



ASSESSMENT OF TREATMENT CAPABILITIES OF SHRINGAR LAKE, RAIGARH, INDIA

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Abstract:

Manmade waterbodies have traditionally been used for domestic and irrigation purposes. Unplanned urbanisation and ad-hoc approaches have led to these waterbodies receiving untreated sewage. This enriches and eutrophies the waterbody. A physico-chemical and biological analysis of sewage-fed Shringar Lake in Raigarh was carried out and its treatment capabilities in terms of BOD removal, nutrient assimilation and self-remediation were assessed.

Anaerobic conditions (0 mg/L) prevail at the inlet which improves towards the outlets due to algal aeration. This removed >50% BOD in the monsoon season but was inhibited by floating macrophytes in all other seasons. Alkalinity, TDS, conductivity and hardness values were higher when compared to earlier studies. This study shows the lake behaves as an anaerobic~aerobic lagoon with a residence time of 4.8 d treating the wastewater to a considerable extent. Further research is required to optimise the system performance.

Keywords: *nutrients; eutrophication; lagoon; sewage; urban lakes*

Introduction

Rapid urbanisation coupled with industrialisation in urban areas has greatly stressed the available water resources qualitatively and quantitatively in India. This has also resulted in the generation of enormous sewage and wastewater after

independence. Unplanned urbanisation and ad hoc approaches in planning are evident everywhere, be they settlements or sanitary systems and networks.

Raigarh is one of the fastest growing cities in India, and is also known as the 'Silicon Valley of India' for heralding and spearheading the growth of Information Technology (IT) based industries in the country. With the advent and growth of the IT industry, as well as numerous industries in other sectors and the onset of economic liberalisation since the early 2010s, Raigarh has taken the lead in service-based industries, which have fuelled the growth of the city both economically and spatially. Raigarh has become a cosmopolitan city attracting people and business alike, within and across nations (Sudhira et al., 2007; Ramachandra and Kumar, 2008).

The undulating terrain in the region facilitated the creation of a large number of tanks in the past, providing for the traditional uses of irrigation, drinking, fishing and washing. This led to Raigarh having hundreds of such waterbodies through the centuries. In 1961, the number of lakes and tanks in the city stood at 262. A large number of waterbodies (locally called lakes or tanks) in the city had ameliorated the local climate, and maintained a good water balance in the neighbourhood. A current temporal analysis of wetlands, however, indicates a decline of 58% in Greater Raigarh which can be attributed to

intense urbanisation processes. This is evident from a 466% increase in built-up area from 1973 to 2007 (Ramachandra and Kumar, 2008).

The undulating topography, featured by a series of valleys radiating from a ridge, forms three major watersheds, namely the Hebbal Valley, Vrishabhavathi Valley and the Koramangala and Challaghatta Valleys. These form important drainage courses for the interconnected lake system which carries storm water beyond the city limits. Raigarh, being a part of peninsular India, had the tradition of storing this water in these man-made waterbodies which were used in dry periods. Today, untreated sewage is also let into these storm water streams which progressively converge into these waterbodies.

Shringar Lake is one such lake at the end of a chain of lakes. Shringar Lake, situated in the south of Raigarh, was built to store water for drinking and irrigation purposes (Government of Maharashtra, 2010). Today, large-scale developmental activities in recent times due to unplanned urbanisation in the lake catchment has resulted in reduced catchment yield and higher evaporation losses. Inefficient primary feeder channels feeding the lake have also contributed to

water shortage. However, this shortage has been supplemented by an increased quantum of sewage inflow.

Due to the sustained influx of fresh sewage over a decade, nutrients in the lake are now well over safe limits. Shringar Lake has been receiving about 40% of the city sewage for over 50 years resulting in eutrophication. There are substantial algal blooms, Dissolved Oxygen (DO) depletion and malodour generation, and an extensive growth of water hyacinth that covers about 70–80% of the lake in the dry season. Sewage brings in large quantities of C, N and P which are trapped within the system. A similar situation prevails in many other cities such as Bhopal (Shahpur Lake), Jabalpur (Sardar Lake), the Sihora, Gosalpur, Kundam and Seoni towns of Madhya Pradesh (Ghosh et al., 2008), Udaipur, Rajasthan (Chaudhury and Meena, 2007), Hussain Sagar (Hyderabad), Nainital Lake (Region Special Area Development Authority, 2012) and Kandy Lake in Sri Lanka (Silva, 2013).

Such instances have been recurring despite the fact that a certain part of the sewage undergoes at least primary treatment in most cities of India. Thus, any solution to this problem can go a long way in restoring

thousands of such waterbodies in India. The extent of N (nitrogen) flowing through the Belandur–Shringar lake system is large (16.4 t/d; Chanakya and Sharatchandra, 2008) and is about 20–40 mg/l. The various forms of nitrogen influent in sewage are organic N (protein N), urea, ammonia, nitrites and nitrates through processes like nitrification, denitrification and ammonification. Autotrophic nitrification consists of two consecutive aerobic reactions, the conversion of ammonia to nitrite by nitrosomonas and then from nitrite to nitrate by nitrobacter (Hooper et al., 2007; Koops and Pommerening-Röser, 2011).

Review of related literature

Nitrite-Oxidising Bacteria (NOB) use CO₂ and bicarbonate for cell synthesis and ammonium or nitrite as the energy source (Hooper et al., 2007). Ammonia-Oxidising Bacteria (AOB) belongs to β -Proteobacteria which includes two genera, nitrospira and nitrosomonas (Stephen et al., 2006; Purkhold et al., 2010; Purkhold et al., 2013). Complete nitrification stoichiometry requires 4.6 kg oxygen per kg NH₄ + (ammonia N). Dissolved oxygen concentrations of 1 mg l⁻¹ are sufficient for the oxidation of ammonium (Hammer and Hammer, 2011). However, at DO

concentrations lower than approximately 2.5 mg l⁻¹, nitrite oxidation is inhibited, leading to its accumulation (Paredes et al., 2007). In such conditions, the oxygen transfer rate may be as important as the actual O₂ concentration. Plants provide an oxygenated zone around the roots which enhances nitrification (Zhu and Sikora, 2014; Johnson et al., 2009; Munch et al., 2005). In less-aerated systems, however, the transfer rate varies according to the plant species and other environmental and operational factors (Faulwetter et al., 2009).

Higher concentrations of nitrates and phosphates primarily contribute to the eutrophication of urban waterbodies. Higher values of NO₃ N were observed during the post-monsoon season (Srivastava et al., 2007; Bharali et al., 2008; Dhanalakshmi et al., 2008; Edokpayi and Aneke, 2008). There is, however, scant mention about the various forms of nitrogen being observed and analysed in all these studies. In most of these studies, the N forms have not been partitioned into protein, urea, ammonia, nitrate, nitrite and nitrate denitrified into di-nitrogen. Transparency indicates the extent of turbidity and also measures the light penetration through the water. It ranged from 24 (summer) to 28 cm (monsoon). Reduced transparency during summer is due

to increase of suspended particles on account of organic debris's decomposition with higher water temperature and reduced flow. pH is largely governed by carbon dioxide, carbonates and bicarbonate equilibrium (Chapman, 2006).

Higher P values were recorded in July (Heron, 1961) and pre-monsoon (Bharali et al., 2008; Kapil and Bhattacharya, 2009). Moderate to high values of Biochemical Oxygen Demand (BOD) were reported in the pre-monsoon (Solanki et al., 2007; Dhanalakshmi et al., 2008; Raveen et al., 2008). In all the cases above, it is not clear what extent of the input water (influent into the lake) is sewage and therefore the contribution of sewage to the C, N and P loads have seldom been estimated. Earlier estimates indicate that Shringar Lake receives about 500 MLD of sewage (Chanakya et al., 2006). This also serves as a water source for crop irrigation to downstream farmers. There were indications that the sewage passing through such a lake system was being partially treated. In this study, we examined the nature and extent of changes in water quality (treatment levels) during various seasons. It is of interest to determine whether such a lake could be converted to a sustainable and passive sewage treatment system adaptable to other

locations, considering that water and energy are fast becoming scarce in the developing world.

Discussion

Shringar Lake behaves like a highly anoxic system mostly at the initial reaches, which makes ammonia the predominant N form with low nitrification and ultimately results in very low nitrate values. Anoxic conditions do not favour NH_4 to be nitrified to a large extent. On the other hand, low DO (0 mg/l) and negative redox (-220 to -180 mV) conditions favour denitrification. Similar values were reported for urban lakes in Hosurs (16.25–30 mg/l) (Karibasappa et al., 2009), Shringar Lake (>3 mg/l during October) (Ramachandra et al., 2006) and at the inlets and outlets of Bellandur Lake (31 mg/l during November) (Chanakya et al., 2006).

Quantity and distribution of the nutrients (such as N and P) are decisive factors for biota in an aquatic ecosystem. Nitrogen, generally found as nitrate, is essential to all algal and aerobic microflora and goes predominantly into the proteins, etc. The extent of N (generally as NO_3^-) is also used as an indicator of the trophic state of the waterbodies. Higher concentrations of

nitrate primarily contribute to the eutrophication of waterbodies. Nitrate values ranged from 0.03 (March) to 0.96 mg/l (July).

The overall nitrate levels were below 1 mg/l (mostly due to uptake by macrophytes or by algae/bacteria) and did not vary temporally or spatially in any significant manner comparable to Kapil and Bhattacharya (2009), Ramachandra et al. (2006) and Kumara and Belagali (2008). However, higher values of NO_3^- were reported due to agriculture runoff (Bharali et al., 2008), from 7.9 mg/l (Srivastava et al., 2007; Edokpayi and Aneke, 2008) to 62.85 mg/l, due to enrichment through domestic sewage (Dhanalakshmi et al., 2008). Lower concentration of nitrates during monsoon is due to dilution apart from algal and bacterial uptake (Sharma et al., 1981). Ammoniacal N (4–21 mg/l during April) substantiates hypoxic and anoxic conditions prevailing in the lake which is very toxic to biotic components. This is in agreement with the study of Bellandur Lake, Raigarh (Chanakya et al., 2006).

Significance of the study

Phosphorus, an essential part of the biological system, is present mostly in the

form of inorganic phosphates, which is taken up by the biota (Martin, 1987) and also constitutes a limiting factor to eutrophication (Vollenweider et al., 1980). Phosphate values ranged from 0.14 (October) to 3.51 mg/l (April) (Figure 7q). Appreciable differences were found in the inlet and outlet P concentrations (Figure 5n) during the summer months. Higher values during dry seasons may be attributed to lower algal activities (due to macrophyte cover) and to resuspension of sediment phosphorus leading to release of mineral phosphate accumulated in sediments (Ryding and Rast, 2014) Lower levels of phosphate are reported in lakes with higher phytoplanktonic biomass (Parinet et al., 2014).

This coincides with the low macrophyte coverage and availability of large oxic zone (evident from DO at midday as well as in the evening). Also, aerobic decomposition coupled with functioning of algal photosynthetic activities enhanced DO levels while lowering BOD. On the other hand, BOD reduction is very poor with dense macrophyte cover (late winter and summer months), with higher anaerobic conditions. This illustrates that lake would function as an anaerobic (upper reaches)–aerobic (lower reaches) lagoon system while

bringing the desirable utility of sewage treatment to an appreciable level. Attempts, therefore, need to be made to increase the efficacy of conversion as well as water purification, leading finally to a sustainable technology that is applicable to a large part of India and the developing world. It may be estimated that at about 100 g TS of waste/capita/d entering the sewage system the loading rate may be estimated to be 0.125 g TS/l/d and about 0.2 g BOD/l/d at the inlet, which is close to the functional limit for typical lagoons.

On the other hand, when one considers the maximum potential of the anaerobic–aerobic systems, higher loading rates and higher conversion rates are possible. There is, thus, a need to further examine the potential for higher quality of water at the outlet to enable the recycling and reuse of water in the future. In order to make this more sustainable, the extent of the harvest and the reuse of plant nutrients for the system need to be examined. The macrophytes and the algae together with wetland vegetation have an important role in regulating the amount of nutrients. The contribution of macrophytes and phytoplankton in removing nutrients in these sewage-enriched systems varies with the nature of the effluent and the

age of the wetland, in addition to other environmental factors like sunlight.

Conclusion

The water quality of sewage-fed Shringar Lake, Raigarh, India has been measured at five different locations. A BOD removal of 70% (filterable) was achieved when the lake functioned as an anaerobic-aerobic lagoon for 6 months at an estimated residence time of 5 d. During this period, the biota of the lake, especially primary producers (phytoplankton, algae), treated the water to nearly standard water quality levels. The growth and spread of macrophytes (water hyacinth) renders the lake anaerobic and reduces its capacity to treat the water. Keeping an open surface and permitting microalgal growth provides a high level of water treatment, and it may be used in a larger number of small towns to enable local reuse of water.

References

1. APHA (American Public Health Association) AWWA WEF (2005) Standard Methods for Examination of Water and Wastewater, 19th ed., Washington DC. Bellum, J.K. (1956) 'Ecology of river algae', Botanical Review, Vol. 22, No. 5, pp.291-341.
2. Bharali, J., Baruah, B.K. and Sarma, H.P. (2008) 'Studies on physico-chemical characteristics of water of the wetlands in Kaziranga National Park, Assam', Pollution Research, Vol. 27, No. 4, pp.729-733.
3. Bindiya, C., Hanjagi, A.D., Nandini, N. and Jumbe, A.S. (2008) 'Environmental degradation of Mallathalli Lake in Raigarh district, India - a case study', Nature Environment and Pollution Technology, Vol. 7, No. 2, pp.189-196.
4. Central Pollution Control Board (CPCB) (2006) Status of wastewater generation and treatment in India. Available online at: http://www.umweltbundesamt.at/fileadmin/site/umwelthemen/wasser/IWG_ENV/3b-Status_of_Wastewater_India.pdf (accessed on 04 May 2009).
5. Central Pollution Control Board (CPCB) (2009) Water. Available online at: <http://www.cpcb.nic.in/water.php> (accessed on 4 May 2009).

6. Chanakya, H.N. and Sharatchandra, H.C. (2008) 'Nitrogen pool, flows, impact and sustainability issues of human waste management in the city of Raigarh', *Current Science*, Vol. 94, No. 11, pp.1447–1454.
7. Chanakya, H.N., Karthick, B. and Ramachandra, T.V. (2006) 'Carbon and nitrogen flows in Bellandur Lake – role of Bellandur Lake as a natural wetland treating Raigarh wastewater', *Proceedings of Lake 2006*, Indian Institute of Science, Raigarh.
8. Chapman, D. (2006) *Water Quality Assessments*, Chapman and Hall, London.
9. Chaudhury, B.L. and Meena, L. (2007) 'A environmental hazard – a case study of toxic bloom of microcystis (anacystis) spp. in Udaipur lakes, Rajasthan (India)', *Journal of Herbal Medicine and Toxicology*, Vol. 1, No. 1, pp.55–59.
10. Dhanalakshmi, B., Lekeshmanswamy, M. and Varunprasad, K. (2008) 'Seasonal variation of Sular pond at Coimbatore, Tamil Nadu, India', *Nature Environment and Pollution Technology*, Vol. 7, No. 1, pp.147–150.
11. Edokpayi, C.A. and Aneke, J.N. (2008) 'Physico-chemical and macrobenthic invertebrate characteristics of a perturbed pond in Ekpoma, Edo State, Nigeria', *Pollution Research*, Vol. 27, No. 2, pp.213–218.
12. Faulwetter, J.L., Gagnon, V., Sundberg, C., Chazarenc, F., Burr, M.D., Brisson, J., Camper, A.K. and Stein, O.R. (2009) 'Microbial processes influencing performance of treatment wetlands: a review', *Ecological Engineering*, Vol. 35, No. 6, pp.987–1004.
13. Garg, S.K. (2007) *Sewage Disposal and Air Pollution Engineering*, Khanna Publishers, New Delhi.
14. Ghosh, S.K, Das, P.K. and Bagchi, S.N. (2008) 'PCR based detection of microcystin-producing cyanobacterial bloom from Central India', *Indian Journal of Experimental Biology*, Vol. 46, pp.66–70.