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Restoration Of Ground Water In Katraj Lake Basin By Determination Of Water Quality Index, Pune, Maharashtra

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Abstract— Water pollution as a consequence of accelerated industrial growth has drawn concerns over public health and environment. Water quality index (WQI) is valuable and unique rating to depict the overall water quality status in a single term that is helpful for the selection of appropriate treatment technique to meet the concerned issues. This paper elaborates on the WQI concepts and current scenario of Katraj Lake which will help in future as natural potable ground water resource. It also focuses on case scenario of calculating WQI using Weighted Arithmetic Water Quality Index an example dataset. The quality of water way to evaluate by testing various physico-chemical parameters such as pH, Total Dissolved Solid (TDS), Total Hardness , Chlorides, Phosphates, Turbidity and Chemical Oxygen Demand (COD) .

Keywords- Quality, Status, WQI, Dataset, Parameter

I. INTRODUCTION

It is well known that hygienic water is undeniably essential for healthy living. Rivers and Lakes are the most important natural resource for human development but they are getting polluted by indiscriminate disposal of sewage, industrial waste and plethora of human activities, which affects its physicochemical and microbiological quality. As deterioration of river and Lakes water quality increasing day by day, it is necessary to monitor the water quality so as to evaluate the production capacity Water quality. Water management practices need a fresh look in order to avoid water crisis in the next successive days. This essentially requires looking for proper management practices for growing economy and population as the water resources of the basins remain almost constant while demand of water for various purposes is increasing.

A. Present Water Supply And Demand Scenario For Pune City

Annual water supply for Pune city is almost 15-16 TMC but today's requirement is 19TMC [13,14]. The two Katraj Lake, which supplied water to old Pune, still harvest huge quantities of water. Volume of the Katraj Lake is almost 1.05 TMC. Many builders used to available water at Katraj Lake for building apartments, complexes in Katraj and its vicinity. Utilizing these types of water sources within and around the city can help Pune's water supply system. Especially in the fulfillment of water demand of nearby areas like Dhankwadi, Ambegoan etc. Today's requirement for this area is up to 0.83 TMC [14]. If it should be possible to do reintegrate water supply in Katraj lakes then the over burden on Parvati water treatment plant will be minimum; which currently provide water in this area.

B. Location and History

Katraj Lake is located in Rajiv Gandhi Zoological Park in Katraj, Pune situated at the bottom of hill ranges of Katraj ghat in Sahyadri hills (18°27′13″N 73°51′42″E). Katraj Lake is manmade water body reservoir and it was developed by Sardar Tulshibagwale in 1750. At that time, the prime purpose of building the Katraj Lake was to supply water to the city of Pune using gravity flow. Katraj Lake was placed at high altitude level than any other part of Pune city so that it got more effective water supply distribution system. In fact, the Katraj Lake comprises two separate lakes, created by two dams that were built on the Ambil Odha in 1775. One lake acts as a sedimentation tank while the main (upper) lake acted as the water reservoir [9,15]. Apart from rains in the catchment area, the main lake is also supplied water by many natural springs. The Katraj Lake covers an area of about 82 hectares. This water supply system has huge ducts and underground tunnels originating from Katraj Lake to the historic place Shaniwarwada. This Earthen duct is about 0.75 m wide and 2 m high, from Katraj to Shaniwarwada there are about 125 openings. This 8 km long duct opens out as a series of water tanks at Shaniwarwada and the nearby area. Even today several part of city gets water through an underground earthen pipeline [9]. Some of these, such as the Kala Haud and the Nana Haud, are still functional. At that time it is said that this water supply scheme was able to supply approx. 29 lakh liters of water per day [11]. This underground water supply system is considered an engineering marvel as it could supply water to practically the whole of Pune without the need for motors and pipelines, which are used at present. This Katraj water supply scheme played vital role as Pune was flooded when Panshet tumbled down in 1961. Today however, water from the Katraj reservoirs is not potable and is not used as drinking water.

Figure.1: Study area Katraj Lakes Location in Pune City from

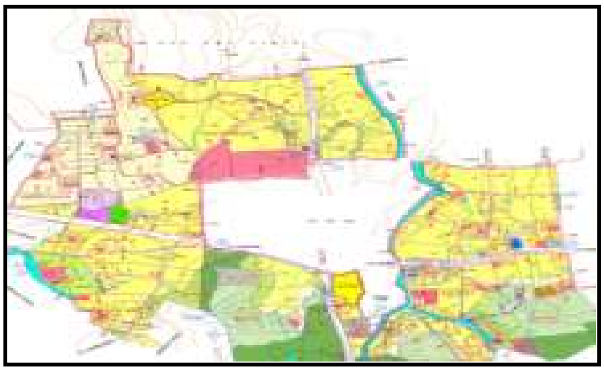

Figure.2: Study area – Municipal area suffering water scarcity in Pune

II. WATER QUALITY INDEX FOR KATRAJ LAKE

The water quality generally defined as its fitness for the beneficial uses for drinking by people & animals, for support of aquatic life, irrigation of land and for recreation [8]. The degradation in the quality of water is however a direct effect of human interference in Natural Cycles. Though this interference affects the quality of water locally as well as on global scale but the studies in a particular area shows that the fresh water quality can be improved. WQI summarizes the relative changes in the underlying group of the water-quality variable. A water quality index provides a single number (like a grade) that expresses overall water quality at a certain location and time based on several water quality parameters [1,7]. The objective of an index is to turn complex water quality data into information that is understandable and useable by the public. A single number cannot tell the whole story of water quality; there are many other water quality parameters that are not included in the index. The index presented here is not specifically aimed at human health or aquatic life regulations. However, a water index based on some very important parameters can provide a simple indicator of water quality. This gives a general idea that the possible problems with the water in the region can be overcome.

A. Method Used For Assessment of Water Quality Index in Katraj Lake:

Initially, WQI was developed by Horton (1965) in United States by selecting ten most commonly used water quality variables like dissolved oxygen (DO), pH, coliforms, electrical conductivity alkalinity and chloride etc. and has been widely applied and accepted in European, African and Asian countries. The assigned weight reflected in significance of a parameter for particular use and has considerable impact on the index. Then after a new WQI similar to Horton's index has also been developed by the group of Brown in 1970, which was based on weights to individual parameter. Recently, many modifications have been considered for WQI concept through various scientists and experts. The values of parameters are harmful for human health if they occurred more than defined limits Table no. 1. Shows the Parameters in defining water quality can be grouped into three board categories: physical, chemical, and biological.

Table 1. Parameters to Define WQI

Physical Factor	Chemical Factor	Biological Factor
Water Temperature	pH	Ephemeroptera
Total dissolve solids	BOD	Trichoptera
Odour of water	COD	Lecoptera
Color of water	Heavy metals	E.coli
Taste of water	Dissolved oxygen	Coliform Bacteria
Total suspended solids	Total Hardness	
Turbidity	Orthophosphates	

B. Weighted Arithmetic Water Quality Index Specifications

The Weighted arithmetic water quality index method classified the water quality according to the degree of purity by using the most commonly measured water quality variables. The method has been widely used by the various scientists and the calculation of WQI was made by using the following equation.

$$WQI = \frac{\sum Q_i W_i}{\sum W_i}$$

The quality rating scale (Qi) for each parameter is calculated by using this expression:

$$Q_i = 100 \left[\frac{V_i - V_0}{S_i - S_0}\right]$$

Where,

V_i is estimated concentration of i^{th}parameter in the analysed water .

$V_0$is the ideal value of this parameter in pure water.

V_0= 0 (except pH =7.0 and DO = 14.6 mg/l).

$S_i$is Recommended standard value of i^{th}parameter.

S0is Maximum permissible limit

The unit weight (W_i) for each water quality parameter is calculated by using the following formula:

$$W_i = \frac{k}{S_i}$$

Where, K = proportionality constant and can also be calculated by using the following equation:

$$k = \frac{1}{\sum \frac{1}{S_i}}$$

Table 2. WQI Rating as per Weighted Arithmetic WQI

Water Quality Index Value	Rating of Water Quality	Grading
0-25	Excellent Water Quality	A
26-50	Good Water Quality	B
51-75	Poor Water Quality	C
76-100	Very Poor Water Quality	D
Above 100	Unsuitable for Drinking Purpose	E

C. Pros and Cons of Weighted Arithmetic WQI

Incorporate data from multiple water quality parameters into a mathematical equation that rates the health of water body with number. Overall less number of parameters required in comparison to all water quality parameters for particular use. It is useful for communication of overall water quality information to the concerned citizens and policy makers. It reflects the composite influence of different parameters i.e. important for the assessment and management of water quality. This properly describes the suitability of both surface and groundwater sources for human consumption. At the same time these points should not be get neglected such as WQI may not carry enough information about the real quality situation of the water. Many uses of water quality data cannot be met with an index. There may be the possibility of eclipsing or over-emphasizing of a single bad parameter value. A single number cannot tell the whole story of water quality; there are many other water quality parameters those were not included in the index. WQI based on some very important parameters can provide a simple indicator of water quality. All these WQI models have been developed for flowing or standing water resources such as lakes, rivers, streams, etc. The WQI takes the complex scientific information and synthesizes into a single number between 0 and 100.

III. MATERIAL AND METHODS

The samples were collected in one liter polythene cane and thoroughly washed thrice with water to be analyzed. The samples were collected on the 10th day of every month around 10.00 a.m. between February 2013 to July 2013, 20cm below water surface and 3cm from the shore from a fixed point. For convenience the monthly samples of water are given the following abbreviated symbols namely S1-February 2013, S2-March 2013, S3-April 2013, S4-May 2013, S5-June 2013 and S6-July 2013. This indicates that four samples S1-S4were taken in the pre-monsoon and the S5-S6 in the monsoon period.

A. Water Quality Indices

a. pH: The hydrogen ion concentration is an important quality parameter of both natural waters and waste waters. The usual means of expressing the hydrogen ion concentration is as pH, which is defined as the negative logarithm of the hydrogen ion concentration. pH = - $\log_{10}$ (H+). The concentration range suitable for the existence of most biological life is quite narrow and critical which lies from 6-9. The high value of pH in river or lake water affects the water users.

b. Total dissolved Solids: A total dissolved solid indicates the salinity or degree of dissolved substances. The amount of total dissolved solids depends on the geological character of watershed, rainfall and amount of surface runoffs. The value of TDS for most of the samples in all the seasons exceed the limits of WHO (500 mg/l) and BIS (300 mg/l). . The total dissolved solid was obtained by gravimetric methods.

c. Total hardness: Determination of hardness of water is important because it causes scaling which results in blocking of pipes, thermal efficiency of air conditioners, scaling in boilers of industries. In presence of alkaline ions, calcium and magnesium cause cardiovascular diseases. EDTA method was used for determination of total hardness. It measures concentration of calcium and magnesium in water as total hardness. It is based upon the principle that the ethylene diamine tetra acetic acid and its sodium salt forms a chelated soluble complex when added to a solution containing metal cations. Very small amount of erichrome black T is added to the aqueous solution containing Ca and Mg, wine red coloured calcium and magnesium complex is formed at pH 10 +/- 1. After the addition of sufficient amount of EDTA to this complex, all the acid magnesium in the solution becomes blue from wine red, which is end point of titration. The hardness was determined by complexometric method.

d. Chlorides: Chloride adds in surface water through various sources such as atmospheric deposition of oceanic aerosols, weathering of sedimentary rocks, industrial effluents and agricultural run-off. High chloride contents in water makes it unfit for human consumption. The chloride concentration is higher in waste water because sodium chloride is unavoidable constituent of our diet which passes unchanged through digestive system. The phosphate content of the sample was obtained by colorimetric method.

e. Turbidity: Turbidity, a measure of the light - transmitting properties of water, is another test used to indicate the quality of water discharges and natural waters with respect to colloidal and residual suspended matter. In lake or other waters existing under relatively quiescent conditions, most of the turbidity will be due to relatively coarse dispersion. The domestic waste may add great quantities of organic and some inorganic materials that contribute turbidity. Certainly industrial wastes may be large amount of organic substances and others inorganic substances that produce turbidity. Turbidity also has role to change water quality of any water body. Therefore, it can be said that there is association between level of turbidity and water quality of any water body.

f. Chemical Oxygen Demand (COD): Chemical Oxygen Demand (COD) test determines the oxygen requirement equivalent of organic matter that is susceptible to oxidation with the help of a strong chemical oxidant. It is important, rapidly measured parameters as a means of measuring organic strength for streams and polluted water bodies. The test can be related empirically to BOD, organic carbon or organic matter in samples from a specific source taking into account its limitations. The open reflux method is suitable for a wide range of wastes with a large sample size. The dichromate reflux method is preferred over procedures using other oxidants (e.g. potassium permanganate) because of its superior oxidizing ability, applicability to a wide variety of samples and ease of manipulation. Oxidation of most organic compounds is up to 95-100% of the theoretical value. The organic matter gets oxidized completely by Potassium dichromate ($K_2Cr_2O_7$) with silver sulphate as catalyst in the presence of concentrated H_2SO_4 to produce CO_2 and H_2O. The excess $K_2Cr_2O_7$ remaining after the reaction is titrated with ferrous ammonium sulphate [$Fe(NH_4)_2(SO_4)_2$]. The dichromate consumed gives the oxygen (O_2) required for oxidation of the organic matter, Chemical oxygen demand (COD) values were determined by titrimetric method.

Table 3. Empirical Reading for WQI Calculation

Sr. No.	Parameter	Unit	Pre – Monsoon Sample				Monsoon Sample	
			S1	S2	S3	S4	S5	S6
1.	pH	-	7.74	8.12	6.60	6.61	6.65	6.45
2.	Turbidity	NTU	21	25	08	07	32	06
3.	Total Hardness	mg/lit	46.8	62.34	47.1	56.4	103.4	94
4.	TDS	mg/lit	600	140	170	230	400	300
5.	Phosphate	mg/lit	0.78×10^{-5}	0.6×10^{-5}	0.2×10^{-5}	0.18×10^{-5}	$0.3x \times 10^{-5}$	0.34×10^{-5}
6.	Chloride	mg/lit	67.4	16.124	31.027	46.5	185.8	354.85
7.	COD	mg/lit	126	120	136	180	160	186

IV. RESULT AND DISCUSSION

Table 4. Result value for WQI

Sr. No.	Parameter	Unit	Mean test results	MPL	Wi	Qi	Wi Qi
1.	pH	-	7.028	8.5	0.01138	82.68	0.9415
2.	Turbidity	NTU	16.5	5	0.01936	330	6.3881
3.	Total Hardness	mg/lit	68.34	300	0.00033	22.78	0.0073
4.	TDS	mg/lit	306.67	500	0.000194	61.334	0.0118
5.	Phosphate	mg/lit	4×10^{-5}	0.1	0.9679	0.04	0.0387
6.	Chloride	mg/lit	116.94	250	0.000387	46.776	0.0181
7.	COD	mg/lit	151.33	250	0.000387	60.532	0.0234

$$\mathrm{WQI} = \frac{\sum Q_i W_i}{\sum W_i}$$

$$\mathrm{WQI} = \frac{7.4289}{0.9999}$$

$$\boxed{\mathrm{WOI} = 7.4296}$$

From WQI Rating as per Weighted Arithmetic WQI is 7.4296 is in grading A hence water quality in Katraj lakes **Excellent Water Quality.**

pH of water is vital for the biotic compound because most of biotic plants and animals can endure in moderate range of pH. It was recorded 6.45 to 8.12. The marked difference in the pH values of S1 and S2 station clearly indicates that the lake is being polluted due to industrial rich dilution of alkaline substances. The turbidity values of the samples are ranges between 06 to 32 NTU with a maximum value of 32 NTU for S5 (Table 3). The obtained value of turbidity exceeds the Indian Standard and WHO standards. The reason for this is that Katraj Lake is a rain fed reservoir and has natural inlets from different areas surrounding hilly region. Hardness of water samples showed values in the range 46.8 to 103.4mg/lit. Calcium, Barium, Magnesium, Strontium etc. are the responsible elements for the total Hardness of water. Total dissolved solids indicate the salinity behavior of ground water. The total dissolved solids values ranged from140-600mg/lit (Table 3) with a maximum value for S1 and S2. It exceeds the Indian standard but it was in the maximum permissible limit of WHO. This variation is because of pollutants which come along with the effluents of the nearby industries and inlets. The chloride range from 16.124 to 354.85 mg/lit shows a marked difference shows chloride impurities during the monsoon period may be because of oils, heavy metals, grease, toxic material and inlets of rain water. COD values for water samples are from 120 to 186 mg/lit. The values of COD are in limit according to Indian Standard.

V. CONCLUSION

Water quality standard vary significantly due to different environmental conditions, with unbalanced ecosystem. It is possible to get maximum utilization of Katraj lakes as natural water supply source for nearby area likes Dhankawadi and Ambegoan, so that over burden form Parvati water treatment plant will be minimum up to some extends (Fig no.2). From above result we forecast that water stored in Katraj lake do not require as much unit operations and unit processes like other conventional filtration plants. Monsoon water naturally gets filtered in lake water body; so it performs as sedimentation basin. Turbidly and total hardness can be control with simple filtration processes like gravity filtration and reverse osmosis along with natural softeners respectively. Water distribution system will also be more economical to that area because of typical topographic feature. For that some restoration actions need to be executed seriously like environmental awareness, Plantation, conservation of natural water sources and its beautification. The conservation of this heritage structure could be an excellent tourist place and so one of the revenue generation sources for municipal authorities. In conclusion it is possible to make water in Katraj Lake as potable with proper conservation and rehabilitation.

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