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A Review on Lake Restoration Measures - An Indian Perspective

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ABSTRACT

The deterioration of freshwater quality in Indian lakes has drawn serious attention to their protection, conservation, and management. The present review focuses on the currently applied restoration methods and new research, their success status, and recommendations for future lake management. In various studies, only a few lakes are found to be restored significantly. Studies reveal that in-lake restoration methods are more prominent than catchment management. A combination of in-lake and watershed management is beneficial rather than a single approach. Along with government schemes, regular monitoring and people's cooperation are required to obtain the projected outcome of restoration efforts.

Key words: *Lake degradation, Eutrophication, Restoration methods, Bioremediation, Pollution abatement, Water resource management*

Introduction

Eutrophication, siltation, pollution, weed invasion, bioaccumulation of contaminants, and waterborne diseases are the major problems faced by the lakes in India. Most of the restoration programs in Indian lakes involve a number of various management approaches (Natarajan *et al.*, 2020). They are usually of a constructive nature and not oriented towards maintaining the lake ecosystem. Although Dalwani and Gopal (2020) pointed out in their review that in India many restoration and management projects of freshwater ecosystems have been based on Nature-based Solutions. Looking into the arena of restoration measures in India, our review mainly focuses on the restoration measures to mitigate lake encroachment, eutrophication, weed invasion, sedimentation, and heavy metal pollution. The general restoration methods applied in India can be categorized as chemical, biological, and physical/mechanical, and some other unique methods identified as per the prevailing conditions.

Chemical methods

Coagulation, flocculation, and precipitation are efficient methods for the reduction of nutrients, pathogens, algae, toxic metals, and other dissolved or suspended impurities. P removal is the most crucial, as eutrophication caused by P loading is the major problem of Indian lakes. The chemical precipitation process is highly effective in P removal (Banu *et al.*, 2008). Aluminum sulfate (Alum) as well as ferric chloride was found significantly efficient for turbidity removal in Kukkarahalli Lake, Mysore (Roopa and Murthy, 2014) and Durgam Cheruvu Lake, Telangana (Kalavathy *et al.*, 2017). Similarly, the addition of alum and potassium permanganate, along with aeration, before, during, and after idol

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immersion, a common religious practice, helped control pollution in Thane lakes (Maharashtra PCB 2010). Using chlorine and potassium permanganate as oxidants and alum as a coagulant, along with lime, helps required pH correction during chemical treatment (Khadse *et al*., 2015).

Use of various adsorbents, Phoslock (lanthanum 5% and bentonite 95 %), zirconium-pillared bentonite clay (ZPBC), has been suggested by various researchers for the removal of N and P (Mahadevan *et al.,* 2020; Tiwari *et al.,* 2021; Priya *et al.,* 2022). Som *et al.* (2022) demonstrated the removal of phosphate from sewage water using nano zerovalent iron (nZVI) particles. Limiting both N and P is vital if high amounts of nutrients enter lakes through various anthropogenic activities. In Hyderabad lakes, a combination of a tertiary treatment plant to remove phosphates and wetland use to reduce nitrates is applied for nutrient removal before sewage enters the lake (Rao, 2012). Nitrification during water treatment, use of microorganisms, wetland construction, and removal through macrophytes are some widespread methods of N removal from water.

Biological methods

Bio manipulation is a top-down control mechanism of lake restoration by introducing algae-feeding fish or by removing zooplankton-feeding fish. Use of fish as a bioremediation agent and their frequent harvesting can be a crucial method to manage eutrophication of lakes (Vass *et al*., 2015). Datta (Saha) and Jana (1998) affirmed that Silver Carp is effective in the removal of *Microcystis*. Nagdali and Gupta (2002) found an increase in zooplanktons, a decrease in phytoplanktons, and an increase in water transparency after the removal of planktivorous fish *Gambusia affinis* in Lake Nainital.

Weed eradication by biological control methods has been applied in some lakes of India. Ramchandra and Ahalya (2001) suggested the introduction of *Pila globosa* (tropical snail) and Chinese grass carp (a fast-growing fish) that feeds on many aquatic plants. Exotic weevil (*Neochetina* spp.) and *Cyrtobagaus salvinae* have been used to eliminate water hyacinth and water fern, while herbivorous fish *Tilapia spp*. and *Ctenopharyngodon idellus* have been used to control submerged species like *Hydrilla spp.* (Varshney *et al.,* 2008). Exotic weevils and fungal pathogens *(Alternaria spp.)* helped in the effective control of the water hyacinth in Lake Rankla, Kolhapur (Ghone and Singal, 2015).

On the other hand, many of the weeds can be used for phyto remediation (Shiny *et al.,* 2004, Dhote and Dixit 2007, Kumar and Anshumali 2014). Weeds that have high mineral absorption capacity and high tolerance towards organic load are suitable. Further, they can be used as animal feed, fish feed, or biofertilizer unless the water has toxic elements (Hasan and Chakrabarti, 2009). Species like *Eichhornia crassipes*, *Lemna minor*, *Azolla pinnata*, *Typha angustifolia*, *Potamogeton crispus*, *Phragmites australis*, *and Ceratophyllum demersum* are found to be potential heavy metal accumulators in various studies (Pandey *et al.,* 2019; Nabi 2021).

A new phyto-remediation approach has been applied in Bangalore lakes by George *et al*. (2016), where water is remediated using dried and chemically modified leaf and bark powders of *Moringa olifera*. It is a fast-growing, drought-resistant tree species that acts as a biosorbent for heavy metals and helps in the reduction of BOD, COD, nitrate, and phosphate content of water samples.

Another biological tool for bioremediation is non-pathogenic, natural microorganisms that degrade organic and toxic pollutants, curb eutrophication, and restore lakes by maintaining their ecological balance (Raghav and Shrivastava 2016). In India, bioremediation of the three lakes, i.e., Powai in Mumbai and Ooty and Kodaikanal lakes in Tamil Nadu was approved in 2001 in the first phase of the NLCP (Gupta 2005). In many lakes of the Thane region, bioremediation was initiated after its successful implementation in Kacharlli Lake (Pradhan and Latkar, 2008).

According to Soumya *et al.* (2014), halophilic bacteria from sediments of Lake Vembanad are capable of removing lead and cadmium. Kiran *et al*. (2016) used "nulagi," a nano-silica-based mixture in Indira Lake, Hyderabad, which triggers the growth of diatom blooms. These were found effective in reducing N, P, as well as BOD and COD. Diatoms fix CO_2, and their biomass can be a source of food for fish. Gahlawat *et al.* (2020) found Pseudomonas aeruginosa to be an effective microbe for faster biodegradation of organic matter, which consumes less oxygen and survives in a wide range of temperature variations. Sajana *et al.* (2017) in their review have advocated a new technology to use sediment microbial fuel cells (SMFCs) for in situ bioremediation of sediments and wastewater, along with harvesting electricity.

Conversely, pathogenic microbes need to be eliminated from lake water. In India, pathogenic contamination is mainly removed by chlorination in addition to other methods like ozonation, UV treatment, bioremediation, and phyto remediation. Skariyachan *et al.* (2021) have recommended the bacteriophage-based therapy to reduce microbial pollution and restrict the growth of drug-resistant bacterial pathogens. To eradicate pathogenic contamination, awareness programs and sanitation improvement missions are run by the government and NGOs, although a large number of infections and deaths occur every year (Sharma *et al.*, 2023).

Physical/Mechanical methods

Physical treatment includes installing liners, dredging, aeration, dilution, and mechanical removal of algae and weeds. Although many of these methods are capable of disturbing the lake ecosystem, they are applied for rapid control of lake deterioration.

Sediment dredging is widely used all over the world in lakes for taking out the nutrient and contaminant-rich surface layers. Pandey and Verma (2004) suggested dredging as an effective tool for P removal in shallow lakes. Dredging has been found helpful in lakes like Dal Lake (Mir, 2015) and Lake Mansagar (Bahadure and Sangeetha, 2014). In Chilka Lake, it resulted in water exchange between the sea and lagoon, leading to migration of fish, prawn, and crab juveniles and increased appearance of seagrass, dolphins, and migratory birds (Naik *et al*., 2008; Sahu *et al*., 2014). In their study, Kundangar and Abubakr (2001) did not find any significant vulnerability for zooplanktons and phyto planktons due to dredging in Dal Lake. Along with dredging, constructions to trap sediments like a settling basin in Dal lake (Khan 2015) or a siltation trap at lake Mansagar (Raina, 2008) have also helped to control siltation. The dredged soil mixed with lime can be used in construction activities and many engineering applications (Mir, 2015).

Aeration units are installed in lakes like Bhoj Wetland, Bhopal (Verma and Dixit, 2006), Hussain Sagar Lake, Hyderabad (Rafi and Kusum, 2018), and Lake Fatehsagar, Udaipur. In Lake Nainital, aeration resulted in the disappearance of Cyanophyceae (Gupta and Gupta, 2012). In a study at Bhoj wetland, aeration along with ozonization increased dissolved oxygen, species diversity, and decreased pathogenic microbes (Varghese *et al*., 2004). Similarly, aeration along with bioremediation has been found useful in increasing dissolved oxygen (Kamath, 2008).

Mechanical and manual weed harvesting has been applied at many Indian lakes like Dal Lake (Zutshi and Ticku, 1990), Rankala Lake, Kolhapur, Lake Fatehsagar, and Pichola of Udaipur. However, mechanical deweeding is not selective and leads to changes in community structure (Habib and Yusuf, 2014). Deweeding is more helpful when heavy metal-extracting weeds are removed from lakes. Control of redundant species is required to maintain the lakes' natural system healthy. Removal of willow plantation in Wular lake (Kumar, 2018; Keller *et al.*, 2018), control of phumdis in Loktak lake (Kangabam *et al.*, 2015) are such examples.

Formation of bird islands helps in attracting bird species and helps in reducing turbulence of the surface layer of lake water (Saraf and Nair, 2015). In Pashan Lake, Pune, the formation of islands along with desiltation and plantation of indigenous species leads to an increase in bird population richness and abundance (Yardi *et al*., 2019).

Catchment management to control nutrient inflow is an initial process for the management of the lake. Contour bunding, tree plantation, and construction of check dams, silt retention dams, mechanical spurs and revetments construction in the catchment of Sukhna lake helped in control of siltation (Singh, 2002; Chaudhary *et al*., 2013). Siddiqui *et al.* (2013) have suggested channelization of manmade storm water drains (formed due to urbanization) along with natural drainage via nallahs and gullies towards the lake and control of evaporation losses by check dams. Shekhar *et al.* (2010) have recommended the construction of a sub-surface dyke for the management of the watershed of Badkal Lake. Rao (2012) has mentioned the importance of examining groundwater contamination to find out the interaction of lake water quality with the groundwater regime. To mitigate the impact of agriculture, Kerala Conservation of Paddy land and wetland 2008 did not allow any further reclamation of land for agriculture in the Vembanad wetland (Checkacherry and Jayakumar, 2011).

Different methods, when incorporated according to lake type and its condition, help in lake restoration. Singh and Bhatnagar (2012) has described the restoration carried out in Hauz Khas, Delhi where introduction of *Spirodella, Lemna* and *Wolffia* spp. in newly constructed check dams, addition of fishes like Indian Carps, Grass Carps and *Gambusia* spp. that consume plankton and also attract birds and inclusion of facultative anaerobic bacteria to reduce

BOD and nitrates and increase oxygen levels helped water quality improvement.

Government Legislative Measures and People's Participation

The organizations are set up for the restoration and management of lakes in India for particular lakes or at the regional level (Reddy and Char, 2006). Few states have set up an apex authority to conserve water bodies to collaborate on the work of different departments. "National Plan for Conservation of Aquatic Eco-systems" (NPCA) helps manage selected lakes. Many Indian wetlands are conserved as Ramsar Sites. Lake Mansagar is an example of successful restoration by the public department and private hands. Lake Chilka sets a nice example of harmony among various departments during its rehabilitation. Successful restoration of Bengaluru lakes ascertains public participation through environmental placemaking and stewardship (Sen and Nagendra, 2020). A good example of public awareness is seen in the case of Thane lakes (Walavalkar and Tekale, 2004).

Discussion

The objective of restoration should be adherence to standard water quality, conservation of biodiversity, catchment area development, soil conservation, microclimatic conditions, livelihood, and facilities for the local community, i.e., fishing, agriculture, drinking water supply, and recreation. Restoration of aquatic ecosystems is specific to site, time, and biota, which need integration of biological processes and abiotic environment along with management of extreme situations (Verdonschot *et al*., 2013). Lake management includes intense monitoring, interaction, and cooperation between different agencies like state governments, local administration, departments of soil, forests, natural resources, agriculture, urban planning, along with citizens and research institutions. National water policies, revised effluent standards, establishment of common effluent treatment plants (CETPs), and adoption projects like zero liquid discharge (ZLD) are all supportive in lake management. Several lakes are covered under a protected area.

Depiction of pollution dynamics and magnitude is basic to the development of management plans and suitable technologies. Watershed mapping, identification of point and nonpoint sources of lake pollution, is decisive in checking the contamination of lakes. In 2011, MoEF, along with ISRO, developed a GIS for mapping all wetlands of India. Baseline studies of lake hydrology, hydro-geomorphology, catchment activities, and socio-economic aspects of the region need to be evaluated. Such prior studies include paleo limnological studies, remote sensing, GIS, and the study of local biota as an indicator (Garg, 2015; Jumbe *et al*., 2008).

Nutrient input control through point sources and non-point sources, and installation of a properly functioning sewage treatment plant (STP) is the most crucial part of lake management. Regulating phosphate-containing detergents and setting up nutrient (N and P) removal units (STPs) significantly reduces phosphorus loading to the aquatic system (Kundu *et al*., 2015; Dash *et al*., 2020). Further, monitoring and training of staff for skillful operation of sewage treatment plants to increase the efficiency of STPs is emphasized by Chatterjee et al. (2016).

Catchment management techniques play a crucial role in lake management. Structural and non-structural best management practices are helpful in controlling non-point pollution (Jain and Singh, 2019). Ramchandra *et al.* (2013) in their study on Bengaluru lakes found that the lakes in more built-up areas were more nutrient-rich, whereas the lakes with more vegetation and sparse population in a catchment were less polluted. In urban areas, the construction of porous pavement, street cleaning, and soil stabilization should be implemented to reduce floods and siltation. As cities are experiencing more torrential rains, systematic channelizing and holding rainwater with traditional as well as advanced techniques will help in rainwater harvesting and increasing lake water levels.

Scientific and technological methods to rejuvenate the self-purification system of water bodies, like bioremediation, bio manipulation, and the green bridge method, are effective approaches for long-term management. Construction of green bridges that comprise biologically originated cellulosic or fibrous material in combination with sand, gravel, and roots of plants helps trap the insoluble pollutants and absorb the soluble pollutants. Further, research on local plant species useful for phyto remediation and food web structures that channelize P to higher consumers will be helpful in the restoration of biological communities.

Sudha *et al.* (2013) proposed the use of a few indicators to formulate the 'water bodies conservation index' in line with monitoring, ranking, and preparing conservation plans. Availability of data helps make management and restoration efforts more effective. Ecological modelling is emphasized as a potent means of understanding case-specific and required eutrophication control methods by Bhagowati *et al*. (2020). Taking into account the threat perceptions by various stakeholders can help in planning lake management (Paonam and Chatterjee, 2022).

Education and dependency on a particular lake decide local people's perception towards the lake (Dash *et al.*, 2022). Nagendra and Ostrom (2014) used a socio-economic framework (SES) and found that such collective action is oriented towards ecological and social restoration goals with reduced costs. Small but significant steps like training of artisans to make idols with natural clay and paints, assistance to fishermen for composite fish culture, may be included in the restoration program.

Conclusion

Long-term studies of ecological processes in lakes and continuous monitoring of water quality help in determining and applying the appropriate method of restoration. Evaluation of proper effective management methods and further selection of a suitable action plan is desirable. Advanced knowledge, like scientific databases, remote sensing, global positioning systems, mathematical modeling, etc., is a crucial and helpful tool. Climate and catchment characteristics need to be considered while planning for lake management. Training and capacity building at all levels, incorporating policies and plans with legal support, are important steps. Awareness and participation of every citizen are essential for successful lake restoration.

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References

Bahadure, S. and Sangeetha, P. 2014. Sustainable approach for conserving and managing for urban water bodies. In: *Proceedings of the Second International Conference on Global Business, Economics, Finance and Social Sciences (GB14 Conference) Chennai, India.* 11(13):1-14.

Banu, R.J., Do, K.U. and Yeom, I.T. 2008. Phosphorus removal in low alkalinity secondary effluent using alum. *International Journal of Environmental Sciences and Technology.* 5(1): 93-98.

Bhagowati, B., Talukdar, B. and Ahamad, K.U. 2020. Lake eutrophication: causes, concerns and remedial measures. In: M. Kumar, D. Snow, R. Honda (Eds), *Emerging Issues in the Water Environment during Anthropocene: A South East Asian Perspective* (pp. 211-222). Springer Transactions in Civil and Environmental Engineering. Springer, Singapore. https://doi.org/10.1007/978-981-32-9771-5_12

Chatterjee, P., Ghangrekar, M.M. and Rao, S. 2016. Low efficiency of sewage treatment plant due to unskilled operations in India. *Enviromental Chemistry Letters.* 14: 407-416. https://doi.org/10.1007/s10311-016-0551-9

Chaudhry, P., Bhargava, R., Sharma, M.P. and Tewari, V.P. 2013. Conserving urban lakes for tourism and recreation in developing countries: a case from Chandigarh, India. *International Journal Leisure and Tourism Marketing.* 3(3): 267-281.

Checkacherry, G. and Jayakumar, K.V. 2011. Conservation and management of Vembanad-Kol Wetland, Kerala. In: *Conference paper: National Workshop on Ramsar Designated Wetlands of India, Kolkata, India* (pp 8).

Dalwani, R. and Gopal, B. 2020. Nature-based solutions for restoration of freshwater ecosystems: Indian Experiences. In: S. Dhyani, A. Gupta, M. Karki (Eds), *Nature-based Solutions for Resilient Ecosystems and Societies,* (pp. 231-245). Disaster Resilience and Green Growth. Springer, Singapore. https://doi.org/10.1007/978-981-15-4712-6_14

Dash, S.K., Payra, A., Sonker, G., Palei, H.S., Mishra, A.K. and Mishra, R.K. 2022. The role of education and resource benefit on people's perception towards conserving the largest freshwater lake of Odisha, India. *Wetlands.* 42(8): 97.

Dash, S., Borah, S.S. and Kalamdhad, A.S. 2020. Study of the limnology of wetlands through a one-dimensional model for assessing the eutrophication levels induced by various pollution sources. *Ecological Modelling.* 416: 108907. https://doi.org/10.1016/j.ecolmodel.2019.108907

Datta (saha), S. and Jana, B.B. 1998. Control of blooms in a tropical lake: Grazing efficiency of some herbivores fishes. *Journal of Fish Biology.* 53(1): 12-24.

Dhote, S. and Dixit, S. 2007. Water quality improvement through Macrophytes: A Case Study. *Asian Journal of Experimental Sciences.* 21 (2): 427-430.

Gahlawat, N., Koli, S.K. and Shanker, U. 2020. Bioremediation: Assessment of microbial strain and cost estimations for the rejuvenation of Tilyar Lake, India. *International Journal of Biotech Trends and Tech-*

nology. 10(4): 20-29. http://ijbttjournal.org/archives/ijbtt-v10i4p603

Garg, J.K. 2015. Wetland assessment, monitoring and management in India using geospatial technique. *Journal of Environment Management.* 148: 112-123.

George, K.S., Revathi, K.B., Deepa, N., Sheregar, C.P., Ashwini, T.S. and Das, S. 2016. A study on the potential of Moringa leaf and bark extract in bioremediation of heavy metals from water collected from various lakes in Bangalore. *Procedia Environmental Sciences.* 35: 869-880. https://doi.org/10.1016/j.proenv.2016.07.104

Ghone, A.S. and Singhal, S.K. 2015. Performance evaluation of deweeding operations implemented or conservation of Rankala lake, Kolhapur, India. *European Academic Research.* 2(11): 14310-14324.

Gupta, K.R. 2005. Regeneration and Development. In: K.R. Gupta (Ed*), Environment: Problems and Policies (encyclopedia of Environment)*, Vol 2 (pp. 50-77). Atlantic Publishers and Distributers, New Delhi.

Gupta, R. and Gupta, P.K. 2012. The impact of artificial circulation on phytoplankton community on a fresh water eutrophic lake. *Journal of Ecophysiology and Occupational Health.* 12(3–4): 1-20

Habib, S. and Yousuf, A.R. 2014. Impact of mechanical deweeding on the phytophilous macroinvertebrate community of a eutrophic lake. *Environmental Science and Pollution Research.* 21: 5653-5659. https://doi.org/10.1007/s11356-013-2470-7

Hasan, M. R., and Chakrabarti, R. 2009. Use of algae and aquatic macrophytes as feed in small scale aquaculture- A review. In: *FAO Fisheries and Aquaculture Technical paper*. No. 531, FAO, Rome, pp.123.

Jain, C.K. and Singh, S. 2019. Best management practices for agricultural nonpoint source pollution: Policy interventions and way forward. *World Water Policy.* 5(2): 207-228. https://doi.org/10.1002/wwp2.12015

Jumbe Aboud, S., Nandini, N., Tandon, S. and Sunitha, N. 2008. Banglore lakes: Issues and perspective on pollution, restoration and management. In: *Proceedings of "Taal 2007: The 12th World Lake Conference", Jaipur, India* (pp1699-1706)

Kalavathy, S., Giridhar, M.V.S.S. and Viswanadh, G.K. 2017. A jar test study on the use of alum and ferric chloride for turbidity removal. In*: Proceedings of "4th National Conference on Water, Environment and Society", Hyderabad, India. BS Publications, Hyderabad*, pp339-346.

Kamath, G. 2008. Bioremediation of lakes: Myths and realities. *In: Proceedings of "Taal 2007:The 12th World Lake Conference", Jaipur, India,* pp 44-49.

Kangabam, R., Boominathan, S.D. and Munisamy, G. 2015. Ecology, disturbance and restoration of Loktak Lake in Indo-Burma Biodiversity Hotspot-An overview. *An International Journal of Environment and Biodiversity.* 6(2): 9-15.

Keller, R.P., Masoodi, A. and Shackleton, R.T. 2018. The impact of invasive aquatic plants on ecosystem services and human well-being in Wular Lake, India. *Regional Environmental Change.* 18: 847-857.

Khadse, G.K., Patni, P.M. and Labhasetwar, P.K. 2015. Removal of iron and manganese from drinking water supply. *Sustainable Water Resources Management.* 1: 157-165. http://10.1007/s40899-015-0017-4

Khan, M.A. 2015. Dal lake of Kashmir: Problems, prospects and perspectives. International *Journal of Multidisciplinary Research and Development.* 2(2): 462-469.

Kiran, M.T., Bhaskar, M.V. and Tiwari, A. 2016. Phycoremediation of eutrophic lakes using diatom algae. In book: M. N. Rashed (Ed.), *Lake Sciences and Climate Change*, pp.103-115. http://dx.doi.org/10.5772/64111

Kumar, B. and Anshumali, 2014. Eutrophication and its control measures: A study of lakes and reservoir. *Journal of Civil Engineering and Environmental Technology.* 1(5): 18-23.

Kumar, R. 2018. Wular Lake, Kashmir. In: C.M. Finlayson, G.M. Milton, C. Prentice, N.E. Davidson (Eds), *The Wetland Book II: Distribution, Description and Conservation*, *(p*p 1705-1710). Springer Netherlands, Netherland.

Kundangar, M.R.D. and Abubakr, A. 2001. Post dredging changes and comparative limnology of Dal lake, Kashmir. *Pollution Research.* (20): 539-547.

Kundu, S., Coumar, M.V., Rajendiran, S., Rao, A. and Rao, A.S. 2015. Phosphates from detergents and eutrophication of surface water ecosystem in India. *Current Science.* 108(7): 1320-1325. http://www.jstor.org/stable/24905495

Mahadevan, H., Krishnan, K.A., Pillai, R.R. and Sudhakaran, S. 2020. Assessment of urban river water quality and developing strategies for phosphate removal from water and wastewaters: Integrated monitoring and mitigation studies. *SN Applied Sciences.* 2(4): 772.https://doi.org/10.1007/s42452-020-2571-0

Maharashtra Pollution Control Board, 2010. Model environmental status report for Thane municipal corporation. *Environmental Status Report*, pp.1-81.

Mir, B.A. 2015. Some studies on geotechnical characterization of dredged soil for sustainable development of Dal Lake and environmental restoration. *International Journal of Technical Research and Applications.* 12: 4-9.

Nabi, M. 2021. Heavy metals accumulation in aquatic macrophytes from an urban lake in Kashmir Himalaya, India. *Environmental Nanotechnology, Monitoring & Management.* 16: 100509. https://doi.org/10.1016/j.enmm.2021.100509

Nagdali, S.S. and Gupta, P.K. 2002. Impact of mass mortality of a mosquito fish, *Gambusia affinison* the ecology of a fresh water eutrophic lake (Lake Nainital, India). *Hydrobiology.* 468(1-3): 45-51.

Nagendra, H. and Ostrom, E. 2014. Applying the social-ecological system framework to the diagnosis of urban lake commons in Bangalore, India. *Ecology and Society*. 19(2):http://dx.doi.org/10.5751/ES-06582-190267

Naik, P.K., Pati G.C., Choudhury, A. and Naik, K.C. 2008. Conservation of Chilika Lake, Orissa, India. In: *Proceedings of "Taal 2007:The 12th World Lake Conference", Jaipur, India*, pp1988-1992.

Natarajan, M., Johnpaul, V., Sindhu, R. and Jayalakshmi, K. 2020. Case study and analysis of ecological restoration plan of lakes in Coimbatore. In: *IOP Conference Series: Materials Science and Engineering.* 1006(1): 012006. IOP Publishing. http://dx.doi.org/10.1088/1757-899X/1006/1/012006

Pandey, J. and Verma, A. 2004. The influence of catchment on chemical and biological characteristics of two freshwater tropical lakes of southern Rajasthan. *Journal of Environmental Biology.* 25(1): 81-87.

Pandey, S.K., Upadhyay, R.K., Gupta, V.K., Worku, K. and Lamba, D. 2019. Phytoremediation potential of macrophytes of urban waterbodies in Central India. *Journal of Health and Pollution.* 9(24): 191206. https://doi.org/10.5696/2156-9614-9.24.191206

Paonam, J. and Chatterjee, S. 2022. Threat perception of stakeholders: Case study of Loktak Lake, a Ramsar Site under Montreux Record in North East India. *Wetlands.* 42(8): 114. https://doi.org/10.1007/s13157-022-01630-x

Pradhan, M. and Latkar, P. 2008. Shallow lakes in urban regions: Ecological restoration of Lakes in Thane city. In: *Proceedings of "Taal 2007:The 12th World Lake Conference", Jaipur, India,* pp 1628-1634.

Priya, E., Kumar, S., Verma, C., Sarkar, S. and Maji, P.K. 2022. A comprehensive review on technological advances of adsorption for removing nitrate and phosphate from wastewater. *Journal of Water Process Engineering.* 49: 103159. https://doi.org/10.1016/j.jwpe.2022.103159

Rafi, P.M. and Kusum, A.J. 2018. Review of Hussain Sagar lake pollution, Hyderabad, India. *International Journal of Agriculture, Environment and Biotechnology* (*IJEAB*). 3(2): 543-549.

Raghav, N. and Shrivastava, J.N. 2016. Toxic pollution in river water and bacterial remediation: An Overview. *International Journal of Current Microbiology and Applied Sciences.* 5(4): 244-266.

Raina, M. 2008. Conservation and management of Mansagar Lake of Jaipur- A Model Study. *In: "Taal 2007: The 12th World Lake Conference", Jaipur, India,* pp 1944-1950.

Ramachandra, T.V., Meera, D.S. and Alakananda, B. 2013. Influence of catchment land cover dynamics on the physical, chemical and biological integrity of Wetlands. *International Journal of Science and Technology.* 8(1): 37-54.

Ramchandra, T.V. and Ahalya, N. 2001. Wetlands restoration and conservation. In: *Proceedings of National Conference on 'Control of Industrial Pollution and Environmental Degradation'*. Dept. of Civil Engineering, PSG College of Technology, Coimbatore, pp 262-275.

Rao, V.V.S.G. 2012. Restoration of urban lakes in the NE Musi Basin, Hyderabad, India. In: L. Bengtsson, R.W. Herschy, R.W. Fairbridge (Eds), *Encyclopedia of Lakes and Reservoirs*, *Encyclopedia of Earth Sciences Series,* pp. 68-672) Springer, Dordrecht. https://doi.org/10.1007/978-1-4020-4410-6_154

Reddy, M.S. and Char, N.V.V. 2006. Management of lakes in India. *Lakes and Reservoir: Research and Management.* 11(4): 227-237.

Roopa, C. and Murthy, B.M. 2014. Evaluation of optimum dose and pH of an in-line alum facility to inlets in Kukkarahalli Lake, Mysore*. International Journal of Innovative Research in Science, Engineering and Technology.* 3(5): 12224-12230.

Sahu, B.K., Pati, P. and Panigrahy, R.C. 2014. Environmental conditions of Chilika Lake during pre and post hydrological intervention: an overview*. Journal of Coastal Conservation.* 18: 285-297. https://doi.org/10.1007/s11852-014-0318-z

Sajana, T.K., Ghangrekar, M.M. and Mitra, A. 2017. In situ bioremediation using sediment microbial fuel cell. *Journal of Hazardous, Toxic, and Radioactive Waste.* 21(2): 04016022. https://doi.org/10.1061/(ASCE)HZ.2153-5515.0000339

Saraf, M. and Nair, S.J. 2015. Restoration and conservation of urban lakes. International *Journal of Advance Engineering and Research Development.* 2(6): 315-323.

Sen, A. and Nagendra, H. 2020. Local community engagement, environmental placemaking and stewardship by migrants: A case study of lake conservation in Bengaluru, India. *Landscape and Urban Planning*. 204: 103933.

Sharma, M.D., Mishra, P., Ali, A., Kumar, P., Kapil, P., Grover, R., Verma, R., Saini, A. and Kulshrestha, S. 2023. Microbial waterborne diseases in India: status, interventions, and future perspectives. *Current Microbiology.* 80(12): 400. https://doi.org/10.1007/s00284-023-03462-2

Shekhar, S., Mukherjee, A., Singh, P.N., Kumar, P., Chandra, R. and Gupta, S. 2010. Conservation of hydrogeological heritage: A case study of Badkhal Lake, Faridabad (Hariyana). *IVth World Aqua Congress 2010*, New Delhi, Vol-II, (pp. 329-338).

Shiny, K.J., Remani, K.N., Jalaja, T.K. and Sasidharan, V.K. 2004. Removal of chromium by two aquatic pteridophytes. *Journal of Environmental Science and Engineering*. 46(3): 249-251.

Siddiqui, R., Mahmood, G. and Ali, S.R. 2013. Analysis of sustainability of Surajkund lake and determination of hydrodynamics of Delhi ridge with special reference to urbanization impact assessment. *International Journal of Management, IT and Engineering.* 3(1): 231-250.

Singh, R. and Bhatnagar, M. 2012. Urban lakes and wetlands: opportunities and challenges in Indian cities - Case study of Delhi. In:*12th edition of the "World Wide Workshop for Young Environmental Scientists (WWW-YES-2012) - Urban waters: resource or risks?"*,(No. 10). HAL-ENPC, Arcueil, France, (pp. 12)

Singh, Y. 2002. Siltation problems in Sukhna lake in Chandigarh, NW India and comments on geohydrological changes in the Yamuna-Satluj region. *ENVIS Bulletin: Himalayan Ecology and Development.* 10(2): 18-31.

Skariyachan, S., Deshpande, D., Joshi, A., Subramanya, N., Kale, S. and Narayanappa, R. 2021. Physicochemical and microbial pollution of a reservoir in South India and role of bacteriophage treatment to curtail drug-resistant bacterial pollution in water. *Environmental Technology & Innovation.* 24: 102012. https://doi.org/10.1016/j.eti.2021.102012

Som, I., Suman, S., Roy, M., Gupta, S. and Saha, R. 2022. Effective phosphate removal from sewage water using zerovalent iron nanomaterial as an adsorbent. *Water Quality Research Journal.* 57(3): 177-199. Doi: https://doi.org/10.2166/wqrj.2022.007

Sowmya, M., Rejula, M. P., Rejith, P. G., Mohan, M., Karuppiah, M. and Hatha, A. M. 2014. Heavy metal tolerant halophilic bacteria from Vembanad Lake as possible source for bioremediation of lead and cadmium. *Journal of Environmental Biology.* 35(4): 655-660.

Sudha, M.C., Ravichandran, S. and Sakthivadivel, R. 2013. Water bodies protection index for assessing the sustainability status of lakes under the influence of urbanization: A case study of south Chennai, India. *Environment, Development and Sustainability.* 15: 1157-1171. https://doi.org/10.1007/s10668-012-9431-z

Tiwari, P.K., Singh, R.K., Khajanchi, S., Kang, Y. and Misra, A.K. 2021. A mathematical model to restore water quality in urban lakes using Phoslock. *Discrete and Continuous Dynamical Systems-B.* 26(6): 3143-3175. https://doi.org/10.3934/dcdsb.2020223

Varghese, B., Dhote, S., Pani, S. and Mishra, S.M. 2004. Impact of artificial aeration and ozonization on pathogenic bacteria of a tropical sewage fed lake. *Pollution Research.* 23(1): 199-203.

Varshney, J., Kumar, S. and Mishra, J. 2008. Current status of aquatic weeds and their management in India. In: *Proceedings of "Taal 2007:The 12th World Lake Conference", Jaipur, India,* pp 1039-1045

Vass, K.K., Wangeneo, A., Samanta, S., Adhikari, S. and Muralidhar, M. 2015. Phosphorus dynamics, eutrophication and fisheries in the aquatic ecosystems in India. *Current Science*. 1306-1314. http://www.jstor.org/stable/24905493.

Verdonschot, P.F.M., Spears, B.M., Feld, C.K., Brucet, S., Keizer-Vlek, H., Borja, A., Elliott, M., Kernan, M. and Johnson, R.K. 2013. A comparative review of recovery processes in rivers, lakes, estuarine and coastal waters. *Hydrobiologia.* 704: 453-474. https://doi.org/10.1007/s10750-012-1294-7

Verma, N. and Dixit, S. 2006. Effectiveness of aeration units in improving water quality of Lower Lake, Bhopal, India. *Asian Journal of Experimental Sciences.* 20(1): 87-95.

Walavalkar, V.A. and Tekale, N. 2004. Impact of environment awareness campaign on 'Ganpati' idol immersion activity in Masunda lake, Thane city. In: *National seminar on "Pollution of Water Bodies in Urban Areas (Case study Thane)" Thane, India*, (pp 19-21).

Yardi, K.D., Bharucha, E. and Girade, S. 2019. Post-restoration monitoring of water quality and avifaunal diversity of Pashan Lake, Pune, India using a citizen science approach. *Freshwater Science.* 38(2). https://doi.org/a10.1086/703440

Zutshi, D.P. and Ticku, A. 1990. Impact of mechanical deweeding on Dal Lake ecosystem. *Developments in Hydrobiology.* 61: 419-426.