Impact of Trace Metals Found in Sediments on Lake Erie's Ecosystem: A Review

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ABSTRACT

Modern day ecosystems are undergoing multiple environmental strains caused by human disruptions, creating anthropogenic problems within various bodies of water. In these ecosystems, algal production has been severely affected, especially in the Great Lakes. The objective of this exploration was to analyze trace metals present in sediment cores from Lake Erie, aiming to reconstruct the lake's history of eutrophication over the past 210 years, specifically focusing on the concentration of nutrients in the water. The research infers that the lake's biological productivity has continued to be fairly high since, despite the rigorous measures that were implemented to control the nutrients in the lake. This study highlights the resilience of Lake Erie's ecosystem and emphasizes the difficulties involved in managing nutrient fluctuations in aquatic environments.

OBJECTIVES

- Understand the historical challenges Lake Erie has faced
  - Overfishing
  - Invasive Species
  - Eutrophication
  - Pollution
- Examine trace metals
  - Asses lake health and productivity
  - Evaluate how the composition reflects environmental factors
- Compare results with historical data to build a timeline

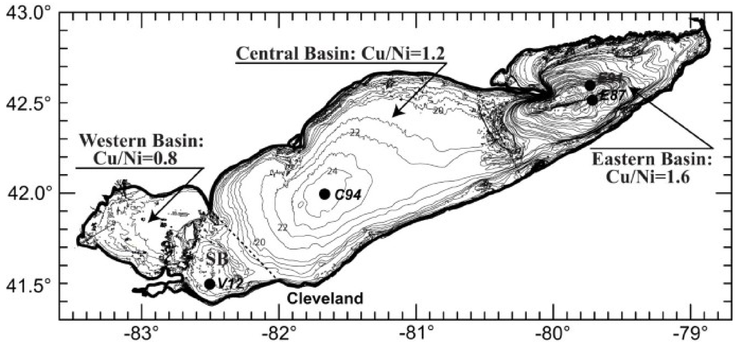

Figure 1. Lake Erie bathymetric map showing locations of coring sites of core V12 in the Sandusky basin, core C94 in the central basin, cores E87 and E91 in the eastern basin. (2)

METHODS

Sediment Collection and Preparation:

- Sediment cores were retrieved from Lake Erie, using a specific coring tool.
- The cores were brought to shore immediately, where they were vertically extruded and sampled every 1 centimeter.
- Thirty-nine samples were taken, dried, and blended together.

Sample Digestion:

- Sediment samples were mixed with strong acids and heated in a microwave at controlled temperatures.
- After cooling, the samples were diluted with water, filtered, and prepared for analysis.

Elemental Analysis:

- Filtered solutions were analyzed using a specialized instrument that measures various elements simultaneously.
- Only results for four trace metals were considered in this report.

Radiometric Dating:

- Selected sediment samples were analyzed for Pb-210, Cs-137, and Ra-226 levels at a research lab.
- Cs-137 activity peaked at a specific depth, indicating the 1963 maximum in atmospheric fallout.
- Pb-210 activity decreased exponentially with depth, providing insight into the sediment's age.

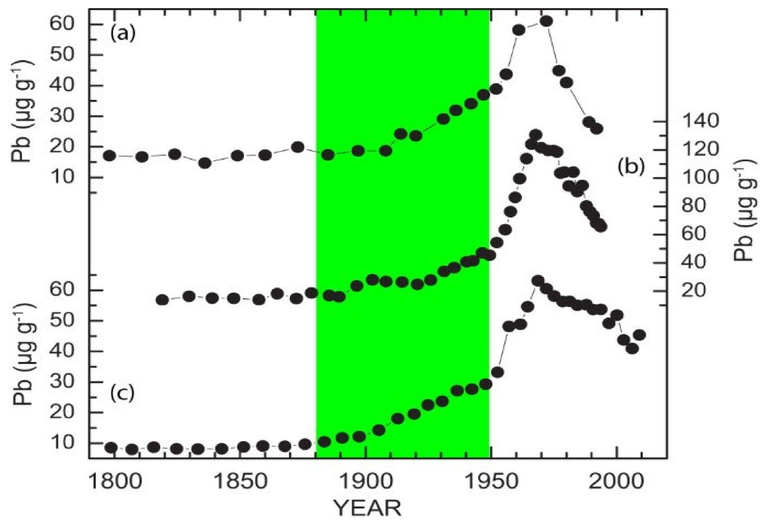

Figure 2. Comparison of lead concentration records derived from different sites in Lake Erie. (2)

RESULTS

Profiles of Cu, Cd, Pb, and Ni concentrations in Sandusky basin sediments show consistent variability (2)	Significant and prolonged increases observed in trace metal ratios suggest a major ecosystem shift in Lake Erie	Ratios like Cu/Ni, Pb/Cu, and Cd/Pb were naturally low but increased notably during this transition, likely due to human activities
Eutrophication likely began around 1880, accelerated during the CIE, and led to an ecosystem regime transition by 1950 (2)	Elevated Cu/Ni values coincide with episodes of massive algal blooms, indicating a eutrophic state in the lake over the past six decades (1)	Central basin saw significant improvements in water quality from 1970 to 1990; Sandusky basin showed minimal changes, indicating limited improvement in pelagic waters

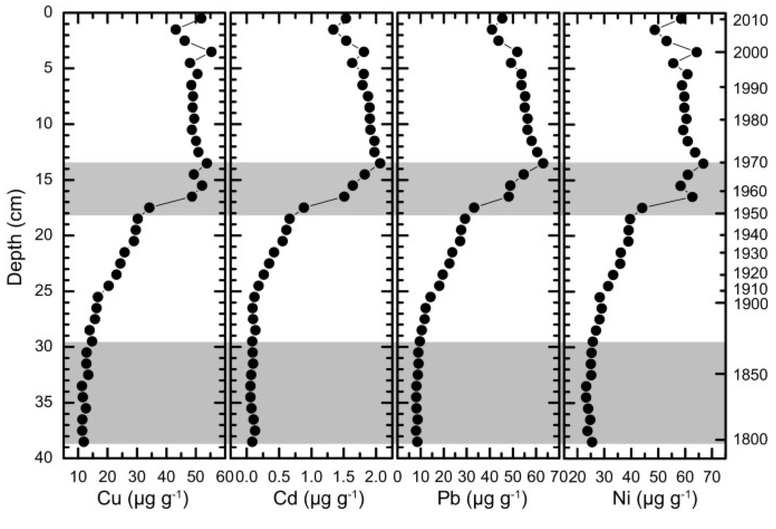

Figure 3. Concentration profiles of Cu, Cd, Pb, and Ni in the sediments from core V12 taken from the Sandusky basin in Lake Erie. (2)

CONCLUSIONS

The analysis of sediment cores from Lake Erie's Sandusky basin shows the lake's ecological evolution over the past two centuries. Through the examination of trace metal concentrations, a notable shift in ecosystem dynamics was uncovered, particularly evident in the transition from oligotrophic to eutrophic conditions between 1880 and 1950. This transition, driven primarily by anthropogenic nutrient inputs, highlights the significant impact of human activities on aquatic systems (1). The use of Cu/Ni ratios as indicators of lake productivity explains the historical progression of eutrophication. The findings describe the effect of human-induced pressures, such as pollution and climate change, and natural processes in shaping lake ecosystems.

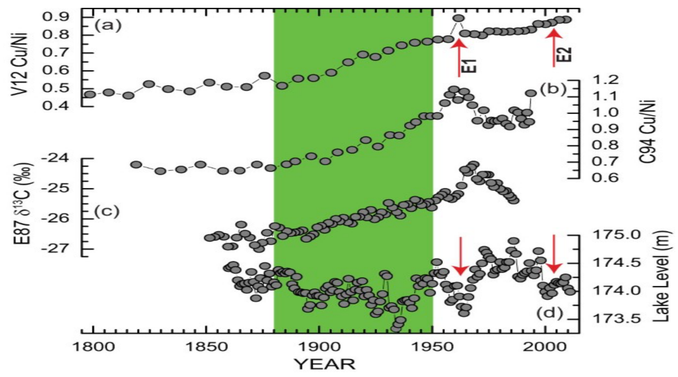

Figure 4. Comparison of the V12 Cu/Ni record with the C94 Cu/Ni, E87 δ13 C and lake-level data from Lake Erie. (2)

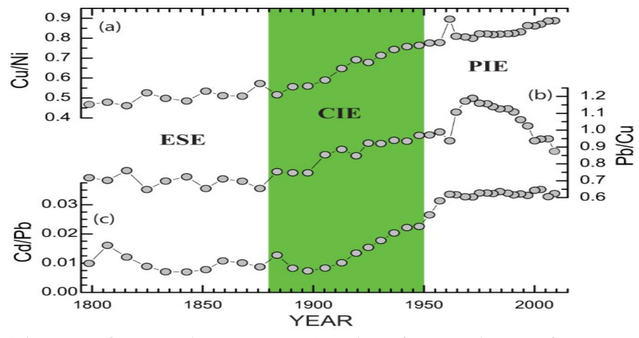

Figure 5. Changes in trace metal ratios of the sediments from core V12 from the Sandusky basin of Lake Erie. (2)

FUTURE WORK

We believe the future direction of this investigation can be expanded to other bodies of water, specifically other Great Lakes within the United States that also struggle with eutrophication and an influx of trace metals within their ecosystems. We think that this study was significant because it helps establish a history for a lake that is important to Cleveland's identity.

Acknowledgments

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References

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(2) Yuan, Fasong & Depew, Richard & Soltis-Muth, Cheryl. (2014). Ecosystem regime change inferred from the distribution of trace metals in Lake Erie sediments. Scientific Reports. 4. 1-7. 10.1038/srep07265. .