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ASSESSMENT OF WATER QUALITY OF TEN URBAN LAKES IN MUMBAI

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Abstract: Freshwater ecosystems are essential for human existence and anthropogenic interventions well impact these systems. The impacts, especially pollution is a serious problem in urban lakes. This paper documents the seasonal changes in water quality of ten urban lakes in Mumbai, India. All the lakes were reported to be highly eutrophic. Low values of dissolved oxygen (DO) and high values of Biological Oxygen Demand (BOD) suggests high level of organic pollution in the water. Water quality was found to be influenced by nature of catchment area. Lakes with no sewage input and good vegetation cover, recorded low levels of nutrients and BOD in comparison with lakes surrounded by highly urbanised watershed. This establishes the importance of good vegetation cover for the health of lake ecosystem.

Key words: Urban lakes, Eutrophication, BOD, Organic pollution

INTRODUCTION

Freshwater ecosystems provide countless ecosystem services such as provision for water, food, and nutrient recycling. Even though their importance is recognized, they are being severely damaged by anthropogenic activities (Brill *et al.,* 2017; Alam *et al.*, 2017). India is a rapidly urbanising country, and the recent studies states that by 2030 nearly 40 % of the Indian population will be living in cities (Yadav *et al.,* 2011). Pollution has severely damaged the water quality of most urban water bodies including lakes and ponds in India. Pollution not only hampers the ability of lake to provide ecosystem services but it is also hazardous to health of the citizens (Crittenden *et al.,* 2012).

Study of water quality in order to understand the ecological health of water bodies is the first and essential step towards ecological restoration of urban lakes. Water quality monitoring of urban lakes is largely ignored by environmental protection agencies (TERI, 2014). In this paper, we present details on the water quality of ten urban lakes of Mumbai.

MATERIALS AND METHODS

Study Area

Mumbai city located at the western coast of India is spread in an area of 468 km² (BMC, 2015). It is one of the biggest city in India in terms of population and population density (BMC, 2015). For this study a total of 10 lakes were selected from 69 lakes from Mumbai city. The lakes were selected randomly and are located in the southern, eastern and western parts of the city. All the lakes are man-made and are constructed before 19th century as sources of drinking water in the city. Selected lakes, their area and geographical location is provided in Table 1 (Gazetteer of Bombay Presidency, 1882). Out of 10 lakes three lakes (Sheetal, Bandra and Shyamnagar) are situated in highly urban areas, two lakes (Banganga and Sion) are temple ponds, two lakes (MNP and Arey) are surrounded by forested watershed, two (Paskal and Madh island) lakes are in semi urban areas, and Powai lake is surrounded by forested areas, but receive large quantity of sewage from nearby households.

Methodology

Surface water samples were collected every month from all the selected lakes. Water was analysed for physicochemical parameters following standard methods as per American Public Health Association (APHA, 2005). The analysis was carried out for a period of two consecutive years. Samples were analysed for pH, transparency, Conductivity, Dissolved oxygen, Biochemical Oxygen Demand (BOD), Total Alkalinity, Total Hardness, Nitrite, Nitrate, Sulphate and Phosphate.

Table 1. Descriptions of the lakes in Mumbai selected for study

Sr.No.	Name of Lake	Area (m^2)	Latitude	Longitude	Usage
1	Bandra	23664	19°3' 18.86" N	72° 49' 50.91" E	Recreational
2	Banganga	2386	18°56'43.72" N	72° 47' 37.24" E	Recreational
3	Powai	1636605	19°07'48.0" N	72°54'36.00" E	Recreational, irrigation, fishing
4	MNP lake	2861	19°03'10.84" N	72° 51' 48.52" E	Rain water harvesting, irrigation
5	Madh island	3436	19º08'24.35" N	72º47'31.63" E	Washing, Bathing, irrigation
6	Sheetal	10748	19º05'2.45" N	72º52'54.48" E	religious rituals, idol immersion
7	Sion	4831	19º02'50.38" N	72º51'57.65" E	Temple pond, religious rituals
8	Shyamnagar	4043	19º08'17.74" N	72º51'47.64" E	recreational
9	Paskal	4100	19º08'46.52" N	72º47'56.38" E	Washing, Bathing, irrigation
10	Arey pond	20426	19° 09' 40.90" N	72° 52' 17.63" E	Recreational, irrigation, fishing

RESULTS

Turbidity

Turbidity of water played a key role in controlling the light penetration and regulating rate of photosynthesis by plants in water. Secchi disk was used for measuring light penetration in water. Values of Secchi depth were less than 1 m in all the lakes in all the seasons. Water of the MNP lake was found to be clearer than all the other lakes in winter (92.31cm, SD = 1.51) and monsoon season (85.12 cm, SD = 4.94). Watershed of MNP lake is wooded with good ground flora and leaf litter, which acts as a filter and reduces the amount of dirt from entering in the lake and reduces soil erosion. This makes it relatively more transparent than other lakes. Water of all the lakes was clearer in winter (68.86 cm) season followed by summer (66.75 cm) and least in monsoon (61.07) season (Table 1.2).

High turbidity is one of the major problems associated with urban lakes throughout the world. It is mainly the result of floating and suspended solid particles that enters the lakes from watershed, dust which settles on the lake's surface and algal bloom caused by nutrient loadings and other contaminants from runoff (Kagalou*et al.*, 2003; Kuehl and Troelstrup, 2013). Radhika *et al.* (2004) recorded elevated level of turbidity in monsoon could be attributed to mixing of dirt though runoff and soil erosion by rain.

pH

pH values ranged from 6.5 (Powai Summer) to 7.4 (Madh Monsoon, Paskal, Winter). Three lakes, Powai, Bandra and MNP were slightly acidic (pH-6.5 to 6.8). Rest of the lakes were reported to be alkaline throughout the sampling period. Seasonal mean value of pH was 7 in summer-winter and 7.1 in monsoon (Table 1.2). No abrupt shift in pH values was recorded during the study period with SD less than 1% at most of the lakes and maximum 4% at MNP lake in the winter season.

Dissolved Oxygen (DO)

The values for DO was highest in winter seasonamong all the sampling stations except for Madh lake. Minimum values for DO were recorded in summer season except at Sion and Powai lakes. Seasonal variation in DO was observed inall the studied lakes. Average mean DO values in summer, monsoon and winter were recorded as 3.7 (SD- 0.9), 3.8 (SD- 0.84) and 4.0 (SD- 0.83) respectively (Table 1.2).

DO in lake water ranged from 2.3- 53 mg/l in Powai lake(monsoon)) and Arey lake (winter) respectively. DO values were highest in Arey lake in all the seasons and it comes under the CPCB (2005) water quality standards suitable for outdoor bathing. This lake is surrounded by forest with a very little runoff entering the lake. Poor DO content in Powai lake could be attributed to sewage and surface runoffand pollution. DO values were above 4 mg/l in MNP, Madh, and Paskal lake in all the seasons whereas, Banganga and Sion lakes showed lower concentration of DO (Avg. 3.04 mg/l; SD= 0.49). Low concentration of DO in these lakes could be attributed to immersion religious offerings.

Biochemical Oxygen demand (BOD)

Mean average BOD values of lake water in Summer, monsoon and winter were recorded as 24 mg/l (SD-3.3), 20.77 mg/l (SD- 3.3) and 23.53 mg/l (SD- 2.9) respectively (Table 1.2). Seasonal variation (15-18%) in BOD was observed at most of the locations. According to the Central pollution Control Board India (CPCB) BOD values for any surface water should be less than 3 mg/l. This indicates high level of organic matter in the lakewater.

Lowest BOD values were recorded in Arey lake in all the seasons. It was the only lake where BOD values were around 15 mg/l throughout the study period. This lake is surrounded by natural forest which reduce the pollutants in the runoff entering the lake. BOD values were under 20 mg/l in MNP lakes. Sheetal lake also recorded higher BOD values. Results are indicating the impact of the watershed on the lake ecosystem. BOD values in Powai lake was attributed to sewage and runoff pollution.

Phosphate

Phosphate concentration is one the important indicator of eutrophication of water bodies. Lakes with phosphate values higher than 0.02 mg/l are considered as eutrophic in nature (Ramachandra, *et al.,* 2015). Phosphate level in the lake water showed very little seasonal fluctuation. Concentration of phosphate was 1.8 mg/l (SD = 0.40) in monsoon and 1.7 mg/l (SD = 0.3) during winter and summer seasons (Table 1.2). Highest level of phosphate was reported from Powai lake in winter (2.2 mg/l, SD = 0.12) and lowest from Arey lake (1.03 mg/l, SD = 0.37), in summer.

Values of phosphate were higher in Madh, Banganga and Paskal lakes duringthe studied period. Madh and Paskal lakes are used by local people surrounding the lake for washing clothes etc. Detergents used for washing have very high concentration of Phosphate. Higher phosphate values forBangangalake can be attributed to regular addition of organic materials in the form of religious offering such as rice balls, ghee etc.

Sulphate

Average values of sulphate ranges from 24.27 mg/ l, (SD = 3.35) – 37.9 mg/ l, (SD = 1.1) (Table 1.2 b). The highest value were reported from Paskal and Powai lakes. Least values were recorded from Banganga lake in summer. Lower values of sulphates were recorded from MNP, Arey, Sion and Banganga lakes (Table 6.12).

Highest mean average concentration of sulphate was reported in winter season (26.65 mg/l, SD = 3.706) followed by 28.66 mg/l, (SD = 2.28) in summer and least in monsoon season (24.27 mg/l, SD = 2.953) (Table 1.2).

Nitrate – Nitrite

Average mean values of nitrate were highest in summer season (0.95 mg/l, SD= 0.28), followed by winter (0.73 mg/l, SD= 0.16) and least in monsoon season (0.72 mg/l, SD= 0.34) Average values of nitrate ranges from 0.36 mg/l, (SD = 0.16) – 1.42 mg/l (SD = 0.37) (table 1.2). The highest value for nitrate was reported from Shyam Nagar lake (1.42 mg/l, SD = 0.3), in summer and lowest from Arey lake (0.3 mg/l, SD= 0.04) in winter. Nitrate values of Arey lake were lowest in all the seasons followed by Paskal lakes. These lakes are free from sewage. Higher values for nitrate were recorded from Powai, Sheetal and Bandra lakes, these lakes are situated in highly urbanised areas. Urban lakes throughout the world undergo a high level of nitrate- nitrate loadings from anthropogenic activities like excavation, vehicular pollution, runoff, building materials etc. as compared to other watersheds (Sharif, *et.al.*,2016**).** Overall mean concentration of nitrite was highest in monsoon season (0.017 mg/l, SD= 0.05), followed by in winter (0.015 mg/l, SD= 0.002) and least in summer season (0.013 mg/l SD= 0.004) (Table 1.2). The highest value was reported from Powai lake (0.023 mg/l, SD= 0.009) in monsoon and lowest from Sion lake (0.008 mg/l, SD= 0.001) in summer. Low values of nitrite were recorded from Arey and Paskal lakes. Higher values for nitrite were recorded from Shyamnagar and Bandra lakes. Lakes with highly urbanised watersheds showed higher value of Nitrite.

Electrical Conductivity

Electrical conductivity is measure of total dissolved solids (TDS) in water (NALMS). The seasonal average of conductivity was 846.1 µS/cm (SD= 153.6) during monsoon, 846.2µS/cm (SD= 175.1) in winter and 887.6 µS/cm (SD = 161) in summer. High fluctuation (18.13%- 20.69% SD) in values of conductivity was recorded in all season (Table 1.2). These higher values of conductivity could be attributed to evaporation of water in summers.

Average values of conductivity were lowest in Arey lake in all the seasons which were 400.06 µS/cm (SD = 43.7) in winter, 504.28 µS/cm (SD = 43.7) in monsoon and 533.43 µS/cm (SD = 259.0395) in summer. Highest value was reported from Powai lake in summer (1121.73 µS/cm, SD = 184.89).

Total hardness

Mean average values total hardness of all the lakes was highest in summer (101.7 mg/l, SD = 22.39)

and lowest in monsoon season (87.25 mg/l, SD = 21.14). Mean average values of total hardness was 98.24 mg/l, (SD = 21.83) in winter (Table 2) Significant seasonal variation from 22-24 % in values of hardness was recorded. These higher values of hardness were attributed to evaporation of water in summer. Water was found to be moderately hard as per guideline of APHA(2005).

Table 2. Seasonal mean values of water quality parameters of urban lakes of Mumbai

	Summer	Monsoon	Winter	Parameter
Minimum	47.32	40.32	47.51	**Water Transparency**
Maximum	84.19	85.12	92.31	**(cm)**
Mean	66.75	61.07	68.86	
Minimum	6.56	6.62	6.55	**pH. (mg/l)**
Maximum	7.41	7.43	7.41	
Mean	7.09	7.11	7.08	
Minimum	2.41	2.34	2.63	**DO (mg/l)**
Maximum	5.05	5.19	5.35	
Mean	3.79	3.8	4.03	
Minimum	17.42	13.5	17.43	**BOD (mg/l)**
Maximum	30.2	27.14	27.13	
Mean	24	20.7	23.53	
Minimum	1.03	1.19	1.11	**PO_4 (mg/l)**
Maximum	2.21	2.46	2.28	
Mean	1.74	1.8	1.74	
Minimum	0.61	0.41	0.36	**NO_3 (mg/l)**
Maximum	1.42	1.02	0.97	
Mean	0.95	0.72	0.73	
Minimum	0.008	0.01	0.01	**No_2 (mg/l)**
Maximum	0.01	0.02	0.01	
Mean	0.013	0.01	0.01	
Minimum	533.4	504.3	**400.1**	**Electrical Conductivity**
Maximum	1122	1040	**1029**	**(mmho/cm).**
Mean	887.6	846.1	846.2	
Minimum	68.33	54.2	64.42	**Total hardness (mg/l)**
Maximum	147.4	123.4	135.8	
Mean	101.7	87.25	98.24	
Minimum	24.26	24.86	26.65	**SO_4 (mg/l)**
Maximum	33.39	32.55	37.9	
Mean	27.31	28.65	30.18	

DISCUSSION

Pollution in the lakes is hindering the ability of the ecosystem to serve the city, which could be a vital asset for the city, if their ecological condition is revived. This study has provided a scientific data for planktonic, aquatic macrophyte diversity and water quality of selected lakes of Mumbai.

Physical and chemical parameters (pH, Temperature, Turbidity, BOD, dissolved oxygen, alkalinity, nutrients, hardness and heavy metals) when analysed to study pollution level in the lakes. Higher level of nutrients and BOD and low values of Turbidity, dissolved oxygen in lake water is indicating heavy organic pollution. Out of 12 lakes studied Powai, Sheetal and Shyam Nagar lakes were most polluted, whereas Arey and MNP lakes were the least polluted lakes.Lakes having vegetated catchment area recordedlow levels of nutrients and BOD in comparison with lakes surrounded by highly urbanised watershed.This establishes the importance of good vegetation cover for the health of lake ecosystem.

The study recommends that all the lakes should be conserved and protected from further degradation.

Urban lakes are an important resource of ecosystem services for the city. The policy makers should consider this study for ecological restoration of the lakes. Concretization of shoreline should be avoided and planting more trees should be taken into consideration. Eco-friendly methods such as construction of wetlands and bioremediation should be used for improving the water quality.

REFERENCES

Alam, M. Z., Carpenter-Boggs, L., Rahman, A., Haque, M. M., Miah, M. R. U., Moniruzzaman, M., and Abdullah, H. M. 2017. Water quality and resident perceptions of declining ecosystem services at Shitalakka wetland in Narayanganj city. *Sustainability of Water Quality and Ecology,* 9: 53-66.

BMC 2015. http://www.mcgm.gov.in/irj/portal/anonymous?NavigationTarget=navurl://35c3d6226ea0411f54de929d60eabd06andguest_user=englis (Accessed October 2015).

Brill, G., Anderson, P. and O'Farrell, P. 2017. Methodological and empirical considerations when assessing freshwater ecosystem service provision in a developing city context: Making the best of what we have. *Ecological Indicators,* 76: 256-274.

CPCB (Central pollution control board) (2005). Status of Sewage Treatment in India, 13 pp.

Crittenden, J. C., Trussell, R. R., Hand, D. W., Howe, K. J., and Tchobanoglous, G. (2012). *MWH's water treatment: principles* and *design*. John Wiley and Sons, 92-93 pp.

Gazetteer of Bombay Presidency, Volume XIII, Thana District, 1882. The Volume was edited by Mr. JAMES M. CAMPBELL.126-128 pp.

Kagalou, I., Papastergiadou, E., Tsimarakis, G., and Petridis, D. 2003. Evaluation of the trophic state of Lake Pamvotis Greece, a shallow urban lake. *Hydrobiologia*, *506*(1-3): 745-752.

Kuehl L.C., Troelstrup Jr, N.H. 2013. Relationships between net primary production, water transparency, chlorophyll a, and total phosphorus in Oak Lake, Brookings county, South Dakota. *Proc. of the South Dakota Academy of Science,* 92:67-7..

Radhika C., Mini, l and Ganga Devi T., 2004. Studies on abiotic parameter of a tropical freshwater lake Vellayani lake Trivendrum Kerala. *Poll. Res.* 23(1):49-69.

Ramachandra, T. V., Durga Madhab Mahapatra, M. D. Subash Chandran, V. Sincy, K. S. Asulabha, G. R. Rao, Vishnu D. Mukri, and C. A. Akhil. (2015). Rejuvenation and Sustainable Management of Gokarna Temple Pond-Kotiteertha. ENVIS Technical Report 99, CES, Indian Institute of Science, Bangalore 560012 ENVIS Technical Report 99.

Sharif, Hatim O., Farhan H. Al-Juaidi, Abdulaziz Al-Othman, Ibrahim Al-Dousary, EyadFadda, Salem Jamal-Uddeen, and Almoutaz Elhassan 2016. Flood hazards in an urbanizing watershed in Riyadh, Saudi Arabia.*Geomatics, Natural Hazards and Risk* 7: 702-720.

TERI (The Energy Research Institute) (2014). NMMC . Environmental Status Report Pp. 201-203.

Yadav, K., Nikhil, S. V. andPandav, C. S. 2011. Urbanization and health challenges: need to fast track launch of the national urban health mission. Indian Journal of Community Medicine, 36(1): 3.