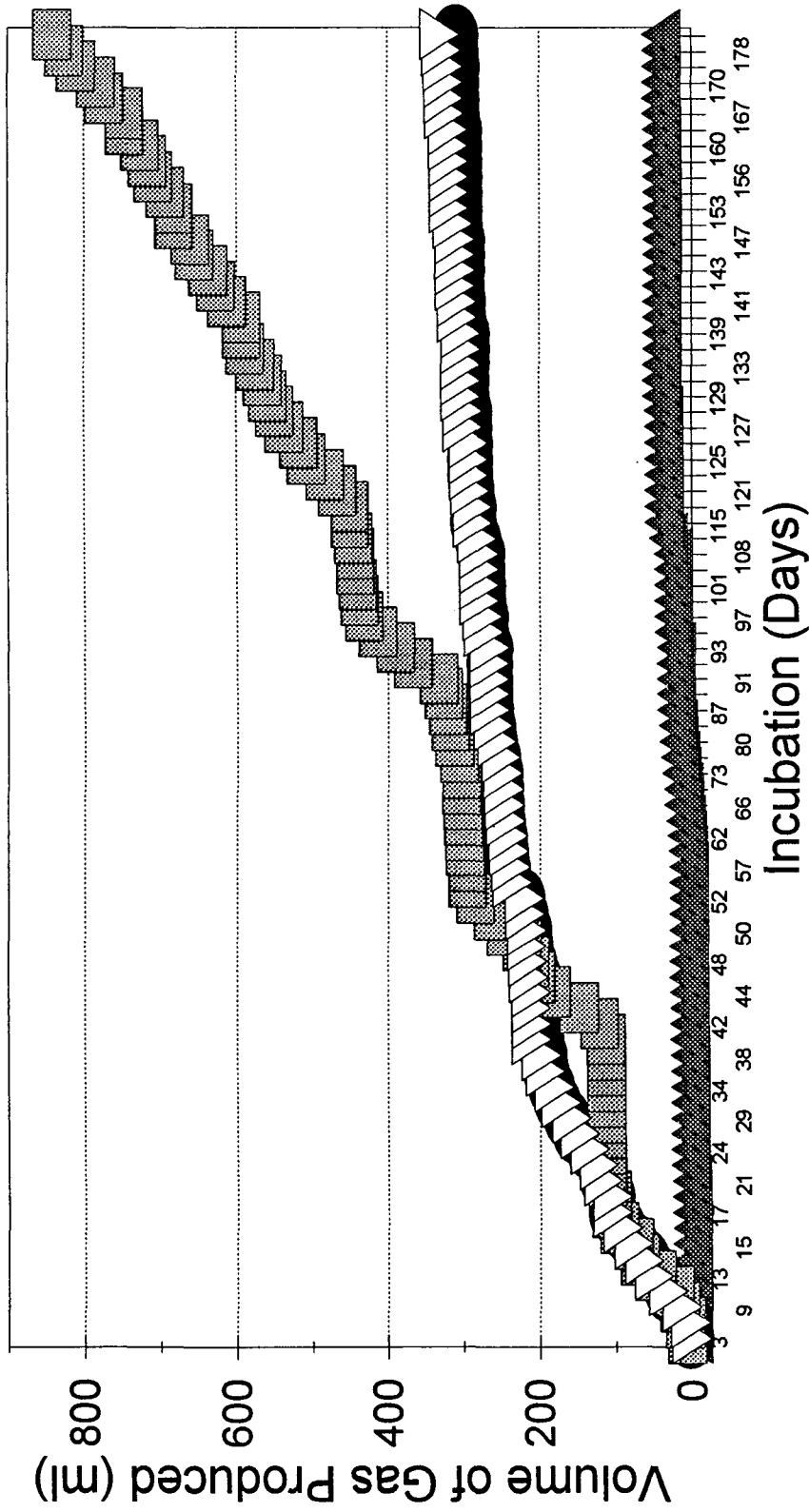


Theory of PAH Biodegradation



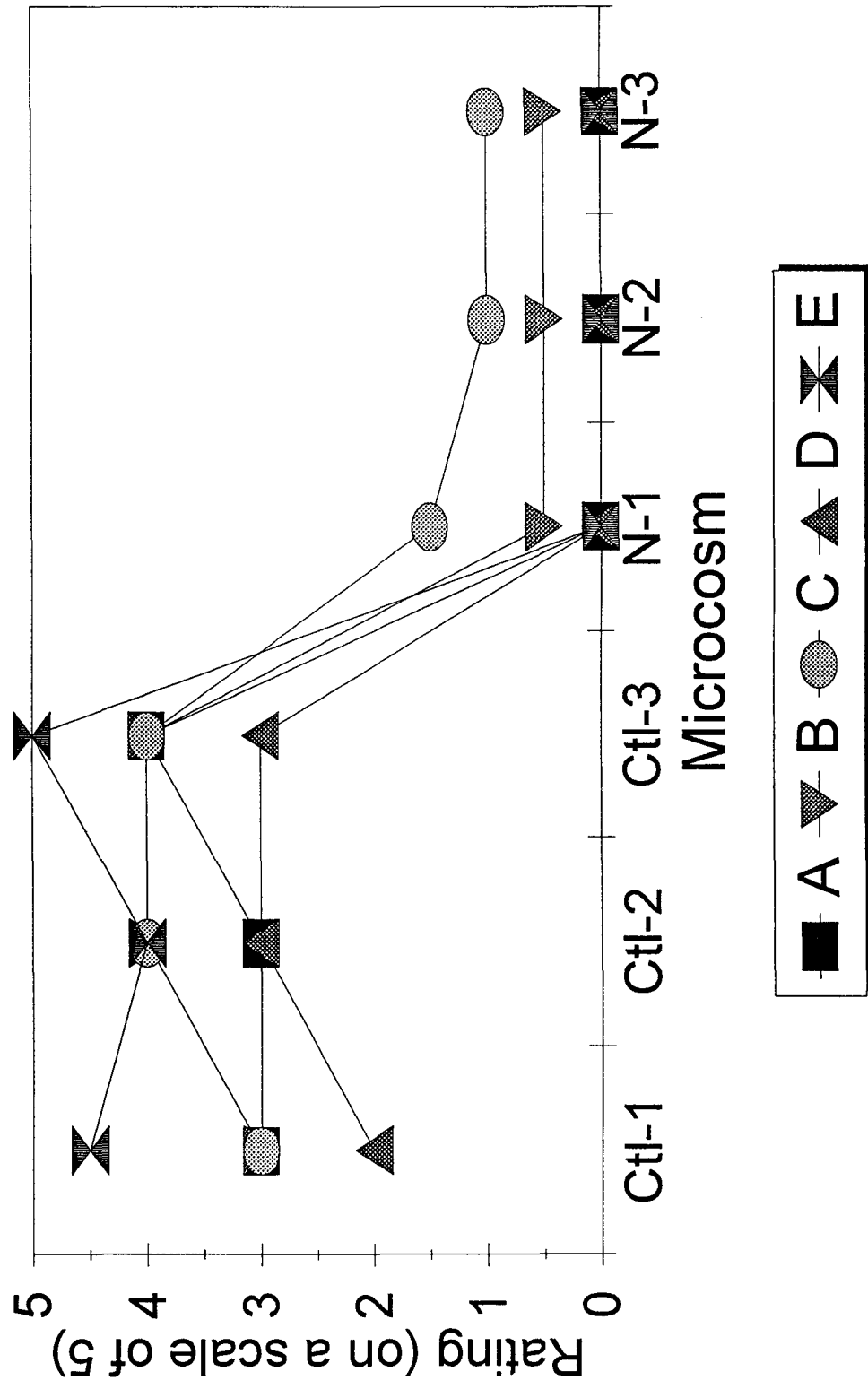
Gas Production in Company Lake Microcosms

High Contaminated Sediment

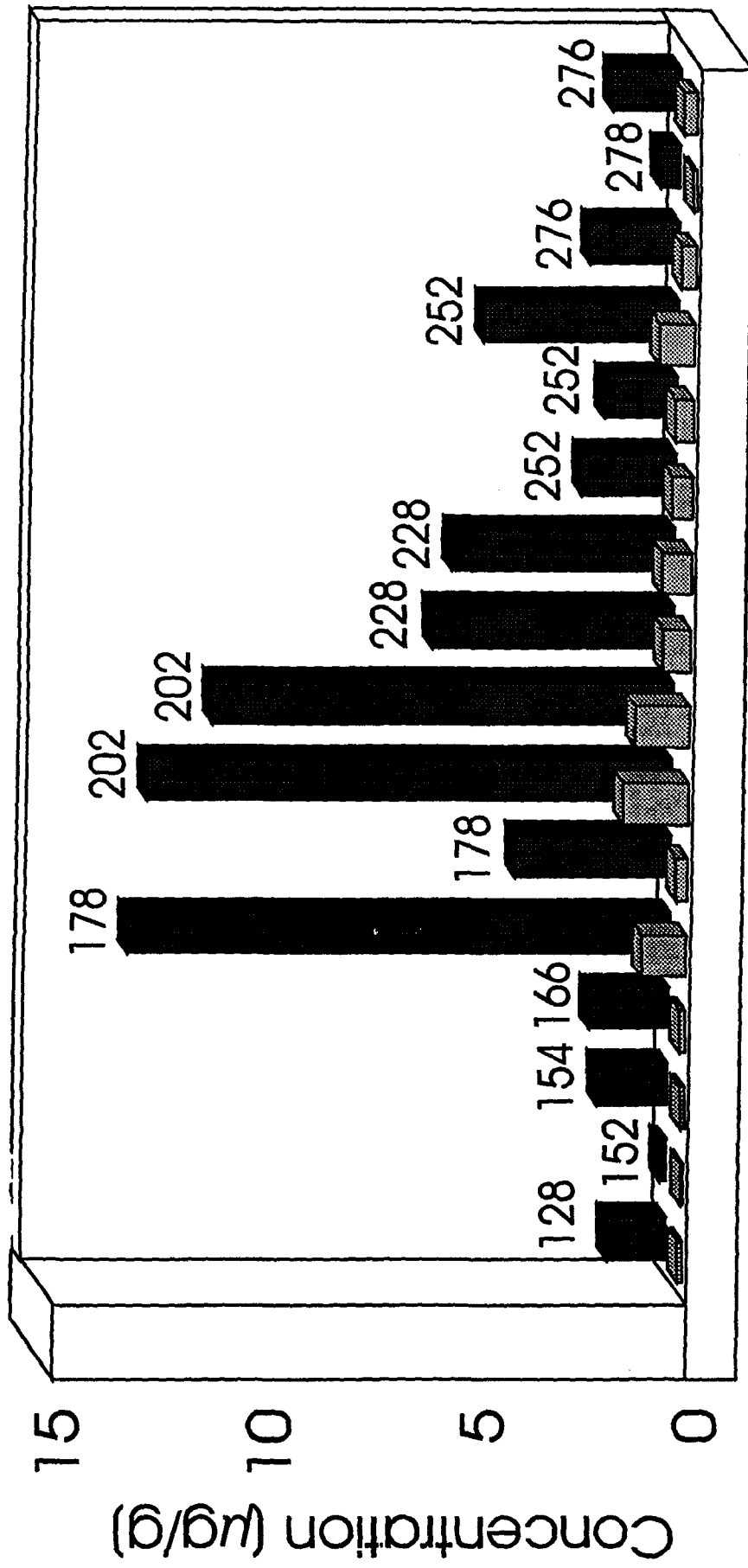


Whitewater Microcosms Odour Test

2 Weeks Incubation: Water



Polynuclear Aromatic Hydrocarbons



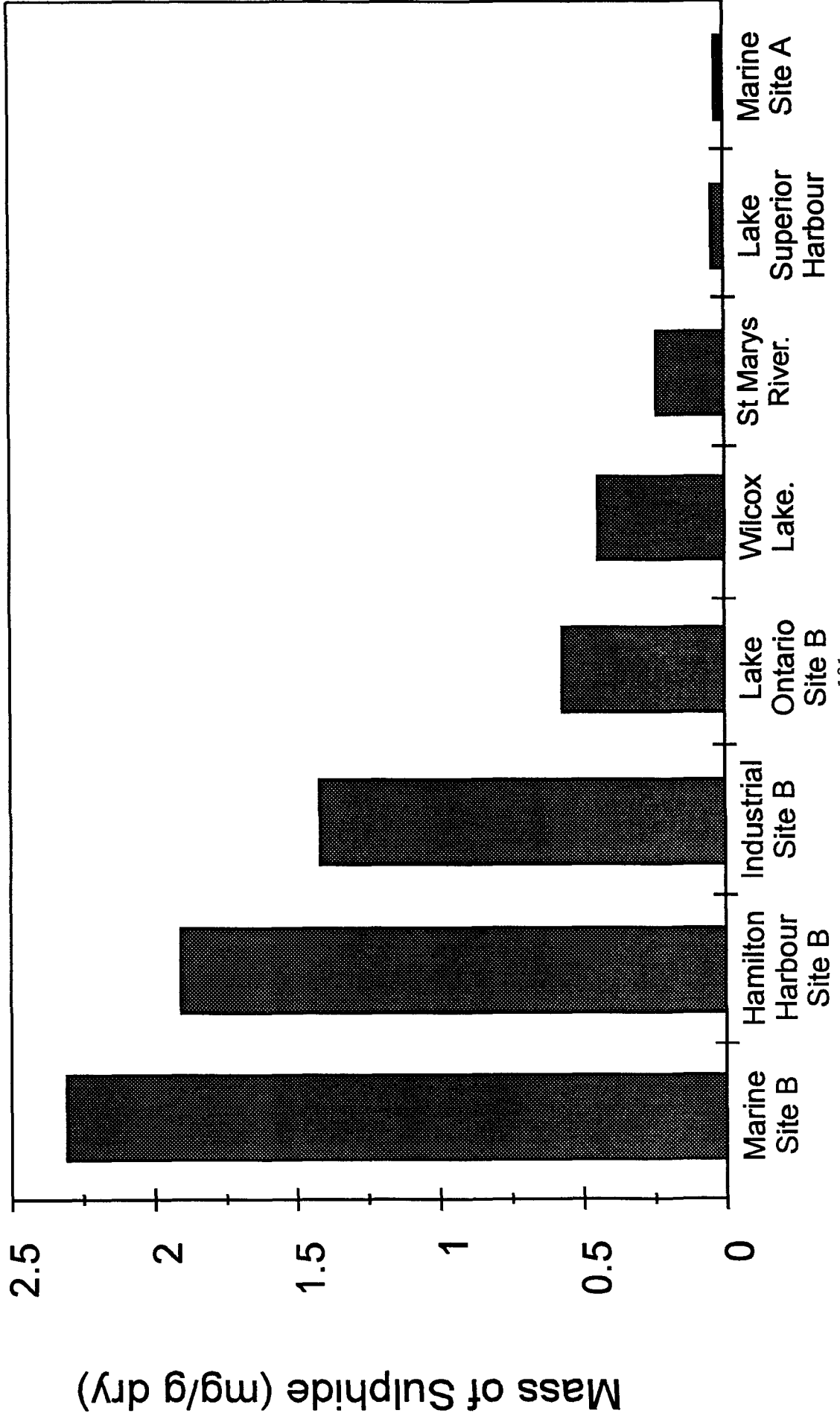
Polynuclear Aromatic Hydrocarbons

Control Treated

-100-

Acid Volatile Sulphide

Average Amounts in Sediments



Soluble Reactive Phosphorus

Marine Site B Reactors 1994

