STUDY ON POLLUTION SOURCES, WATER QUALITY AND CONSERVATION OF RANKALA LAKE, KOLHAPUR, INDIA

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ABSTRACT

Rankala Lake is situated in the heart of Kolhapur city of Maharashtra. The lake was earlier used for providing drinking water to Kolhapur city but now confined to irrigational and recreational use. Presently, lake serves as a popular picnic spot for the tourists and local residents. Four nallas are contributing sewage to Rankala Lake thus heavily polluting the lake. Lake is turning green since 2011 because of the presence of these blue green algae. The present paper is aimed to evaluate various pollution aspects like water hyacinth, pesticide and heavy metals contamination in lake water, sewage flow into lake and other activities like the submersion of Ganesh idols, cattle washing which are the main pollution causes of Rankala Lake water and steps required for lake conservation. The physicochemical parameters of lake like BOD, TDS, TS, DO, pH, chlorides, hardness, conductivity, turbidity, and alkalinity were analysed. To determine the pollution status of the lake water quality index is calculated and it showed very poor quality of the lake water. Overall water quality analysis of the Rankala Lake suggested that though the pollution is in moderate condition but continues supply of sewage is augmenting the severity of water pollution.

Keywords: Blue Green Algae, Recreational, Sewage Flow, Water Hyacinth, Water Quality Index

I. INTRODUCTION

Rankala Lake located in Kolhapur city of Maharashtra is a manmade lake constructed during the reign of Chhatrapati Shahu Maharaja. Rankala Lake is situated on the west side of the very famous Mahalaxmi temple having elevation of 550 m above sea level. The catchment area and total water spread area of the lake is 700 and 107 ha respectively whereas the maximum depth is 15m. Command area under irrigation is 80 ha of land in and around the city. The average annual rainfall in the lake catchments area is 1000 mm. It is having a fan type catchment. The lake was earlier used for providing drinking water to Kolhapur city but now confined to irrigational and recreational use [1]. The total storage capacity and the useful capacity of the lake water is 43, 40, 141 M^3 and 27, 45, 042 M^3 respectively.

Rajghat and Marathghat are the two ghats for the lake. On the Rajghat there is a Rankala tower and wall is constructed around the Rankala Lake. There are two major streams as source of water to the lake which flows from southern side. From three out-lets the water drains to irrigate 80 hectares of land of Mirabag, Dhunyachi Chavi, Phulewadi. As Rankala Lake is located in the center of the city, there are many sewage terminals pouring sewages in the Rankala lake water and thus heavily polluting the lake.

II. AIMS AND OBJECTIVES

To recognise the main sources of pollution which are contributing in lake and water quality analysis to ascertain the present pollution status of the lake and suggesting appropriate measures to maintain water quality of lake and lake conservation measures for future.

III. MATERIALS AND METHODS

3.1 Study Area Characteristics

The Rankala Lake is spread in an area of about 6682 ha in the Southern part of Maharashtra and in the Western Ghats at 550 m above mean sea level between 16^{O} 42" N Latitude to 74^{O} 14" E Longitude. It is located in area where there is a gradual change in land forms from hilly west to the bare open east. Land use and land cover percentage of Rankala lake catchment area is given in Fig. 2. Kolhapur is located in Panchganga river basin which is formed by the tributaries that is Kasari, Kumbi, Tulsi, Dhamani and Bhogavati. The Rankala Lake is shown in fig. 1 is an image taken from Indian satellite BHUVAN.

Fig. 1: Satellite Image of Rankala Lake [2]

The minimum and maximum temperatures of the Kolhapur city are 15^{0}C and 40^{0} C respectively with the average temperature is 27^{0}. Three fourth of annual rainfall occurs between June to September and average annual rainfall is 1025 mm. The wind direction in the city is from western side about 5 km/hr. The relative humidity in the atmosphere is about 55 %. The geology of Kolhapur is been consisted by the Deccan traps with inter-trapped beds. In the form of horizontal sheets and beds volcanic lava flows are spread out. The rock type is primarily of igneous basalt types. The soil type consists of black soil and red soil.

Rankala Lake supports aquatic flora and fauna. A lot of aquatic life and fish culture is recorded in Rankala Lake and thus 24 different types of fishes are recorded in the lake. It is an important bird area. Many bird and wildlife species gets attracted by it. Nearly 5000 birds of 74 species for example *grebes*, *spoonbills*, *cormorants*, *shop bird*, *ibises*, *cooches*, *jacanas*, geese , *ducks* and other migratory birds from Central Asia, Siberia and Europe

gathered in and around the lake and from which 20 species are the aquatic ones showed by the "Asian Waterfowl" 1994-96 census. Other fauna like 11 species of snakes and 2 species of lizards have been recorded in lake area. In the marshes 7 species of insects are found of "Partala" region and around the lake water.

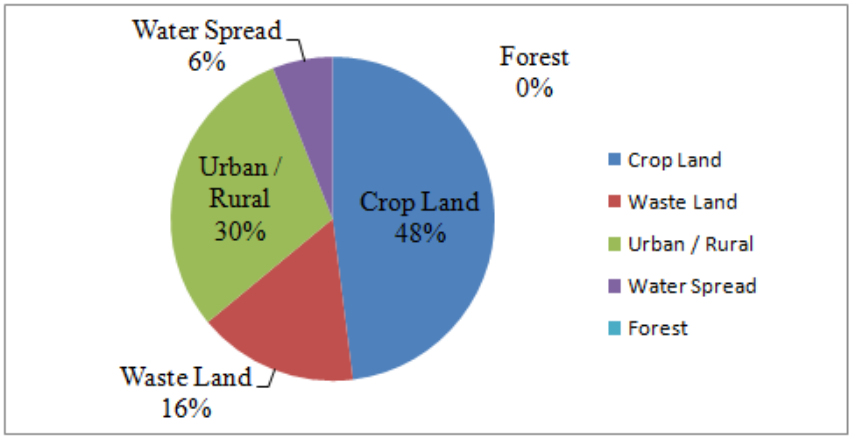

Fig. 2: Rankala Lake Land use & land cover percentage [3]

3.2 Pollution Sources in Rankala Lake

Due to increased urbanisation and uncontrolled human interference and encroachment the lake is under severe threat of pollution due to thousands of litters of sewage entering into its body as well as due to the solid waste dumping practises in the lakes catchment. Being the location of this lake in centre of the city, there are many sewage terminals pouring sewages in the lake water and therefore heavily polluting the lake. Wastewater flows into the lake through various drains entering the lake on its southern, western and south eastern sides. There are mainly 4 nallas which are sources of sewage and major cause of lake pollution to Rankala Lake which are located in Fig.3.

1. Sham Society Nalla – 8 MLD (Fig. 5 (a))
2. Sairnaik Colony Nalla – 0.9 MLD
3. Partala Nallla – 0.4 MLD
4. Deshmukh Nalla – 0.1 MLD

Fig 3: Sources of Sewage to Rankala Lake and Water Sampling Points in Rankala Lake

3.2.1 Water Hyacinth

Streams carrying the sewage from the lake catchment are the main sources of pollution and subsequent deterioration [4]. The deteriorating water quality is reflected in profuse growth of water hyacinth as well as other submerged plants like *hydrilla*. In this lake, the *Eichhornia crassipes* plant species were growing enormously up to 2008 and they occupied whole lake 3 times [5], but in the year 2009 *Eichhornia* seems to be replaced by *Salvinia molesta* which also occupied whole lake. The enormous growths of these plants indicate the nature and volume of pollution of Rankala Lake which shows the initiation of eutrophication. The large area and good sunlight, supports rapid growth of aquatic/eutrophic plants like *Salvinia*, *Eichhornia*, *hydrilla* and other macrophytes in the lake. The growth of water hyacinth in Rankala Lake is shown in Fig 4 (b).

3.2.2 Pesticide Contamination and Heavy Metals

Because of rapid urbanization, increasing use of fertilizers and pesticides in the agricultural land around, the lake is subjected to great amount of ecological stress. The lake water is polluted by pesticide residues entering through the irrigation of agricultural lands in vicinity. The residues of eleven pesticides have been found in the water. The lake water is also found to be contaminated by heavy metal ions like Pb, Cr, Zn and Cd probably entering from industrial waste, through drainage and battery industries in the vicinity [6]. The mixing of sewage and agricultural waste, results into the increase of organic matter, silt and nutrients like nitrogen, potassium and phosphorus in the lake.

3.2.3 Other Activities

There are many activities which are contributing in lake pollution. Following are some activities mentioned:

- Draining of several terminals of sewage
- The submersion of Ganesh idols, Nirmalya
- Food wastages
- Cattle washing, mass bathing, cloth washing, vehicle washing
- Adding human waste, manures
- The dumping of batteries
- Effluents from the electroplating industries, leather industry effluent
- Leaching of the residue due to rain water and effluent to the lake water

These activities are contributing to the pollution in significant amount. Contribution of animal washing, cloth washing and solid waste dumping in lake pollution is shown in Fig. 4 (c) and Fig. 4 (d) respectively.

(a)

(b)

(c) **(d)**

Fig 4: (A) Shyam Society Nallah (B) Water Hyacinth in Rankala Lake (C) Animal Washing, Cloth Washing In Rankala Lake (D) Solid Waste Dumping In Rankala Lake

3.3 Present Status of the Rankala Lake

Rankala Lake was earlier used for providing drinking water to Kolhapur city but is now limited mainly to irrigational and recreational use. Presently, lake serves as a popular picnic spot for the tourists and local residents.

Because of increased N, P, K content in Rankala Lake, there is algal bloom of blue green algae. Because of the presence of these blue green algae, the water has become green in colour. Lake is turning green since 2011 in every August as this year also. The algae is continuously increasing, multiplying and dyeing, this cycle is continuous. The dead algal blooms are floating on the water surface coming towards the bank near dense population at east direction of lake, causing malodour, nussainase and blind mosquitoes. Last 2 years the lake totally covered by blue green algae which are dissolved from top to bottom in Lake Waterbody, as this algae is fully dissolved in water, it is difficult to remove the algae by traditional methods (boat, pock lain, JCB, dumpers) adopted before for the removal of *Salvinia molesta* and *Eichhornia crassipes*. The presence of blue green algae in Rankala Lake is shown in Fig. 5.

Fig. 5: Rankala Lake Turning Green Due To Blue Green Algae

3.4 Water Quality Analysis

Water samples were collected from the study area. The sampling locations were selected on the basis of their proneness to pollution, approachability etc. On the basis of above criteria, sampling points were points were selected which are shown in Table 1. To study the various effects on the lakes, water samples were collected from various points of the lakes were taken and analyzed. The data of the physicochemical analysis of lakes like BOD,TDS, DO, pH, chlorides, hardness, conductivity, turbidity etc.

Table 1: Sampling Locations and Co-Ordinates

Sampling Locations	**keywords**	**Co-ordinates**	**Elevation above MSE**
Infront of shalini palace	S1	16^{O} 41’497’’ N 74^{O}12’338’’ E	560 m
Infront of Rankala Tower – Rajghat	S2	16^{O} 41’658’’ N 74^{O}12’855’’ E	560 m
Near Padma Ghat	S3	16^{O} 41’119’’ N 74^{O}12’889’’ E	558 m
Near Irani Khan	S4	16^{O} 41’070’’ N 74^{O}12’620’’ E	560 m
Sham Society nallah	S5	16^{O} 40’922’’ N 74^{O}12’668’’ E	558 m

3.4.1 Water Quality Analysis Results of Rankala Lake

Sampling was done through various experimental methods to check the various physic chemical parameters along with the metal analysis. The results of the sampling are given in Table 2.

Table 2: Water Quality Analysis Results

Parameters	Infront of Shalini Palace **S1**	Rajghat **S2**	Near Padma Ghat **S3**	Near Irani Kahn **S4**	Sham Society Nallah **S5**
pH	7.8	8.2	8.3	8.6	7.9
DO (Mg/L)	6.8	6.6	5.9	5.6	5.29
BOD (Mg/L)	2.8	3.2	3.36	4.02	3.81
TS (Mg/L)	223.6	203.8	196.5	201.2	283
TSS (Mg/L)	58	40	28	35	53
TDS (Mg/L)	165.6	163.8	168.5	166.2	230
Coductivity (µs/cm)	344	341	350	346	469
Chlorides (Mg/L)	59.56	51.05	59.56	59.56	53.89
Alkalinity (Mg/L)	44	36	44	44	24
Total Hardness (Mg/L)	132	124	124	116	168
Calcium Hardness (Mg/L)	30.27	28.59	30.27	30.27	50.46
Magnesium Hardness (Mg/L)	24.82	23.28	22.87	20.91	28.67
Tubidity (NTU)	27	17	45	41	27
Salinity	0.1	0.1	0.1	0.1	0.2

3.4.2 Water Quality Index (WQI)

For the calculation of water quality index the weighted arithmetic index method has been used [7, 8]. In this study ten important parameters were chosen for the calculation of water quality index. The WQI has been calculated by using the standards of drinking water quality recommended by the Indian council of Medical Research (ICMR) and Bureau of Indian Standards (BIS) which is given in Table 4 and has been used for the calculation of WQI of the Rankala Lake. Further quality rating (Qn) was calculated using the Equation 1:

Equation 1: $Qn = \{100 * [(Vn-Vio / Sn-Vio)]\}$

Where,

Qn = Quality rating for nth water quality parameter.

Vn = Estimated value of nth parameter at a given sampling location.

Sn = Standard permissible value of the nth parameter

Vio = Ideal value of the nth parameter in pure water.

In most cases ideal value Vio = 0 except in certain parameters like dissolved oxygen and pH. The quality rating calculation for the DO and pH (Vio $\neq$ 0) is 14.6 mg/l and 7.0 respectively. Unit weight (Wn) is calculated by Equation 2. It is a value inversely proportional to the recommended standard values Sn of the corresponding parameters.

Equation 2: $Wn = (K/Sn)$

Where,

Wn = Unit weight for nth parameter

Sn = Standard value for nth parameters

K = Proportionality constant.

The overall water quality index is calculated by aggregating the quality rating with the unit weight linearly. It is given in Equation 3.

Equation 3: $WQI = [(\Sigma QnWn) / (\Sigma Wn)]$

The range of water quality index and status of water quality as worked out is given in Table 3 and a sample calculation of water quality index for S1 sampling site is given in Table 5. The water quality index calculations for rest of the sampling sites were performed by the same method.

Table 3: Status of the Water Quality Based On the Range Of WQI [7, 8]

Range of WQI	Status of Water Quality
00 – 25	Excellent for Drinking
26 – 50	Good for Drinking
51 – 75	Poor for Drinking
76 – 100	Very Poor for Drinking
< 100	Unsuitable for Drinking

Table 4: Drinking Water Standards by Recommended Agencies and Unit Weights [9, 10]

Parameter	**Standard Units: (Sn)**	**Recommended Agency**	**Unit Weight**
pH	6.5-8.5	[ICMR],[BIS]	0.2190
DO (Mg/L)	5	[ICMR], [BIS]	0.3723
BOD (Mg/L)	5	[ICMR], [BIS]	0.3723
TDS (Mg/L)	500	[ICMR], [BIS]	0.0037
Conductivity (Milli moles)	300	[ICMR]	0.371
Total hardness (Mg/L)	300	[ICMR], [BIS]	0.0062
Calcium Hardness (Mg/L)	75	[ICMR], [BIS]	0.025
Magnesium Hardness (Mg/L)	30	[ICMR], [BIS]	0.061
Total Alkalinity (Mg/L)	120	[ICMR]	0.0155
Chlorides (Mg/L)	250	[ICMR]	0.0074

Table 5: Sample Calculation of Water Quality Index of Sample 1 (S1)

Parameters	**Observed Values: (Vn)**	**Standard Value: (Sn)**	**Unit Weight: (Wn)**	**Quality Rating: (Qn)**	**Wn*Qn**
pH	7.8	8.5	0.2190	53.33	11.67
DO (Mg/L)	6.8	5	0.3723	81.25	30.24
BOD (Mg/L)	2.8	5	0.3723	56	20.84
TDS (Mg/L)	165.6	500	0.0037	33.12	0.1225
Conductivity (Milli moles)	344	300	0.371	114.66	42.53
Total Hardness (Mg/L)	132	300	0.0062	44	0.2728
Calcium Hardness (Mg/L)	30.27	75	0.025	40.36	1.009
Magnesium Hardness (Mg/L)	24.82	30	0.061	82.73	5.046
Total Alkalinity (Mg/L)	44	120	0.0155	36.66	0.5682
Chlorides (Mg/L)	59.56	250	0.0074	23.82	0.1762
			ΣWn= 1.4534		ΣWnQn= 112.47
			WQI = {[ΣQnWn] / [ΣWn]} = 77.38		

IV. RESULTS

Table 6: Results of Water Quality Index

Sample Location	WQI
Infront of shalini palace (S1)	**77.38**
Infront of Rankala Tower – Rajghat (S2)	**83.39**
Near Padma Ghat (S3)	**87.91**
Near Irani Khan (S4)	**94.70**
Sham Society nallah(S5)	**99.37**

V. DISCUSSION

Water quality index of the present lake is established from important various physicochemical parameters. The results obtained for water quality index is shown in Table 6. The pH of the lake water was found to be in the range of 7.8 to 8.6 and this range of pH is favourable for the growth of flora and fauna. Total solids were found to be in the range of 200 to 290 mg/l. Most of the lakes have chloride concentration of about 50 mg/l. Based on the calcium hardness lake water can be classified as rich in inorganic constituent. The water quality index study clearly showed that the status of the Rankala Lake is very poor showing eutrophic nature of the lake and it is unsuitable for the human uses.

Overall water quality analysis of the Rankala Lake suggested that though the pollution is in moderate condition as main use of Rankala Lake is for recreation purpose but continues supply of sewage is augmenting the severity of water pollution.

VI. CONCLUSIONS

From the present study, it is found that there are 4 major sewage terminals pouring sewages in the Rankala lake water and thus heavily polluting the lake. In Lake catchment area, insufficient underground drainage system was also observed. Based on water quality index status of the lake was found to be very poor. Eutrophication promotes excessive plant growth and decay, favours certain weedy species over others, and is likely to cause severe reductions in water quality. Washing of animals, clothes, vehicles, bathing activities, immersion of Ganesh idol and Nirmalya, disposal of remains of fast foods at Chaupati in lake, are also contributing pollution in the lake. Following some suggestions are made for the conservation of lake.

1. Prevention of pollutant inflows into lake
2. Removal of submerged and floating aquatic weeds from the Rankala lake
3. Catchment treatment plan for the Rankala Lake
4. Proper disposal of solid waste in the Rankala Lake catchment area

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