DESIGN OF ORIFICE FOR NON MECHANISED TREATMENT OF RIVER MUTHA

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Abstract: *Pune is blessed with mula and Mutha River that originate in the Sahyadri range. Mutha River is one of the most polluted water body in India. The river covers the rural area of Pune in the initial stage hence it receives agricultural runoff in large proportion, the disposal of waste, hospital and industrial effluents etc. In this river is treated like open drain by the citizen who discharges raw sewage and industrial waste hence, DO, BOD, and COD is affected. The aim of the project is to improve the existing condition of the river and make them more accessible for the people. Therefore ,providing non-mechanized treatment to the river flow by providing baffles with alternate orifices of different sizes to increase the contact of river water to the atmosphere. With the help of this, self- purification can be achieved.*

Keywords : *Non Mechanised , Flow Pattern , Rectangular Orifice , Coefficient of Discharge*

I. INTRODUCTION

Half a century ago, most of the rivers in India were biologically in good condition, amply met the water needs of their basin populations and supported diverse fish and flora species. Today, it would be difficult to find a single river in the plains area of the country that would have potable water Increasing urbanization coupled with industrialization during the past few decades are depleting water ecosystem goods and services irreparably in Pune City. With the rapid increase in the population of the city and the need to meet the increasing demands of human and industrial consumption, the available water resources of the city are getting depleted and the water quality has deteriorated.

In view of the economic reality of developing countries, it will not be possible to build all the necessary wastewater treatment plants (WWTP) needed to control the pollution of their rivers in the next 20 years. Therefore, low-cost alternative technologies must be developed to restore the water quality of polluted rivers. In this work a structure is proposed to improve the water quality of those rivers that continuously receive wastewater.

II. CURRENT SCENARIO

Approximately 80% of the total supplied water for the domestic use comes out as waste water. In most of the cases, waste water is discharge untreated and it sinks into the ground as a pollutant to ground water or is discharge into the river as in Pune, causing pollution in downstream areas. Total 943MLD of waste water is generated in Pune city, out of total generated waste only 36% waste water is treated and Remaining 64% waste water directly release into river. So this affects the dissolved oxygen demand, biological oxygen demand, chemical oxygen demand, pH value, temperature, of river water.

III. SCOPE

The project will have a significant direct beneficial impact in terms of reduction of pollution load on the river and the improvements of its water quality without consumption of any energy.

- To design physical model from river data.
- Calculating the actual discharge of the river.
- Design of orifice to maintain velocity, flow and to obtain required discharge.

- Observation of flow pattern into the model.
- Coefficient of discharge for each orifice.
- Calculating the actual discharge and theoretical discharge through the orifice.
- To check range of discharges using orifice of different sizes and obtaining the optimum size.

IV. LITERATURE REVIEW

- **Ankush Anil Kohale, "**Design of orifice for modified flow in river bed for online treatment of polluted water case study : river mutha**".**
- **Hamidreza Jamashidnia** , **Yasushi Takeda**-"Effect of standing baffle on the structure of flow in a rectangular open channel".
- **N Ramirez-Baca,RSaucedo-Teran**-"Treatment for small polluted rivers: Design and performance of an experimental structure".
- **Navaneetha krishnan P,Nrupan Ghosh K S, Pradeep K, Praveen Divakaran K, Rahul R,** "General correlations of the effect of orifice shapes on coefficient of discharge".
- **V. M. Wagh, V. S. Ghole, P. N. Wavde, V. V. Todkar, K. K. Kokate** , "Assessment of Water Quality of Mutha River in Pune City".

V. RESEARCH METHODOLOGY

Orifice is a small opening of any cross-section (such as circular triangular rectangular etc) on the side are at the bottom of the tank through which a fluid is flowing. Depending upon size, shape, nature of discharge and shape of upstream edge the orifice can be classified. The orifice are classified as small orifice and large orifice depending upon the size of orifice and the head of liquid from the centre of orifice. If the head of the liquid from the center of orifice is more than five times the depth of orifice, then the orifice is called as small orifice. And if the head of the liquid is less than the five times the depth of the orifice is called as large orifice. Circular orifice, triangular orifice, rectangular orifice, square orifice, are the orifices classified depending upon the cross sectional areas. Free discharging orifice and drowned or submerged orifice are classified depending upon the nature of discharge. The submerged orifice are further classified into fully submerged orifice and partially submerged orifice. Depending upon the ages of orifices are classified into sharp-edge orifice and Bell mounted orifice.

Study area

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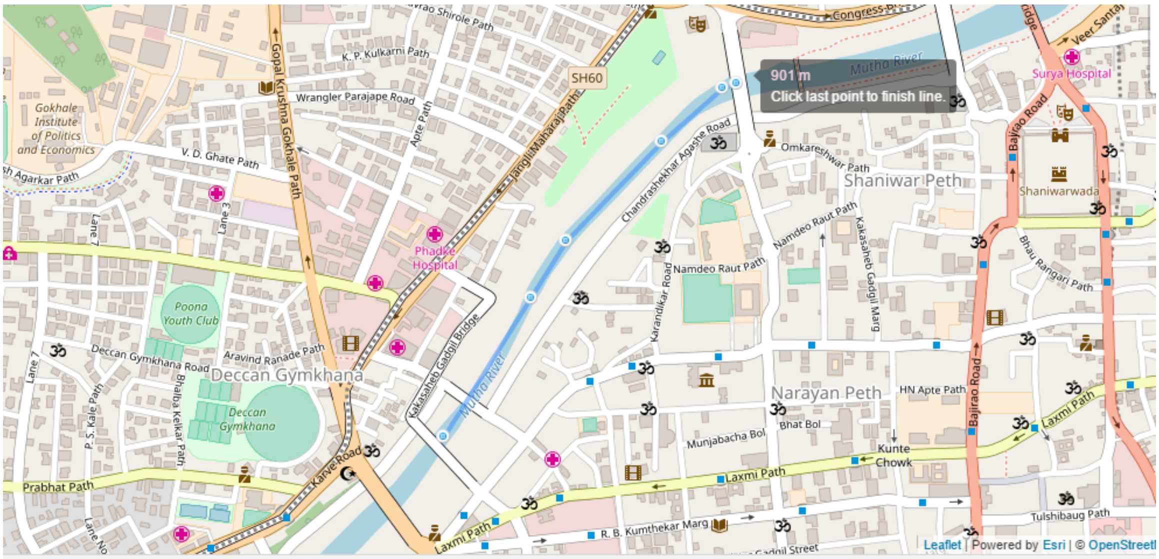

Site Map

VI. Data Collection

River mutha flows through the heart of the city. The velocity and discharge for 3 times for week were calculated. Average velocity of river was calculated by using manning's formula

$$V = \frac{1}{n} \times R^{0.67} \times S^{0.5}$$

Where V =velocity (m/s), R =Hydraulic radius, S = Slope of hydraulic grade line

$$R = \frac{A}{P}$$

Where A= wetted area, P= wetted perimeter

SR NO	DEPTH (m)	VELOCITY (m/s)	DISCHARGE (m^3/s)	AVG.DISCHARGE (m^3/s)
1	0.65	0.68	13.36	
2	0.70	0.719	15	
3	0.63	0.67	12.73	13.34
4	0.62	0.66	12.27	

Actual site Calculation

Testing Procedure

- First the water is allowed to flow through the model without the provision of baffle and then the discharge is calculated.
- Baffles were design with rectangular orifice in such a way that the discharge through orifice in model is equal to the discharge of normal river flowing on site.
- Co-efficient of discharge for its single orifice and discharging failure was calculated.

- Then the whole model is divided into three section with the help of bands which are placed at a fixed distance of 1.2 m from each other.
- The baffles are provided with the rectangular orifice with alternate opening such that the flow occurs in the zig-zag pattern and the ideal plug flow condition is a achieved.
- water is diverted from the upstream side of the model with the help of control velocity
- The discharge was varied with the help of mental of discharge control valve.

The theoretical discharge and theoretical velocity where calculated for different combination of different size orifice series.

VII. Model Design

Data from the site was collected. Discharge and velocity where calculated with average depth and width. Generation of savage in the river was studied according to the data. Length of the river section is very large as compared to its depth hence distorted model law is used. A distorted model is the one that it is so constructed through either ignorance , unavoidably or deliberately. This model is the one, which one of the Pi terms is not equal to corresponding Pi term in the prototype. One possible solution to overcome this problem is an introduction of some fudge factor (prediction factor) or an estimate of the error by distortion should be introduced and be formulated .This Collected model was scaled down to distorted model by using Froude's law. Geometry can kinematics properties well studied for the preparation of models. Baffles with alternate opening were provided as shown in following figure

Discharge on Model

$Q_r = D_r^{1.5} \times L_r$

$Q_r = 10^{1.5} \times 300$

$= 9486.83$

$Q_r = \frac{Qp}{Qm}$

Where

Q_p= Discharge on prototype

Q_m= Discharge on model

Hence $Q_m = \frac{Qp}{Qr}$

$= \frac{13.34}{9486.83}$

$= 1406$ cm^3/s

VIII. Design of orifice sizes

Orifice at top

Size (cm)	Head (H_1) (cm)	Discharge (cm^3/s)
3.8 ×4.8	2.5	1862

	2	1760.41
	1.5	1650.79
	1	1531.7
	0.1	1238
4 × 5	2.5	1959
	2	1853.48
	1.5	1740.44
	1	1617
	0.1	1238
3.5 × 5	2.5	1714.3
	2	1621.8
	1.5	1522.88
	1	1415.36
	0.1	1187.1

Calculations for orifice at top

Sample Calculation

Size of orifice = 4cm x5 cm

Head (H_1) =2.5cm H_2= 5+2.5=7.5cm

Q= $2/3 \times b \times \sqrt{2g}\ (H_2^{1.5}-H_1^{1.5})$

$=2/3 \times 4 \times \sqrt{2 \times 981}\ (7.5^{1.5}-2.5^{1.5})$

=1959 cm^3/s

Orifice at bottom

Distance of orifice from bottom =2.5

Size (cm)	Head (H_1) (cm)	Discharge (cm^3/s)
3.5 × 4	8.5	2006.36
	6.5	1803.73
	4.5	1574.65
	2.5	1304.2
	0.1	854.76
3 × 4	8.5	1719.74
	6.5	1546.06
	4.5	1349.7
	2.5	1117.9
	1	901.86
	0.1	732.65
3 × 4.5	8	1910.57

	6	1883.36
	4	1635.32
	2	1339.26
	0.1	958.32
3.3 × 4.2	8.3	1976.44
	6.3	1774.62
	4.3	1545.99
	2.3	1274.97
	0.1	865.82

Calculation for orifice at Bottom from 2.5 cm

Size (cm)	Head (H_1) (cm)	Discharge (cm^3/s)
3 ×3.5	9.5	1558
	7.5	1412
	5.5	1249
	3.5	1060
	1.5	827.7
	0.1	602.3
3×4	9	1760
	7	1591.28
	5	1401.45
	3	1180
	0.1	854.76
3.5× 4	9	2053
	7	1856.5
	5	1635
	3	1377
	0.1	854.76
3 × 4.5	8.5	1956.98
	6.5	1763
	4.5	1546.23
	2.5	1290.51
	0.1	871.20

Calculation for orifice at bottom from 2cm

IX. Observation and Calculation

SIZE (cm)	H_1 (cm)	H_2 (cm)	TIME sec	VOLUME (cm^3)	DISCHRGE (cm^3/sec)	TH. DISCHARGE (cm^3/sec)	C_d
4x4.5	4.6	8.9	30.5	17764.33	582.43	-	-
3.8x4.8	3.7	8.5	29.21	17764.33	608.15	-	-
4x5	3	8	31.64	17764.33	561.45	-	-
3.5x5	3.3	8.3	30.5	17764.33	582	-	-

Orifice at top position (head=2.5cm)

size (cm)	h_1 (cm)	h_2 (cm)	time sec	volume (cm^3)	dischrge (cm^3/sec)	th. discharge (cm^3/sec)	c_d
3X4.5	0.2	4.7	32.57	17764.33	545.42	894.74	0.6
3.3X4.2	0.4	4.5	30.93	17764.33	574.33	905.57	0.63
3x4	0.4	4.4	30.93	17764.33	574.33	795.61	0.72
3.5x4	0.3	4.3	30	17764.33	592.14	905.04	0.65

Orifice at bottom position (head=2.5cm)

SIZE (cm)	H_1 (cm)	H_2 (cm)	TIME sec	VOLUME (cm^3)	DISCHRGE (cm^3/sec)	TH. DISCHARGE (cm^3/sec)	C_d
3X3.5	0.3	3.8	29.2	17764.33	608.36	641.99	0.94
3X4	0.2	4.2	32.7	17764.33	543.25	754.97	0.71
3.5x4	0.3	4.3	29.61	17764.33	599.99	905.04	0.66
3x4.5	0.2	4.7	28.61	17764.33	620.91	894.52	0.69

Orifice at bottom position (head=2cm)

Orifice In Series

SIZE (cm)	**H_1** (cm)	**H_2** (cm)	**TIME** sec	**VOLUME** (cm^3)	**DISCHRGE** (cm^3/sec)	**TH. DISCHARGE** (cm^3/sec)
3X3.5, 4X4.5, 3X4	0.5	4.5	30	17764.33	592.14	814.34
3x4 ,3.5x5,3x4.5	0.2	4.7	28	17764.33	623.4	894.74
3x4.5,4x5, 3.3x4.2	0.3	4.5	27	17764.33	650.5	914.21
3.5x4,3.8x4.8,3.3x4.2	0.6	4.8	26	17764.33	670.2	979.49
3.5x4,4x5,3.5x4,	0.6	4.6	26	17764.33	680.45	971.64
3.5x4,4x5,3.5x4	0.7	4.7	29	17764.33	710.5	992.5

Discharge through orifice in series

X. Results

SIZE (cm)	**DISCHRGE** (cm^3/sec)	**TH. DISCHARGE** (cm^3/sec)	**C_d**
3X4.5	545.42	894.74	0.6
3.3X4.2	574.33	905.57	0.63
3x4	5574.33	795.61	0.72
3.5x4	592.14	905.04	0.65

Orifice at bottom position (head=2.5cm)

SIZE (cm)	**DISCHRGE** (cm^3/sec)	**TH. DISCHARGE** (cm^3/sec)	**C_d**
4x4.5	582.43	-	-
3.8x4.8	608.15	-	-
4x5	561.45	-	-
3.5x5	582	-	-

Orifice at top position (head=2.5cm)

SIZE (cm)	**DISCHRGE** (cm^3/sec)	**TH. DISCHARGE** (cm^3/sec)	**C_d**
3X3.5	608.36	641.99	0.94

3X4	543.25	754.97	0.71
3.5x4	599.99	905.04	0.66
3x4.5	620.91	894.52	0.69

Orifice at bottom position (head=2cm)

PARAMETERS	**RANGE**
PH	6.3-8.4
DISSOLVED OXYGEN	0
BIOLOGICAL OXYGEN DEMAND	5.5-12.5
CHEMICAL OXYGEN DEMAND	38-48

Environmental Parameter

SIZE (cm)	**H_1** (cm)	**H_2** (cm)	**TIME** sec	**VOLUME** (cm^3)	**DISCHRGE** (cm^3/sec)	**TH. DISCHARGE** (cm^3/sec)
3X3.5, 4X4.5, 3X4	0.5	4.5	30	17764.33	592.14	814.34
3x4 ,3.5x5,3x4.5	0.2	4.7	28	17764.33	623.4	894.74
3x4.5,4x5, 3.3x4.2	0.3	4.5	27	17764.33	650.5	914.21
3.5x4,3.8x4.8,3.3x4.2	0.6	4.8	26	17764.33	670.2	979.49
3.5x4,4x5,3.5x4,	**0.6**	**4.6**	**26**	**17764.33**	**680.45**	**971.64**
3.5x4,4x5,3.5x4	0.7	4.7	29	17764.33	710.5	992.5

Discharge through orifice in series

XI Conclusion

- Series of orifice size **3.5x4, 4x5, 3.5x4** has optimum discharge.
- Series of 3.5x4, 4x5, 3.5x4cm passes highest discharge of 710.5 cm^3/s in the model whereas in prototype it will pass discharge of 6.74 m^3/s.
- The maximum and minimum actual discharge for single rectangular orifice are 620.91 cm^3/s and 543.25cm^3/s respectively.
- Series of 3 x3.5, 4 x 4.5, 3 x 4 cm passes lowest discharge of 592.14 cm^3 /s in the model whereas in prototype it will pass a discharge of 5.61 m^3/s.
- Environmental parameters like ph , DO , BOD , COD are ranges from 6.3 -8.4 ,
  0,5. 5 -12.5 , 38 -48 .
- Coefficient of discharge is ranges from 0.6 to 0.7

REFERENCES

1. Ankush Anil Kohale, "Design of orifice for modified flow in river bed for online treatment of polluted water case study : river mutha",
2. Rohit Dhobale ,Dr.S.S.Shastri ,"Feasibility study for use of river bed for treatment of polluted river water using modified flow pattern for river Mutha",
3. Hamidreza Jamshindna and Yasushi Takeda, "Effect of standing baffle on the structure of flow in a rectangular open channel ,
4. Pravin Manatkar, Anuj Chordia, Roche Harry-"Physio-chemical analysis and curative approach to mutha river pollution".
5. N Ramirez-Baca,RSaucedo-Teran-Case study on Treatment for small polluted rivers: Design and performance of an experimental structure.
6. Navaneetha krishnan P,Nrupan Ghosh K S, Pradeep K, Praveen Divakaran K, Rahul R, "General correlations of the effect of orifice shapes on coefficient of discharge".
7. V. M. Wagh, V. S. Ghole, P. N. Wavde, V. V. Todkar, K. K. Kokate , "Assessment of Water Quality of Mutha River in Pune City".
8. James C. Y. Guo and Ryan P. Stitt,"The flow through partially submerged Orifice