Water pollutants and Eutrophication

Dr. Shalini Minz, Assistant Professor, St. Xavier's College (Autonomous), Ranchi

Introduction

Surface water bodies play a crucial role in the ecosystem, serving as lifelines for countless organisms. However, beneath this surface lies a silent threat — water pollutants, infiltrating and disrupting these aquatic sanctuaries.

Water pollution is the contamination of water bodies, including the surface and groundwater resources. With rapid urbanisation, surface water pollution is also increasing exponentially. This also includes agricultural and industrial water pollution from different sources wherein untreated or inadequately treated water is discharged into water bodies, such as rivers. The contaminants or pollutants may come from various sources causing either point-source pollution or nonpoint-source pollution. (Wato and Amare 2020) In addition, water bodies such as lakes and reservoirs have lesser potential for dilution of the discharged pollutants than water bodies such as streams as it takes around 1 to 100 years to flush and change the water compared to streams. (Miller and Spoolman 2013)

There have been efforts at the global and national levels to address the issue. Every year, March 22 is observed as the World Water Day by the United Nations. It highlights and raises awareness on one of the most significant environmental issues — the availability of safe water for all. In India, the Water (Prevention and Control of Pollution) Act was enacted in 1974, with an amendment in 1988, "to provide for the prevention and control of water pollution, and for the maintenance or restoration of water resources in the country."[1]
The Central Pollution Control Board (CPCB) along with State Boards has been monitoring the water quality of rivers and other water bodies through a network of monitoring stations under the National Water Quality Monitoring Programme (NWMP). However, the question of how effective these efforts and mitigation measures are remains.

Sources of pollutants

The pollutants can be discharged into water bodies from single sources, also called **point sources**, where the pollutants are discharged in the surface water bodies at specific locations via drainage, outlets, or sewer networks. These include sewage treatment plants, oil tankers, etc.

The pollutants from **nonpoint sources** are discharged through broad and diffuse areas that include runoff chemicals, sediments from agricultural areas, urban areas, etc.

Point sources are found at specific locations whereas the nonpoint sources are more diffused. Therefore, it is much easier to regulate the discharge from point sources. Developing countries like India have seen little control over these pollutant sources as compared to the developed countries that have laws to control the discharge of harmful chemicals in the aquatic systems.

Agricultural activities, industrial activities and mining are three major sources of water pollution. These anthropogenic sources accelerate the addition of nutrients such as Nitrogen and phosphorous in water bodies from different point sources (untreated sewage, municipal and industrial effluents) and nonpoint sources (fertiliser runoff from agriculture). (Smol 2008) The National Oceanic and Atmospheric Administration states that harmful algal blooms, fish kills, and dead zones (hypoxia) are the result of a process known as eutrophication which results from a nutrient-enriched environment leading to the intensified growth of plants and algae in the estuaries and coastal waters.[2]

Eutrophication

Eutrophication refers to the natural enrichment of water bodies such as shallow lakes, estuaries or slow-moving streams primarily due to runoff plant nutrients such as nitrates and phosphates from the adjacent land areas. An oligotrophic lake is a clear lake characterised by a lower concentration of nutrients, whereas a eutrophic lake is characterised as a water body enriched with nutrients from natural and human sources in the surrounding watersheds. (Miller and Spoolman 2013).

Eutrophication has been recognised since the 20^{th} century and was believed to be majorly due to point sources. However, in the present, the nonpoint sources discharging nitrogen and phosphorous have been identified as key contributors to the process. Due to agricultural, domestic and urban settlements, the nutrient levels of many lakes and rivers across the globe have increased greatly in the last 50 years (Kakade et al., 2021)

Types of eutrophication

Eutrophication is of two types: natural and cultural.

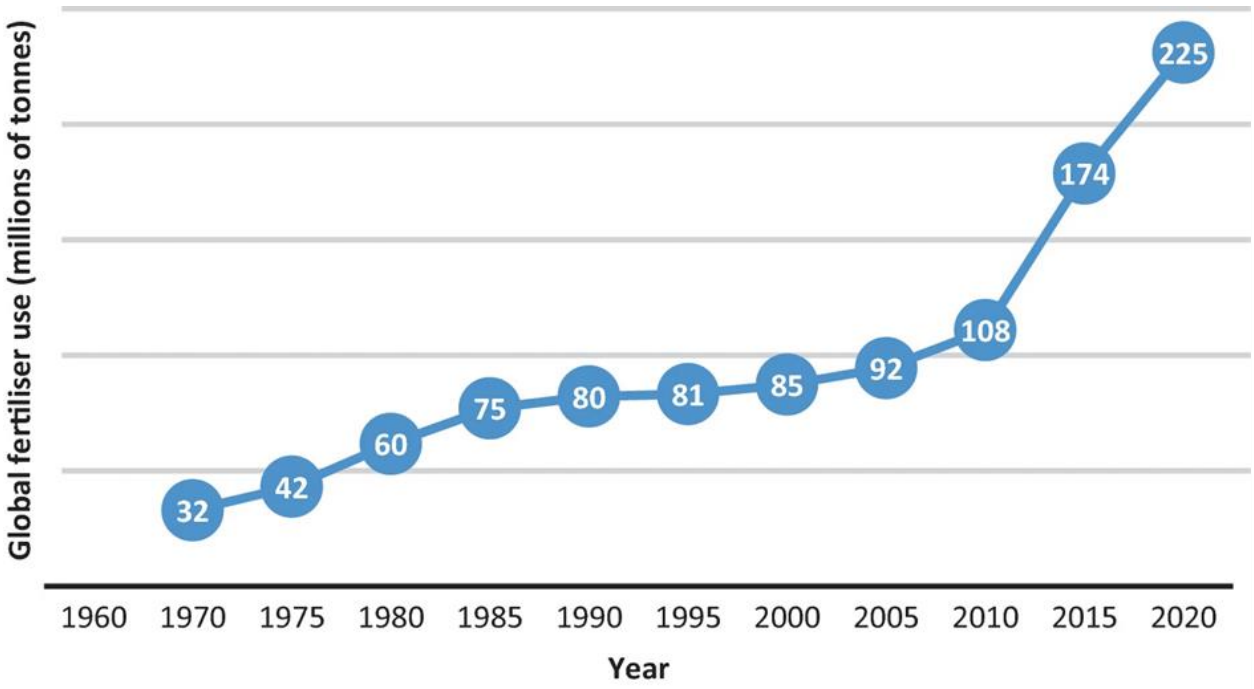
Natural eutrophication is characterised by runoff nutrients in stormwater getting into water bodies such as lakes, estuaries and slow-moving streams, resulting in the enrichment of water bodies with nitrates and phosphates. It leads to low and high levels of biological activity in the young (usually oligotrophic) and old (usually Eutrophic) water bodies respectively. (Akinnawo 2023).

Cultural eutrophication, also called anthropogenic eutrophication, is defined by the addition of nutrients such as phosphates and nitrates into the lakes due to human activities. Human activities such as the disposal of fertilisers, detergents, untreated sewage, and aquaculture effluents continuously increase the number of nutrients in the water bodies. This could reach an extent where the water body loses its capacity for self-purification. (Akinnawo 2023)

The global nitrogen (N) and phosphorous (P) load in coastal and marine water is expected to double by 2050 owing to the increased use of fertilisers and other anthropogenic factors. (Delvin and Brodie 2023). There has been a significant increase in the consumption and use of fertilisers in the last few decades and it is projected to increase in the next few decades (Graph 1) which can further aggravate the issues associated with eutrophication.
Several point and nonpoint sources serve as eutrophication accelerators. They are also chief nutrient loaders in aquatic ecosystems. Recent studies have also suggested that the construction of dams on rivers and the increase in the withdrawal of water has also led to greater nitrogen and phosphorous accumulations.

As a result of cultural eutrophication, algal blooms — rapid growth of large mass of phytoplankton (cyanobacteria, algae, dinoflagellates, and diatoms) — have been observed in certain inland water ecosystems. In India, algal blooms have been reported by many researchers in the Udaisagar Lake in Udaipur, Rajasthan, Dal Lake of Jammu and Kashmir, Chilka Lake of Odisha and river Ganges in Varanasi (Prasad and Prasad 2019).

GRAPH 1



Source:(Delvin and Brodie 2023). World fertiliser consumption from 1970 to 2010 and projections to 2020. Based on available statistics (FAO 2012), and global estimates for 2013 and 2020 based on use projections.

Management of Eutrophication

Extensive research on eutrophication in the past few decades identifies major advances in its management. **The restoration of eutrophic lakes can be classified into the following categories: managing nutrient inputs; removing algal blooms: biomanipulation; and bioremediation.** (Zhu et al., 2020)

According to the report *Assessment of eutrophication abatement measures across land-based sources, inland and marine waters, 2016*, managing nutrient inputs is a traditionally effective method that includes strategies to reduce P and N input in the receiving water bodies from point sources. For nonpoint sources, the most effective measure is nutrient application management and strategies based on change in crop management, for example, avoiding leaching and erosion and change in the cropping system. Strategies and initiatives involving livestock management and production of minerals in manure, soil management, agricultural water management, land use and land infrastructure management are significant measures proven to reduce nutrient input from diffuse sources. Biomanipulation is another restoration method used for reducing the internal phosphorous (P) load. It is a biological engineering method where lake food webs are manipulated

to reduce algal biomass (Kaur, 2020). Bioremediation is the use of microbial organisms to degrade pollutants.

Teacher aide

Eutrophication is a global environmental problem. The key terms to study could be:

- Point and nonpoint sources of water pollution
- Oligotrophic and eutrophic water bodies
- Hypoxia and dead zones
- Natural and cultural eutrophication
- Algal blooms
- Eutrophication mitigation and management
- Bioremediation and biomanipulation

Activity ideas

- A case study of any local water body to identify the point and nonpoint sources of water pollution
- Data analysis and comparison of the prevalence of nitrates and phosphates in the identified water body in the past few years

Project Ideas

- A study on different kinds of fertilisers used in the agricultural areas close to water bodies
- A small survey and study of any eutrophication mitigation plan, management policies or initiatives in the nearby areas

Relevant resources

- Earth to Florida: Nutrient Pollution and Eutrophication
- Eutrophication: Policies, Action, and Strategies to Address Nutrient Pollution | World Resources Institute (wri.org)
- Varanasi | Algae shadow on river water near Varanasi - Telegraph India

Syllabus tracker

This issue is relevant to the following topics from the UGC syllabus for Environmental Studies:

- Awareness on environment
- Environmental pollution (soil and water pollution)

- Solid waste management
- Field study and activity

References

- Akinnawo, S. O. (2023). Eutrophication: Causes, Consequences, Physical, Chemical and Biological Techniques for Mitigation Strategies. *Environmental Challenges*, 12, pp.1-18
- Dalton, C. J.P. Smol, (2009). Pollution of lakes and rivers: a paleoenvironmental perspective, 2nd edition. *J Paleolimnol* 42, pp. 301–302 https://doi.org/10.1007/s10933-009-9320-0
- Devlin, M., Brodie, J. (2023). Nutrients and Eutrophication. In: Reichelt-Brushett, A. (eds) Marine Pollution – Monitoring, Management and Mitigation. Springer Textbooks in Earth Sciences, Geography and Environment. Springer, Cham. pp.75-100 https://doi.org/10.1007/978-3-031-10127-4_4
- Kakade, A., Salama, E. S., Han, H., Zheng, Y., Kulshrestha, S., Jalalah, M., ... & Li, X. (2021). World eutrophic pollution of lake and river: Biotreatment potential and future perspectives. *Environmental Technology & Innovation*, *23*, 101604.
- Kaur, Sarbjeet. 2020. "Bio-manipulation: A restoration tool for eutrophied." *International Journal of fauna and biological studies.* 7(6), pp. 1-4.
- Miller T. G., Spoolman S. E., 2014. *Environmental Science.* 14e. brooks/cole. Pp.217-251.
- Prasad R., Prasad S., 2019. "Algal Blooms and Phosphate Eutrophication of Inland Water." *Int J of Plant and envision* 5 (1), pp.1-8. doi:DOI: 10.18811/ijpen.v5i01.1.
- Smol, J. P. (2008). Pollution of lakes and rivers : A paleoenvironmental perspective. John Wiley & Sons, Incorporated. 2008. *Pollution of lakes and rivers : A paleoenvironmental perspective.* John Wiley & Sons.
- Wato T., Amare M., 2020. "The Agricultural Water Pollution and Its Minimization Strategies." *Journal of Resources Development and Management,* Vol.64, pp. 10-22. doi: 10.7176/JRDM/64-02.
- Zhu, K., Wu, Y., Li, C., Xu, J., & Zhang, M. (2020). Ecosystem-Based Restoration to Mitigate Eutrophication: A Case Study in a Shallow Lake. *Water, 12*(8), pp. 1-19 MDPI AG. Retrieved from http://dx.doi.org/10.3390/w12082141

About the author

Shalini Minz is currently working as Assistant professor in the department of Environmental science (Zoology) at St. Xavier's college (Autonomous), Ranchi. She is an active member of the Green Educators' Network of the Centre for Science and Environment. She has a keen interest in environmental education and working on Indigenous knowledge on ethnobotanical diversity among various tribes in Jharkhand. She is a member of green campus committee at St. Xavier's college (Autonomous), Ranchi.