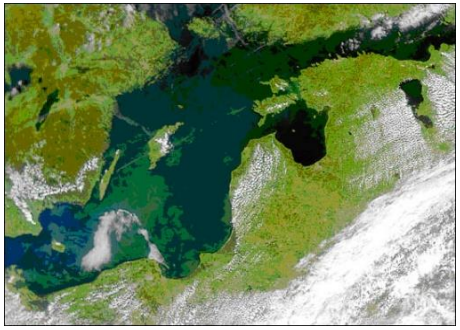
UNIVERSITÄT BAYREUTH

EUTROPHICATION OF SURFACE WATERS

A4b Seminar: Water resources in a quickly changing world

Emmanuel Adeleke. D.

Overview

- A quick run-through on the concepts of EUTROPHICATION
- Eutrophication as a persistent-global problem
- Proposed solutions to the problems of eutrophication
- Discussions

A QUICK INTRODUCTION TO EUTROPHICATION

EUTROPHICATION

When a body of water becomes overly enriched with minerals and nutrients which induces excessive growth of plants & algae

EUTROPHICATION PROCESSES

- Natural & slow eutrophication process
- Cultural eutrophication process → Human activities
  - Different ecological & societal effects

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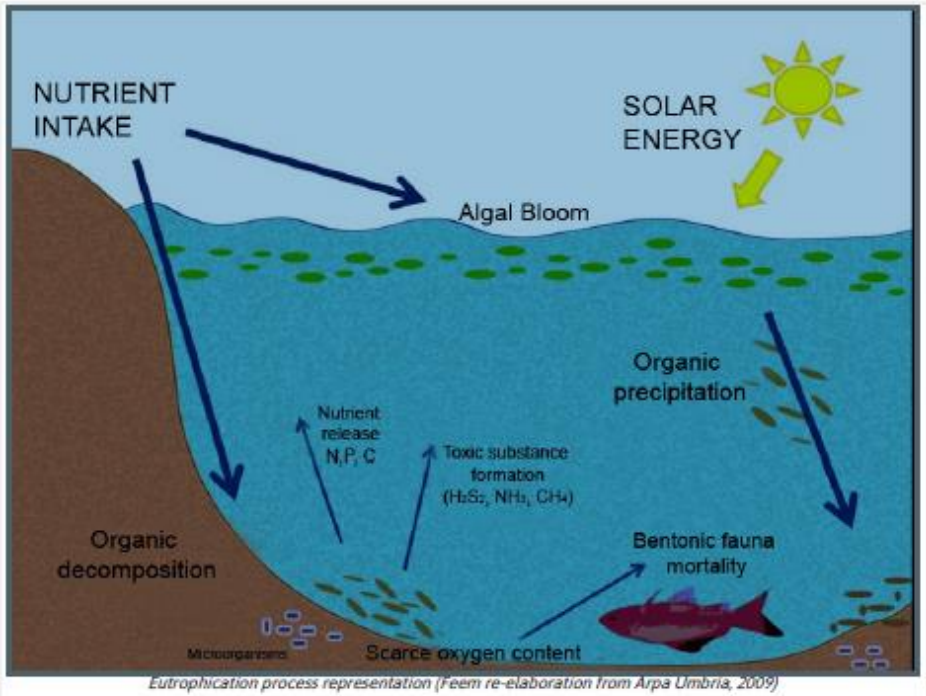

Eutrophication process representation (Feem re-elaboration from Arpa Umbria, 2009)

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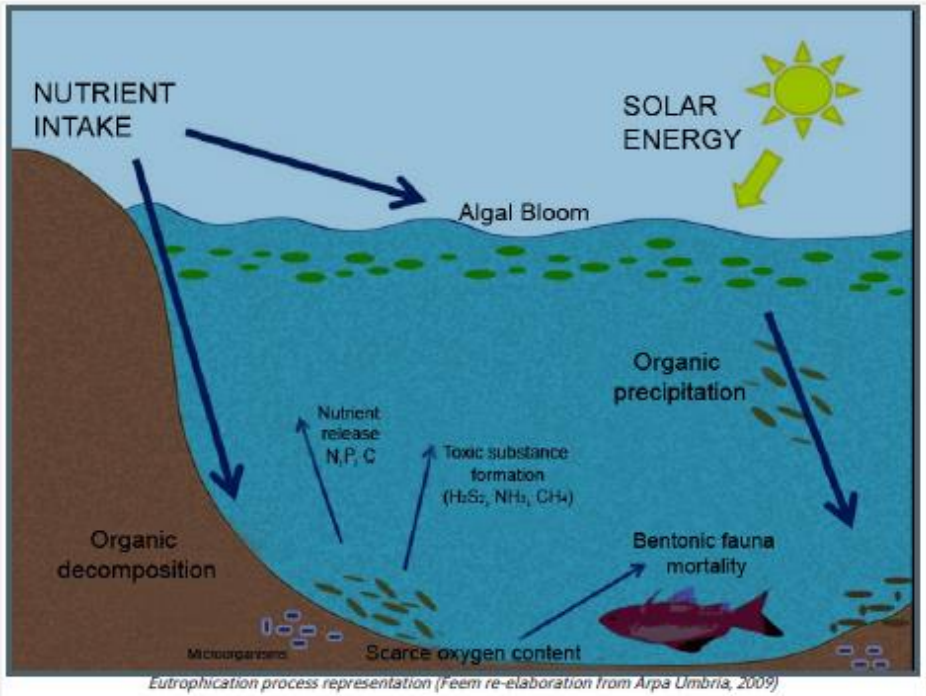

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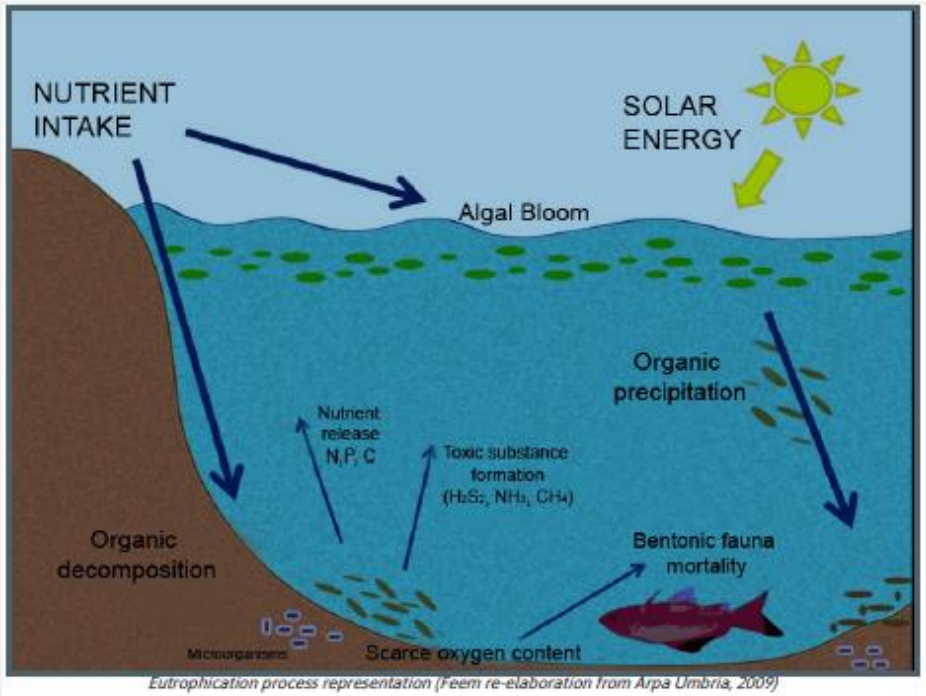

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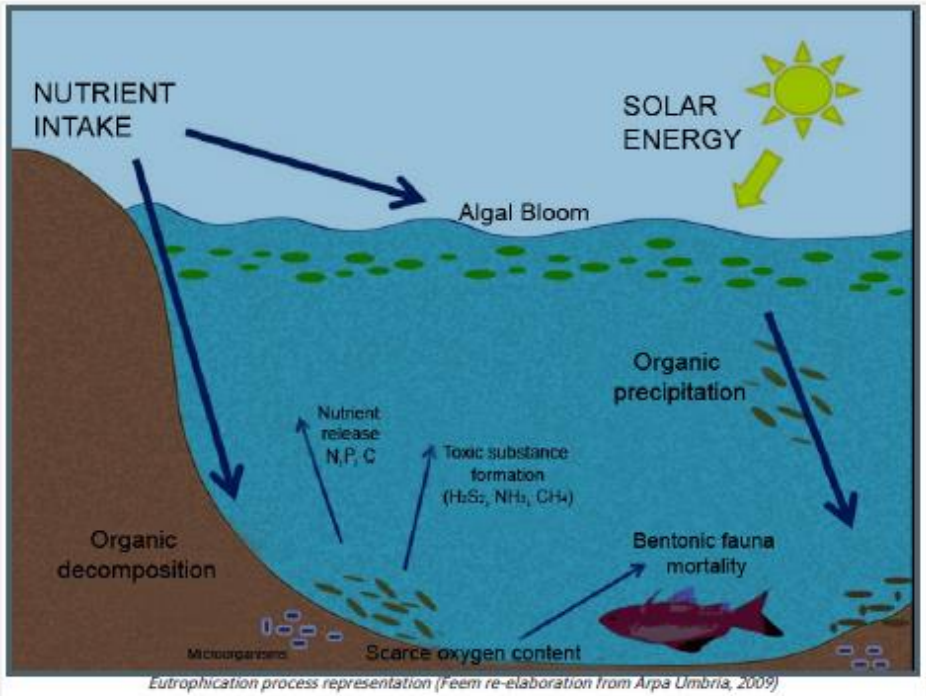

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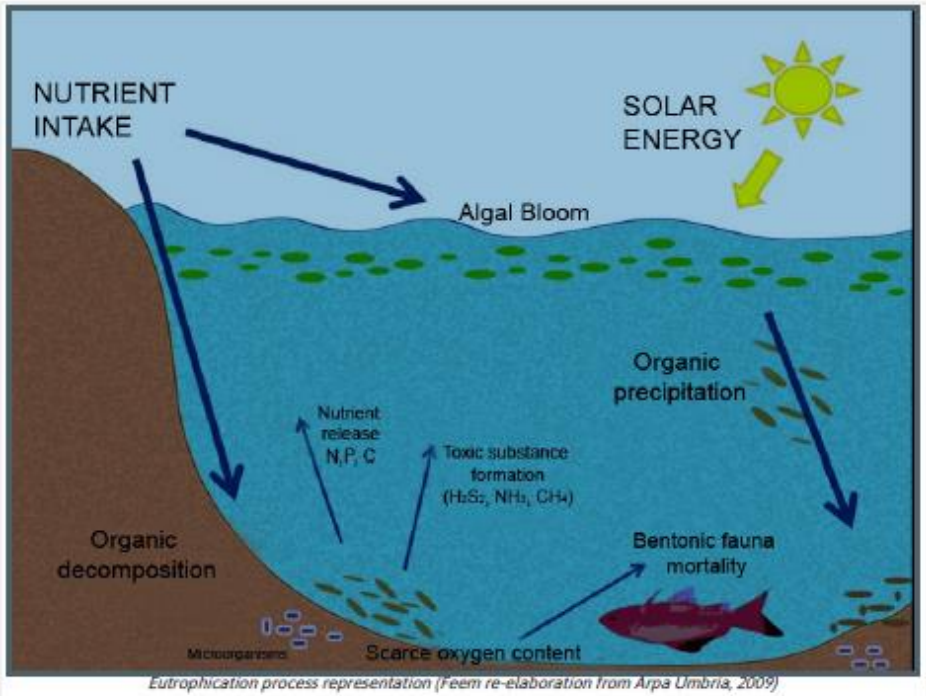

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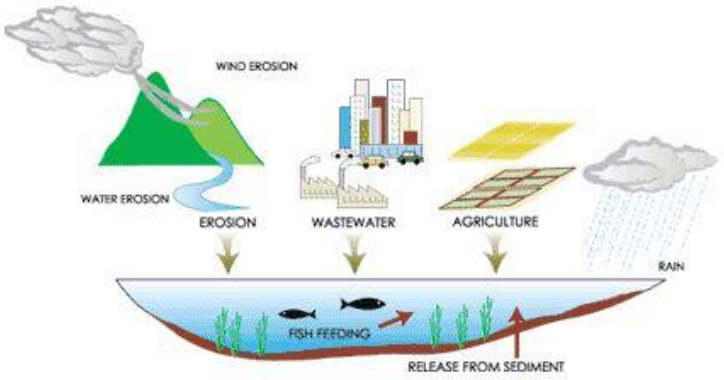
- ➢ Algal bloom
- ➢ Sunlight blockage
- ➢ Death of aquatic flora
- ➢ Oxygen depletion
- ➢ Formation of dead zones(hypoxia)
- Toxic emissions (CO_2, H_2S, CH_4)

Sources that contribute to nutrient loading

- Point sources:
  - Runoff and leachate from waste disposal system
  - Untreated sewage

- Non-point sources:
  - Ploughing in agriculture and development
  - Industrial effluents
  - Urban runoff

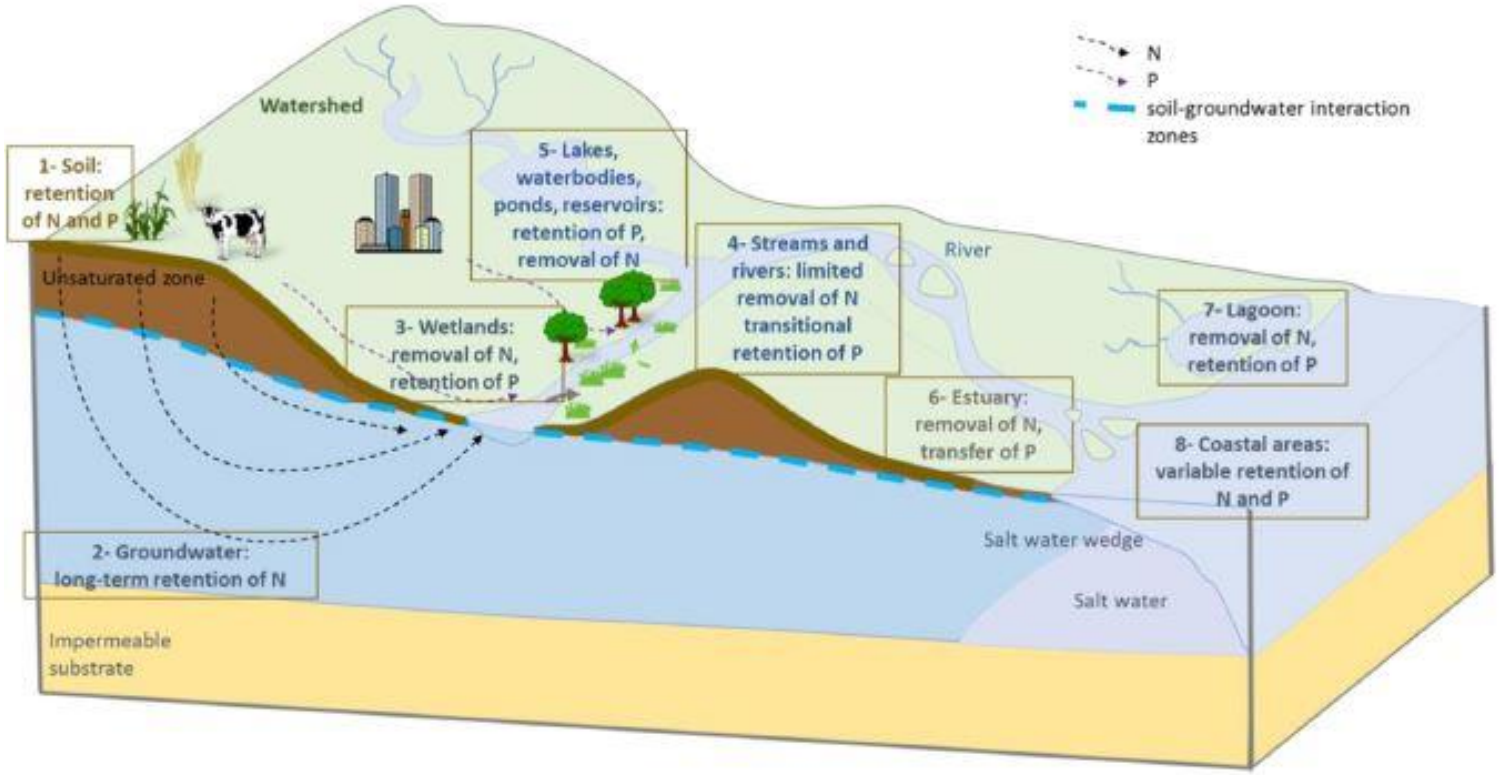
- Atmospheric deposition from fossil fuel combustion



Major sources of nutrients in lakes

  - Significant variations in the relative importance of each nutrient source among regions

Conceptual diagram of the transfer, retention and removal zones of nitrogen and phosphorus along the land-sea continuum.



Source: Moal et al. 2018. Eutrophication: A new wine in an old bottle. Science of the Total Environment 651 (2019) 1–11

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	Phosphorus	Nitrogen
Cycle	Solid or liquid form	Gas phase
Movement	Less mobile	More mobile
Storage time	Centuries	Decades
Capacity	Retention	Elimination
	Soils and sediments	Atmosphere, waterbodies
Wastewater contains..	25-40 mg per liter	6 - 10 mg per liter

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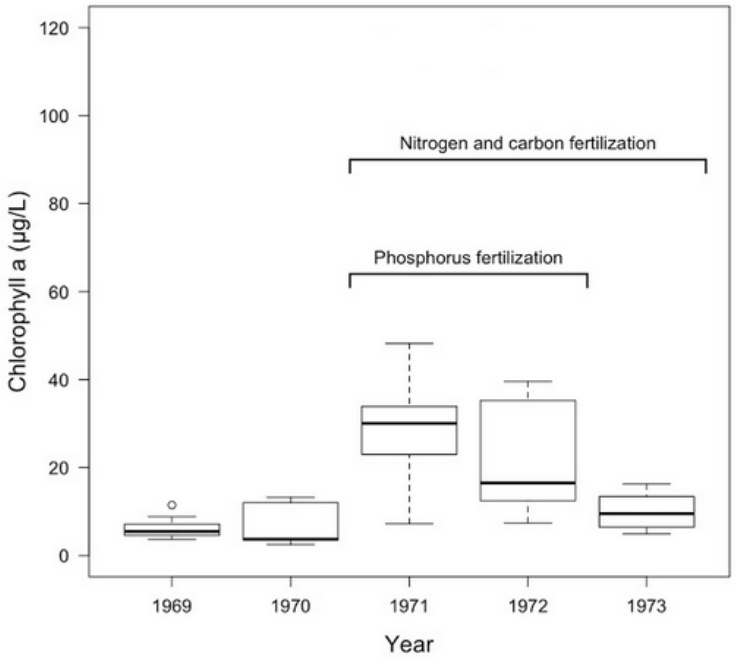
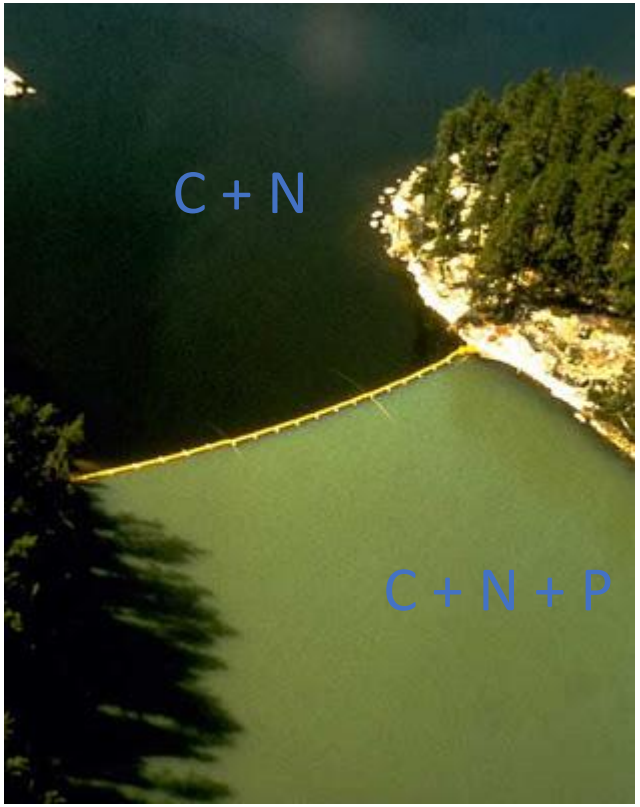
EXPERIMENTAL LAKES AREA – CANADA





Schindler et al. 1974

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EUTROPHICATION as a global & stubborn problem!

Eutrophication is not a new phenomenon

- Each day, Detroit, Cleveland and 120 other municipalities fill Erie with 1.5 billion gallons of inadequately treated wastes, including nitrates and phosphates. These chemicals act as fertilizer for growths of algae that suck oxygen from the lower depths and rise to the surface as odoriferous green scum. Commercial and game fish … have nearly vanished ... Weeds proliferate, turning water frontage into swamp. In short, Lake Erie is in danger of dying by suffocation.

The August 1969 issue of Time Magazine

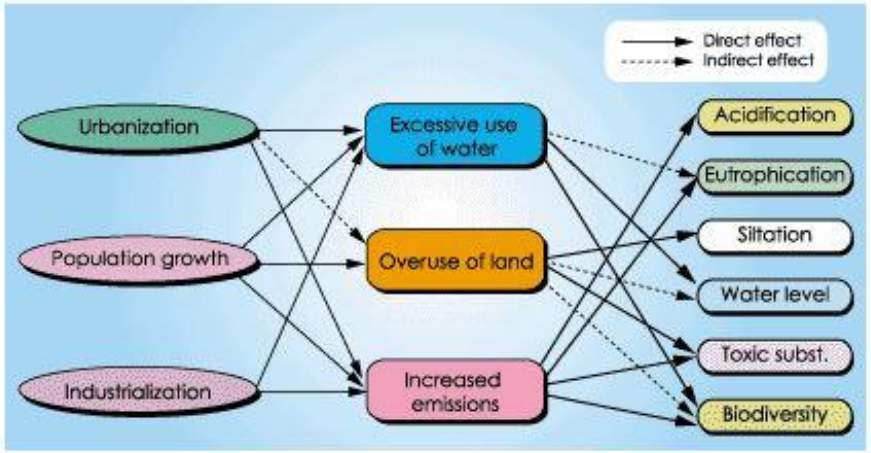
Case Study – The North American Great Lakes

- Lake Superior, Michigan, Ontario, Erie and Huron
- Industrial growth in the 1940s & 1950s resulted in oil pollution
- Eutrophication began in the 1960s as a result of excessive P inputs
- Massive fish die-offs in Erie, Michigan and Ontario.
- 1972 Great Lakes Water Quality Agreement
- Great Lakes Nutrient Initiative with a focus on Erie

Eutrophication at present

Table 2. Major environmental problems occurring in lakes throughout the world

- Low water-level due to the over-use of water from lakes resulting in a pronounced deterioration of water quality and adverse changes in the ecosystems.
- Rapid siltation in lakes and reservoirs caused by accelerated soil erosion resulting from the overuse or misuse of arable and grazing lands and forests within their drainage areas.
- Acidification of lakes due to acid precipitation, resulting in the extinction of fish and the degradation of ecosystems.
- Contamination of the water, sediment and organisms with toxic chemicals originated from agriculture (pesticides) and industrial wastes.
- Eutrophication from inputs of nitrogen and/or phosphorus compounds discharged from industries, agricultural land, homes, urban and road surfaces etc., and resulting in heavy blooms of phytoplankton, deterioration of water quality, and a decrease of biodiversity.
- In extreme cases, the complete collapse of aquatic ecosystems.



http://www.unep.or.jp/ietc/publications/short_series/lakereservoirs-3/2.asp

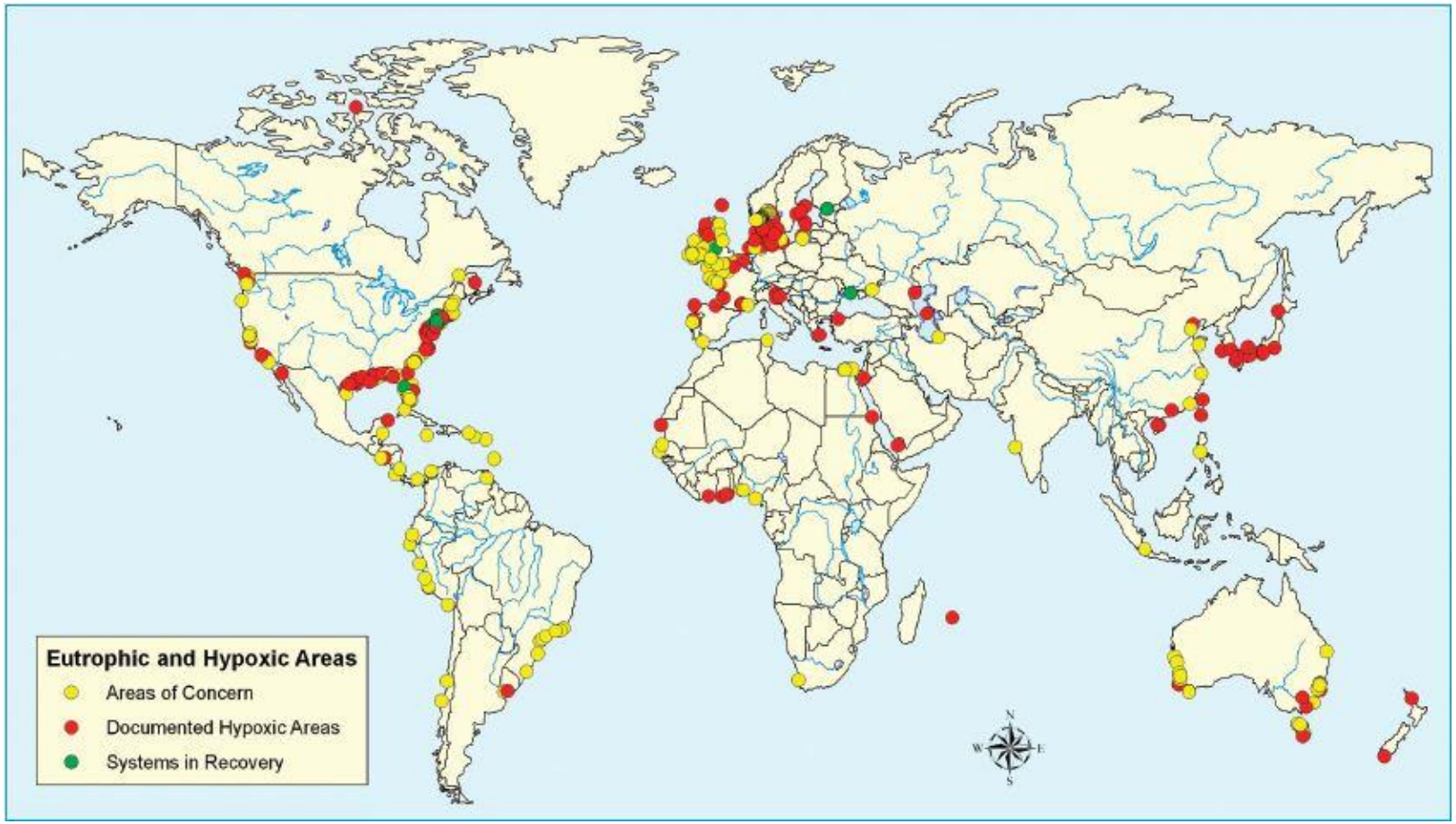
Eutrophication at present – drivers

- Direct drivers
  - Energy consumption
  - Fertilizer consumption
  - Land-use conversion
- Indirect drivers
  - Population growth
  - Economic growth
  - Agricultural intensification

➢ „Diffuse nitrogen and phosphorus pollutions
are now the main drivers of the new wave of eutrophication"

WRI POLICY NOTE 2008. Water Quality: Eutrophication and Hypoxia
Moal et al. 2018. Eutrophication: A new wine in an old bottle. Science of the Total Environment 651 (2019) 1–11

World Hypoxic and Eutrophic Areas



Of the 415 areas around the world, 169 are hypoxic, 13 classified as „systems in recovery“ and 233 are eutrophic areas.

- The Baltic Sea
- Laurentian Great Lakes
- Gulf of Mexico
- The Venice Lagoon
- Most lakes & coastal areas in China, Lake Victoria, the Brittany coast, Mediterranean lagoons and sea

- Goal 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development

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- Progress as of 2018: Continued deterioration of coastal waters due to pollution and eutrophication.
  - By 2050, coastal eutrophication will increase by 20%

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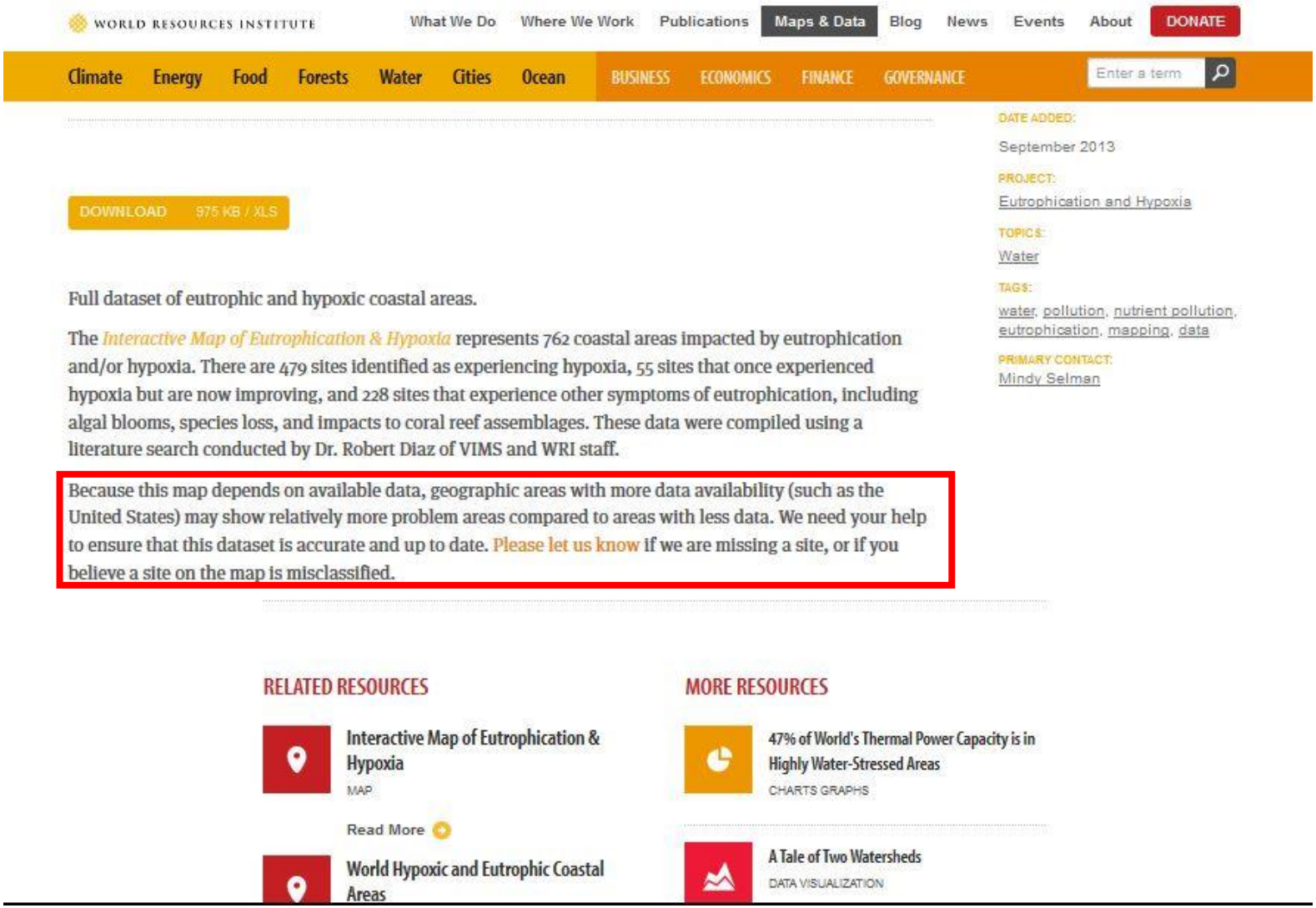
➢ absence of detailed nutrient budgets → lack of research efforts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DOWNLOAD 975 KB / XLS
Full dataset of eutrophic and hypoxic coastal areas.
The Interactive Map of Eutrophication & Hypoxia represents 762 coastal areas impacted by eutrophication and/or hypoxia. There are 479 sites identified as experiencing hypoxia, 55 sites that once experienced hypoxia but are now improving, and 228 sites that experience other symptoms of eutrophication, including algal blooms, species loss, and impacts to coral reef assemblages. These data were compiled using a literature search conducted by Dr. Robert Diaz of VIMS and WRI staff.
Because this map depends on available data, geographic areas with more data availability (such as the United States) may show relatively more problem areas compared to areas with less data. We need your help to ensure that this dataset is accurate and up to date. Please let us know if we are missing a site, or if you believe a site on the map is misclassified.
DATE ADDED:
September 2013
PROJECT:
Eutrophication and Hypoxia
TOPICS:
Water
TAGS:
water, pollution, nutrient pollution, eutrophication, mapping, data
PRIMARY CONTACT:
Mindy Selman
RELATED RESOURCES
Interactive Map of Eutrophication & Hypoxia
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47% of World's Thermal Power Capacity is in Highly Water-Stressed Areas
CHARTS GRAPHS
A Tale of Two Watersheds
DATA VISUALIZATION

ADDRESSING THE PROBLEMS OF EUTROPHICATION

OPTIONS FOR CONTROL

- Limit aquatic fertility
  - Diversion of nutrient-bearing streams
  - Sewage treatment
- Stimulate diseases & parasites among unwanted plants
- Use toxic chemicals
- Biological or tranditional methods

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- Nitrogen N 
- Carbon C
- +16 other micronutrients e.g. O, H2, Si, K, Mg, S, Cl, Na, Fe, Zn, Cu.

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ROLE OF GOVERNMENTS

- Grant Funds for Municipal waste treatments
- Research and development
- Enforcement
- Legislation

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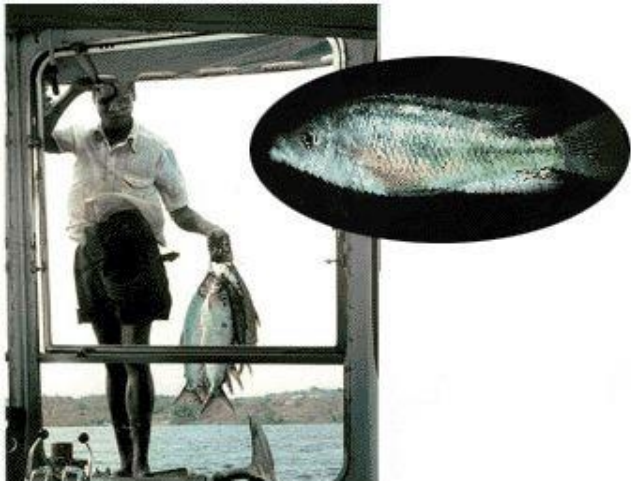
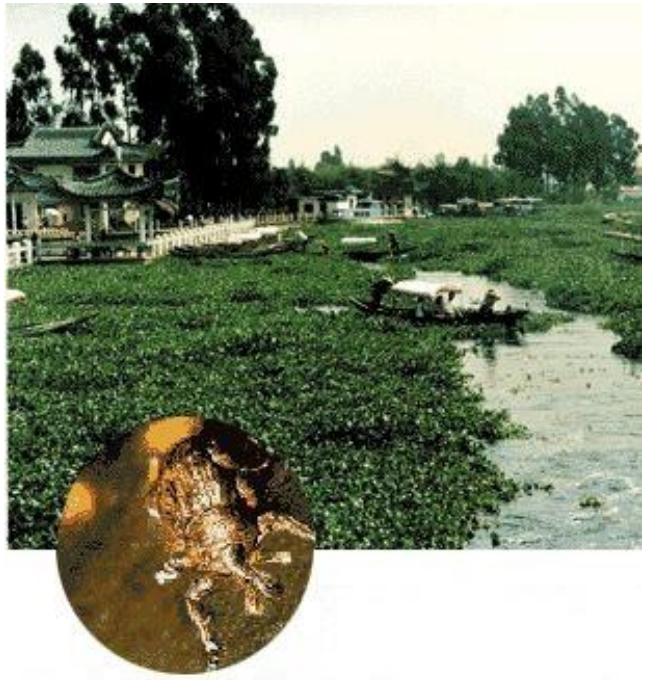
Case Study: Lake Victoria

- dense mats of water hyacinth float on huge surface areas
- most parts show oxygen depletion and reduced transparency
- many haplochromis or „furu“ fish species are extinct
- eutrophication controlled by biological methods
- a beetle feeding on water hyacinths
- weevil N. eichhornaiae





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➢ improving knowledge on eutrophication is the first step in developing robust policy measures to reverse its impacts.

Conclusions

- Eutrophication is a unique problem, not limited spatially or temporally.
- Point sources of phosphates in industrial effluents and sewage were the drivers of eutrophication in the past.
- Non-point source of nitrogen and phosphorus pollutions are the new drivers of eutrophication today
- There is need to improve knowledge & provide data on eutrophic systems

Discussion

- Can you think of other ways by which nutrient loading of surface waters can be controlled?
- How do we provide more globally representative datasets on eutrophic & hypoxic systems?
- Global or regional (national) approach towards nutrient control?
- Best approach to control fertilizer use and stop nutrient runoff from agricultural sources? legislation? enforcement?