Restorative Option of Katraj Lake Water for Domestic Use in Emergency

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Abstract-After stone-age man started to live on the banks of river and lakes, human societies developed and grew on the banks of river and lake. The purpose of this was that man use water for various purposes like drinking and irrigation. After the growth of industrialization and urbanization, there has been an increased pollution load on the rivers in India. The most important sources of pollution in rivers and lakes are the untreated sewage and direct discharge of waste water in sewage. Due to direct discharge of waste water in the river and lake bodies, the water gets polluted and affects the aquatic life and also causes a lot of water epidemic diseases. This affects the water quality and ecology. Factors such as types of industries, habits of people and non-point sources are responsible for the increase of the wastewater discharged into water body. Increase in globalization and industrialization country faces the various challenges for providing clean and safe water to the public. In terms of its quick growth and development, Pune city becomes one of the growing and emerging cities of India. More and additional individuals from outside city are migrating into Pune town. The population increase in Pune throughout the last 2-3 decades has been significantly fast with a resultant outcome on the rise of pollution level. In this paper study is concentrated on Katraj Lake water pollution and curative measures. It is a perennial urban pond, located close to temple and encircled by the city slum and human habitation, that is employed by inhabiting individuals around it for numerous activities like bathing, fishing, washing clothes, and dumping sewages etc. The focus of this study is to analyse physical and chemical properties of lake water so that quality of discharged water is improved. Also to design water treatment plant to reuse lake water as an emergency supply in nearby area. Generally, in summer season there is always scarcity of water in Katraj Area. We can use this treated water wherever required for domestic purpose by tankers.

Keywords- Katraj Lake, Water Quality, Analysis, Design, Reuse

I. INTRODUCTION

Katraj lake is located in Pune city, constructed in 1750 by BalajiBajiraoPeshwa, the water system comprises huge ducts and underground tunnels originating from Katraj lake of the city to the historic Shaniwarwada fort. Conveyance system from Katraj Lake to the historic place Shaniwarwada's supplied water for all the fountains in the fort. Even today, several old Wadas and tanks in the city get water through an underground earthen pipeline. Water of the lake is also used for recreation purposes and plantations. The water level of the lake is controlled by a unique Persian water control system. The entire system works under the action of gravity. In ancient time the lake water was used for drinking purposes. But now a day, the water is polluted due to some unauthorised discharges of wastewater from the nearby area. In the present study water quality analysis was done for all three seasons. After the findings, it is decided that lake water can be used after treatment for domestic purpose in emergency.

II. METHODODLGY

A) Dimensional Data of Katraj Lake

Area of the Lake	: 3002 x 102 m^2
Volume of the Lake	: 3002000 m^3
Maximum length	: 790 m
Depth	: 8-10 m
Shape	: Sub rectangular

Classification:

Based on presence of outlet	: Open Lake
Based on the nature of inflow	: Seepage Lake.
Based on shape	: Sub rectangular lake.

B) Sampling:

The lake has prominent locations of unauthorised discharge points of wastewater and also natural surface runoff discharge. The water samples of the present lake were collected from the maximum unauthorised wastewater discharge. The three different points of the lake are located for physico-chemical analysis in Monsoon, Winter and Summer in the year 2018-19[1][2]. The samples for analysis were collected in sterilized bottles using standard procedure in accordance with the standard method of American Public Health Association (1995). In this study surface water samples are collected and analysed in the laboratory[3]. The parameters examinedin the laboratory are:

a) pH,	b) Chemical Oxygen Demand,
c) Alkalinity,	d) Total Dissolved Solids,
e) Hardness	f) Biochemical Oxygen Demand,
g) Turbidity,	h) Dissolved Oxygen,
i) Mercury,	j) Electrical Conductivity
k) Irons.	

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Figure 1: Unauthorized Discharge into Lake

C) Analysis and Test Result Table:

After physic-chemical analysis, the results obtained from the laboratory are shown in the following tables. These result tables include the maximum values of all three samples and compared with the permissible limits of BIS-10500[11].

Table No. 1: Parameters in Monsoon

S. N.	PARAMETER	Sample 1 Result	Sample 2 Result	Sample 3 Result	PERMISSIBLE VALUE
1	Colour (Hazen units)	8	8.5	8.3	15
2	Odour	Agreeable	Agreeable	Agreeable	Agreeable
3	Taste	Not Agreeable	Not Agreeable	Not Agreeable	Agreeable
4	Turbidity (NTU)	3.0	3.7	4	1-5
5	DO (mg/lit)	6.0	6.3	5.8	6-8
6	pH	6.01	6.5	6.3	6.5-8.5
7	COD (mg/lit)	**298**	**289.0**	**278**	10
8	BOD (mg/lit)	**77**	**83.3**	**75.02**	30
9	TDS (mg/lit)	**800**	**796**	**805.01**	<500
10	Electrical Conductivity (milli Siemens/cm)	0.230	0.4	0.445	1
11	Total Iron (mg/lit)	0.017	0.04	0.05	0.01-0.05
12	Mercury (mg/lit)	-	-	-	0.02
13	Total alkalinity (mg/lit)	**245**	**257.1**	**234.9**	20-200
14	Total Hardness (mg/lit)	**357**	**361**	**345**	160-180

Table No. 2: Parameters in Winter

S. N.	PARAMETER	Sample 1 Result	Sample 2 Result	Sample 3 Result	PERMISSIBLE VALUE
1	Colour (Hazen units)	10	11.5	10.3	15
2	Odour	Agreeable	Not Agreeable	Not Agreeable	Agreeable
3	Taste	Not Agreeable	Not Agreeable	Not Agreeable	Agreeable
4	Turbidity (NTU)	1.8	2.45	1.5	1-5
5	DO (mg/lit)	**5.0**	**4.92**	**5.08**	6-8
6	pH	7.98	7.2	7.5	6.5-8.5
7	COD (mg/lit)	**289.0**	**291**	**283.1**	10
8	BOD (mg/lit)	**80**	**76**	**72**	30
9	TDS (mg/lit)	**780**	**810**	**814**	<500
10	Electrical conductivity (milliSiemens/cm)	0.540	0.478	0.440	1
11	Total Iron (mg/lit)	0.045	0.050	0.042	0.01-0.05
12	Mercury (mg/lit)	-	-	-	0.02
13	Total alkalinity (mg/lit)	**230**	**232**	**228.1**	20-200
15	Total Hardness (mg/lit)	**345**	**340.1**	**349**	160-180

Table No. 3: Parameters in Summer

S. N.	PARAMETER	Sample 1 Result	Sample 2 Result	Sample 3 Result	PERMISSIBLE VALUE
1	Colour (Hazen units)	8	8.5	8.3	15
2	Odour	Not Agreeable	Not Agreeable	Not Agreeable	Agreeable
3	Taste	Not Agreeable	Not Agreeable	Not Agreeable	Agreeable
4	Turbidity (NTU)	0.78	1	1.2	1-5
5	DO (mg/lit)	**3.0**	**3.72**	**4.0**	6-8
6	pH	8.02	8.3	7.5	6.5-8.5
7	COD (mg/lit)	**140**	**127**	**135**	10
8	BOD (mg/lit)	**42**	**37**	**42.77**	30
9	TDS (mg/lit)	**670**	**630**	**685**	<500
10	Electrical conductivity (milliSiemens/cm)	0.834	0.701	0.78	1
11	Total Iron (mg/lit)	0.03	0.031	0.023	0.01-0.05
12	Mercury (mg/lit)	-	-	-	0.02
13	Total alkalinity (mg/lit)	200	180	217.1	20-200
14	Total Hardness (mg/lit)	**310**	**245**	**268**	160-180

D) Design of Water treatment Units:

The lake water parameters Colour, odour, taste, DO, COD, BOD, Total Alkalinity and Total Hardness varied and values shows out of permissible limits during all the three seasons within a year of all the samples collected. Total alkalinity was found within the permissible limit in summer season as well as odour and DO in monsoon season only. Remaining parameters i.e. Turbidity, pH, Electrical Conductivity, total iron, mercury were within the BIS permissible limits throughout the year [8][11]. The test results were used to design the treatment units. To treat this water for domestic use various treatment units were designed like Primary Sedimentation Tank (PST), Aeration unit and Secondary Sedimentation Tank (SST) and Filtration unit to treat 0.2 MLD per day for the emergency supply of domestic water to the nearby katraj area[6][9].

Starting with Primary Sedimentation Tank which removes large particles from the lake water to reduce solids. Cascade aeration tank provided removes colour, odour, and taste as well as increase oxygen level in the water[4][5]. Secondary Sedimentation tank settles the small size particles and the remaining inorganic and organic matter present in the water are treated by Alum dose as a coagulant. At last, filtration removes the remaining very fine particles as well as BOD and COD[10].

i. Primary Sedimentation Tank Design

a) Max daily demand of water to be treated $= 0.2$ MLD

$= 0.2*10^6$ lit/day

Assume Detention Period = 2hrs

Velocity of Flow = 0.06 m/min

b) To find quantity of water during d.t of 2 hr to be treated

Volume of water in 2hr $= 0.2*10^6 *(2/24)$

$= 16.66*10^3$ lit

$= 16.66\ m^3$

c) To find length of tank(L) = flow velocity* Detention Time

= 0.06*120

= 7.2 m

d) C/s of tank = A = Tank capacity(V) / tank length(L)

= 16.66/7.2

$= 2.31\ m^2$

e) Width of tank-

Assume depth = 2.5m

Width = area of tank/depth

= 2.91/2.5

= 0.9 m

f) Find total depth of tank

Provide extra length of 1m for sludge storage & 0.5 m for free board.

= 2.5+1+0.5

= 4m

- Dimensions of tank

Length = 7.2 m

Width = 1.5 m

Depth = 4 m

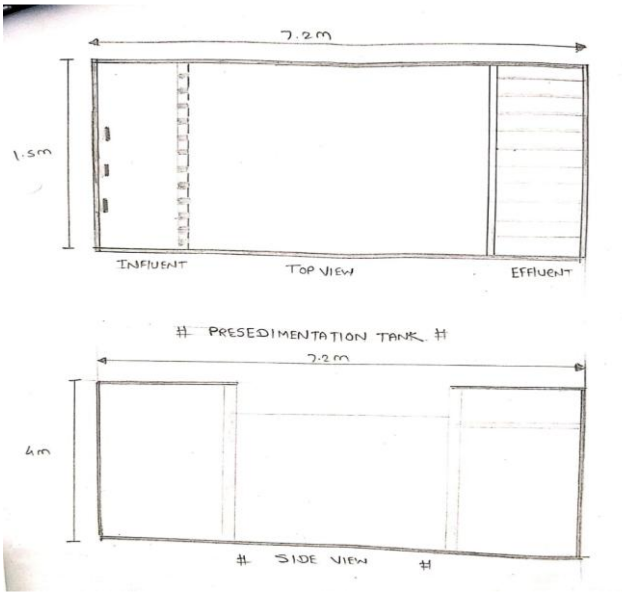

Figure 2: Primary Sedimentation Tank (Plan and Cross-section)

ii. Cascade Aeration Unit

a) Determine the discharge Q in m^3/hr

$Q = 0.2*10^6$ lit/day

$= 8.33\ m^3/hr$

b) To determine area required :

Assume loading rate $= 0.02\ m^2/m^3/hr$

A= area required = Q*loading rate

= 8.33 * 0.02

$= 0.166\ m^2$

c) To determine total area of unit required

Assume d = diameter Of inlet pipe=500mm

Total Area of unit required $= A + (3.14/4)\ D^2$

$= 0.166 + (3.14/4)\ 0.5^2$

$= 0.3629\ m^2$

$= 0.4\ m^2$

d) To find outer diameter of unit required

$D^2= (0.4*4)/3.14$

$D = 0.8$ m

e) To determine no. Of cascade:

Assume rise = 0.15 m and trade = 0.2 m

No. of cascades = Outer dia/(2 * trade)

= 0.8/(2*0.2)

= 2

f) To find diameter Of bottom cascade :

= (2*trade*no. of cascade) + inlet dia.

= (2*0.2*2) + 0.5

= 1.3 m

g) To determine size of collecting channel outside to aeration

foundation-

Design flow = $(0.2 * 10^{6)}/2 = 100 * 10^3$ lit/day

= 100 m^3/day

= 0.001157 m^3/sec

- To determine size of launder

Adopt velocity = 0.6 m^3/sec

Area = $(1.15*10^{-3})/0.6$

= 0.001929 m^2

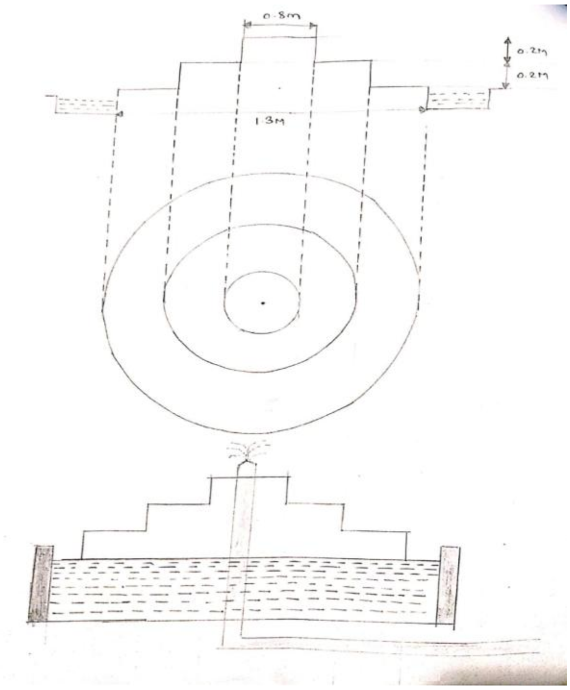

Figure 3: Cascade Aerator (Plan and Cross-section)

iii. Clari-floculator

A) Coagulation

a) To find alum dose and quantity of Alum required:

By using Jar Test in Laboratory, Alum Dose of 5 mg/lit is fixed.

- Quantity of water to be treated

= 0.2 MLD

= $0.2 * 10^6$ lit/day

- Quantity of alum required per day

= $(5*0.2 * 10^6)/10^6$

= 1 kg

- Quantity of alum required per month

= 1 kg *30 days

= 30 kg

B) Flocculation tank

Design of flocculation tank for 0.5 MLD

Discharge, Q = 0.5 MLD

= $0.5 * 10^6$lit/day

= 0.347 = 0.4 m^3/min

a) Find dimension of flocculator unit

Assume avg value of G = 30 sec^{-1}

Where G = Velocity gradient

T = Detention time (D.T.)

Factor (g*t) is in between $4*10^4$to 10^5

$G*T= 4 * 10^4$

$T = (4 * 10^4) / 30$

= 1333.33 sec

= 22.22 min

b) Volume of tank = Q* D.T.

= 0.347 * 22.22

= 7.7 = 8 m^3

Assuming depth of flocculator = 2 m

c) Area of tank = Volume / Depth

$(3.14/4)* D^2 = 8 / 2$

$(3.14/4) * D^2 = 4$

D = 2 m

Providing free board = 0.2 m

Total Depth of Tank = 2 + 0.2= 2.2 m

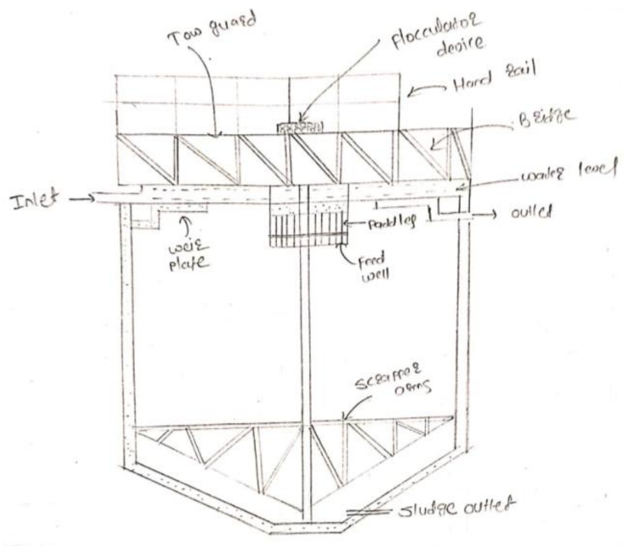

Figure 4: Circular Floculator Tank cross-section

iv. Filtration Unit

- Slow Sand Gravity Filter

Water to be treated = $0.2 * 10^6$ lit / day

Assume,

Per day working of filter bed = 23 hr

Filter washed twice a day & duration of each washing is 15 min

Rate of filtration through rapid filter = 150 lit/m^2/hr

a) Design of filter bed

Per day working of filter bed = 24hr – 2*15 min

= 23.5 hr

By design criteria size of unit between 8 to 40 m^2

Assume proportioning size of unit = 18 m^2

One unit of filter gives quantity of water in one day

= 200*15*23.5

= 0.071 * 10^6 lit / day

No. of units required = $(0.2 * 10^6) / (0.075 * 10^6)$
= 2.82 = 3 no.
Provide 1 standby unit, total 4 units.
b) Dimensions of 1 filter bed.
Assume Length/width=1.25
Area = A = L* B
15 = 1.25 B * B
$B^2 = 12$
B = 3.5 m
L= 1.25 * 2.82
= 4.375= 4.4 m
Hence filter size = 4.4 * 3.5 m

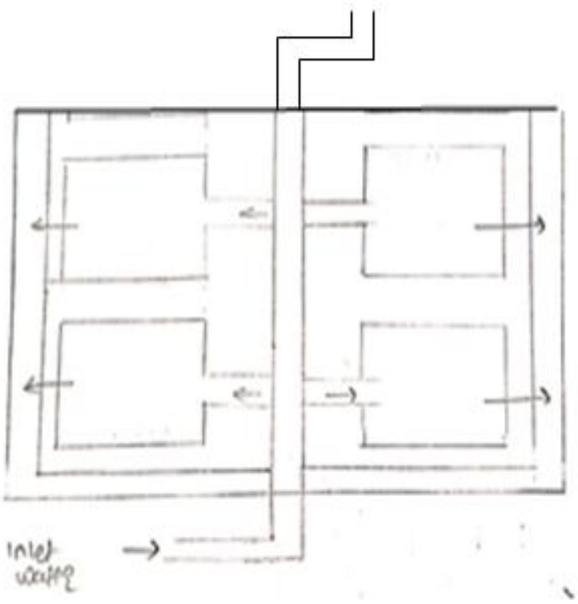

Figure 5: Slow Sand Filter Plan

v. Treated water Storage tank
Assume,
Volume of tank, V = 2 times * 0.2 MLD = 0.4 MLD
Depth of tank D = 1.5 m
a) Area of the tank
$A = V/D = 0.4/1.5 = 0.266 = 0.3\ m^2$
b) Diameter of tank
$A = (3.14/4)\ D^2$
$0.3 = 0.785\ D^2$
$D^2 = 0.382$
D = 0.62 =0.65 m

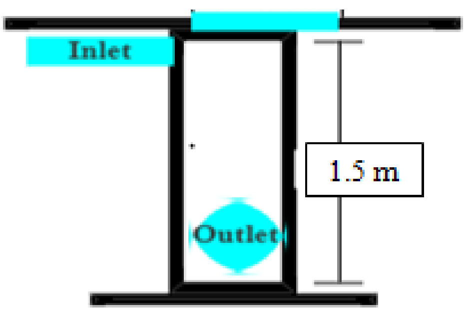

Figure 6: Treated Water Storage Tank

III. CONCLUSION

Lakes are vital part of rural and urban ecosystem. Lakes are comparatively small in size but it perform significant role in environmental, drinking water recharging groundwater social and economic functions. From the above observations, it may be concluded that the physico-chemical characteristics of three sites of katraj lake water varied considerably and showed characteristic change in relation to the seasonal changes. Based on the results of the above parameters, the Water Treatment Plant designed which will be useful to provide water to surrounding areas emergency supply. As there is sufficient space readily available near the Kratraj lake, Pune Municipal Corporation can build these suggested units and supply water by means of tankers in emergency. Mainly in summer season when there is scarcity of water this treated water can be supplied for the domestic purpose. Based on the available storage it was found that lake water can be used for 50 days (0.2 mld) for domestic purpose after treatment.

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