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Bio Domes for River Water Treatment: A Case Study of Machchhu River

Mr. Arpit Dakh[1], Prof. Mehul.R.Vithalani[2], Prof. Neelkanth.J.Bhatt[3]
[1]*PG Student (WRM), Lukhdhirji Engineering College, Morvi-363642, India.*
[2, 3]*Assistant Professor, Civil Engineering Department, Lukhdhirji Engineering College, Morvi-363642, India*

Abstract: ***For sustaining life, water is one of the most important component that plays a very vital role. The most useful source of water like river is deteriorating due to various activities like dumping bio-waste, industrial waste and sewage. Due to this, the taste, odour and other chemical, physical and biological parameters of river water has been influenced. Morbi city lying along the Machchhu river disposes all its waste in Machchhu river and hence has a negative effects on water quality parameters on river water. To control the deteriorating quality of river and eutrophication, Bio-Dome can prove to be an effective technique. Bio-Domes are dome shaped structure that treats organic impurities using Bio-films under aerobic conditions. An experimental investigation with "Bio-Dome" was carried out to ascertain the applicability and effectiveness of the same. The "Bio-media" moving bed bio-reactor (MBBR) was used to build the "Bio-Dome". The level of pollution in the river was found out and the entire stretch of almost 12 kms of river between Machchhu dam –II and Machchhu dam-III was categorized into 4 zones based on the sources of pollution. The result reveals that the efficiency of "Bio-Dome was around 85.38% Machchhu river can be rejuvenated if 310 "Bio-Domes" are placed in the river at the most polluted zones.***
Keywords: Bio-dome, Eutrophication, Machchhu River, Bio-media, Morbi.

I. INTRODUCTION

For sustaining life, water is one of the most important component that plays a very vital role. Now-a-days, various water sources like river, pond, sea and ocean have started depleting as the water quality is continuously hampered due to man-made activities. The most useful source like river is deteriorating due to various activities like dumping bio-waste, industrial waste and sewer waste. Due to this, the taste, odour and other chemical, physical and biological parameters of river water has been negatively influenced. To treat this waste-water several measures are now being taken like waste-water treatment plant, oxidation pond etc.

According to a government report presented by 'Central Board Control Pollution' the number of rivers that are defined as 'polluted' in India has increased from 121 to 275 in the last five years, with increased sewage waste being primary pollutant. Hence, more than half of the rivers in India are now polluted to such a level that attention is required as India is a developing economic power which would be unable to meet the demand of fresh water for its over increasing population. Hence dramatic measures are required to treat river water. Moreover, the country's waterway has suffered very badly in recent years with vast quantities of municipal and industrial waste discharged into them every day. Morbi city which is divided in two parts by Machchhu river is an enormous industrial zone. Due to this heavy pollution both from industries and city sewage system being disposed into the river thereby leading to eutrophication of river Machchhu in the last decade. There are several emerging techniques used world over to treat the polluted rivers. One such technique is using Bio-Dome to treat the polluted river. Bio-Domes are dome shaped structure that treats organic impurities using Bio-films under aerobic conditions. 'Bio-Domes' is an award-winning patented[*6] technology which consists of concentrically nested domes that are infused with air from the bottom. They sit on the floor of a lagoon and are completely submerged. As water flows through them, bottom-to-top, beneficial bacteria (bio-films) effectively reduce ammonia-nitrogen, BOD, and TSS in wastewater. Unlike other systems, the growth of the naturally occurring bio-films is maximized by the way in which oxygen is optimally guided through the domes by their geometry. Figure 1 shows the working mechanism of a "Bio-Dome".

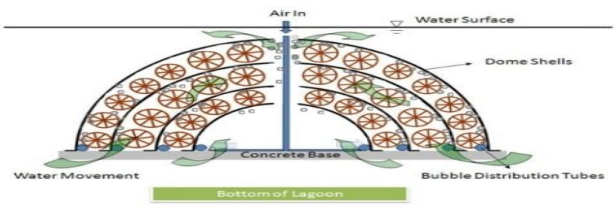

Fig. 1 working mechanisms of Bio-Dome

Benefits of bio-domes are:

1) Low maintenance cost
2) Low operation cos
3) Low power consumption
4) Capable of operating off-grid
5) Requires very less area

Since, the river Machchhu happens to be the life-line of the area as many small villages are receiving water for drinking purpose from the river. The extent and the degree of pollution in the river between the entire stretches of almost 12 kilometers of river from Machchhu dam –II to Machchhu dam-III was found out. The polluted packets of the river were categorized into 4 zones based on the sources of pollution. Prototype of "bio-dome" with moving bed bio reactor was fabricated and experimental investigations to ascertain the applicability and the effectiveness of Bio-dome to treat River Machchhu water was carried out subsequently. Three dams viz. Machchhu dam-I, Machchhu dam-II, and Machchhu dam-III dams are built on the river and hence this makes it even more imperative to study the water quality parameters of the river.

II. STUDY AREA

Machchhu river rises in the hills of Jasdan near village Khokhara in Chotila Tehsil of Surendranagar district at an elevation of 220 m above mean sea level. This is one of the North flowing rivers of Saurashtra in Gujarat state. The Machchhu basin is situated between 22º10' to 23º10'North latitude and 70º40'to 71º15'East longitude.The study was carried out between Latitude 22°49'14.2"N and Longitude 70°50'31.6"E. Figure 2 depicts the study area.

Fig. 2 Study area

III. MATERIALS AND METHODOLOGY

A. *Material used for construction of prototype Bio-dome*

The following materials are used for experimental setup:

1) Glass container for water storage
2) Funnel and Basket for Dome construction
3) Pumps for aeration
4) Diffusers and Pipes
5) Bio media (mbbr)

B. *Properties of prototype Bio-dome*

1) Total Weight- 700 grams approx
2) Total Volume- 13629.05 cm^3 i.e. 13.629 litres of water
3) Total Area- 6185.62 cm^2
4) Shape- Dome shape with extended length of funnel mouthpiece.

C. Pump Specification

The aquarium pumps are used for aeration process. Two pumps are used. Figure 3 shows the image of pump used. Following are the parameters of both pumps:

Table 1 Specification of Pumps

Pump-1:	Pump-2:
Brand- Venusaqua	Brand- Sobo
Model-608A	Model-SB-548A
Frequency-50/60Hz	Pressure-0.02Mpa
Watt-5W	Watt-3W
Max.output-8L/min	Max.output-3.5L/min
No. of outlet-2	No. of outlet-1

Fig.3 Pump

D. Bio-Media Carrier Specification

Fig. 4 Bio-media carrier

Table 2 shows the specification of Bio-media carrier that was used for experiment. Figure 4 shows the image of Bio-media used for experiment.

Table 2 Specification of MBBR

Type of media	Moving Bed Bio-reactor
Material of construction	Polypropylene
Specific gravity	0.9
Shape	Cylindrical
Height*Diameter*Thickness	16mm*22mm*1mm
Protected surface area	400 sq. M
Total surface area	450-475 sq. M
Color	Black
Max. working temp	55^{o}C

For the experimental study following methodology was adopted

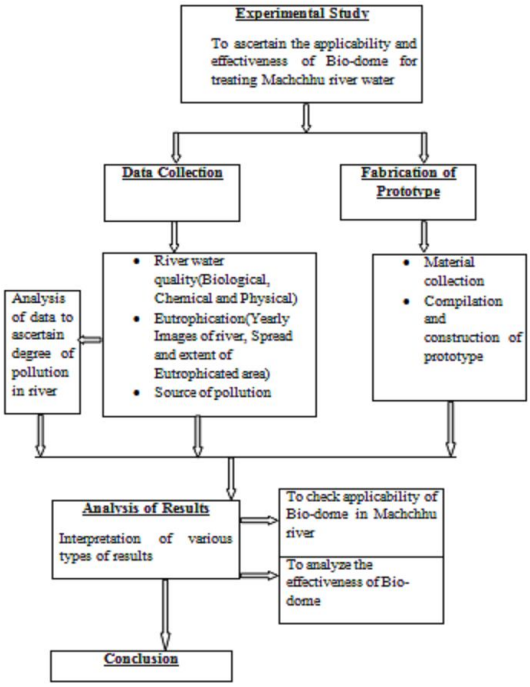

Fig. 5 Proposed Methodology

IV. EXPERIMENTAL SETUP

A. *Practical Experiment Data*

Around 170 litres of sewage water was poured into the Prototype Bio-dome. The dome along with diffusers and bio-media carrier was submerged inside the water. Heavy iron rod was used to keep the prototype submerged inside the water. Pumps were connected to electricity boards. The temperature noted was 21°C. The water level was 45.72 cm in the prototype Bio-dome i.e. around 169.901 litres of water was filled.

Then the experiment was started and the results were recorded.

V. POLLUTION MAPPING

To begin the feasibility test of Bio-Dome in Machchhu river, after conducting experiment, various images from Google Earth Pro were taken year wise by dividing the river area into different zones. Most eutrofied areas were identified based on Google images. Consecutive 5 years of images were taken for proper understanding of the most polluted zone of the river. Images of all Zones of year 2012, 2013, 2014, 2015, and 2016 were taken and also sources of pollution were identified and marked in the image.

The following figure shows all the zones of river which starts at 5.54 km on downstream of Machchhu river and ends on periphery of Machchhu dam-III. Figure 6a shows the different zones while Figure 6b shows various pollution entrance points.

Fig. 6a River zoning

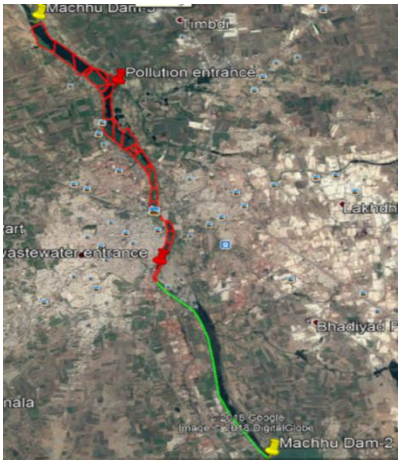

Fig. 6b Images showing all zones and dam site

VI. RESULTS

A. Analysis of water report data

Table 3 shows various quality parameters of untreated and treated water.

Table 3 Effectiveness of Bio-dome

Parameters	Untreated water	Permissible limit	Treated water			
			12/2/18	28/2/18	12/3/18	28/3/18
T.D.S.(mg/l)	710	500	676	486	408	399
TURBIDITY (NTU)	72.5	5	16.3	4.28	3.12	3.10
COLOR (Hazens)	116	5	4	2	<2	<2
T.S.S. (mg/l)	1706	5	1.02	<1	<1	<1
COD (mg/l)	120	100	33.7	24.9	19.2	18.4
BOD (mg/l)	57.6	30	12.4	8.80	5.86	5.79

The results show that there was 43.80% reduction in T.D.S. Turbidity was drastically reduced by 95.72%. Moreover, Color reduction was also 98.27% while T.S.S. was reduced by 99.94%. The COD and BOD were reduced by 84.66% and 89.94% respectively.

B. Eutrophication area analysis

Table 4 shows the year-wise Eutrophicated area in all the zones. Results show that there is an increase in eutrophication area in the river. Out of the total area, in 2012 22.28% of area was found to be Eutrophicated which later on increased to 71.15% in 2016. Figure 7 shows the graphical representation of Eutrophicated area cover.

Table 4 Year wise Eutrophicated area

Area(m^2)-Year	2012	2013	2014	2015	2016
Eutrophicated Area	42860	755946	877765	885820	1333262
Total Area	1873637	1873637	1873637	1873637	1873637
% Eutrophicated	22.28	40.34	46.84	47.27	71.15

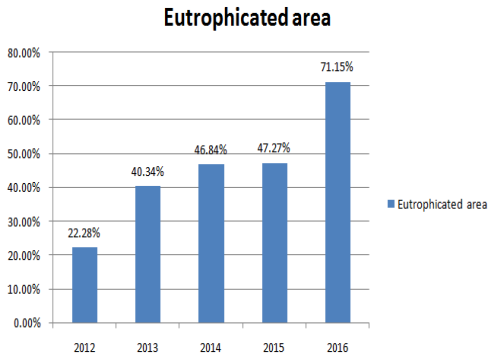

Fig. 7 Eutrophication of river zone

C. Zone wise location of bio-dome

Table 5 shows the minimum estimated domes required in various zones of river to treat water effectively.

Table 5 No. of domes required

Zone	Eutrophicated area(m^2)	Depth of water (approx) (m)	Litre of water	No. of Domes required
Zone-1	103615	2.1336	221072964	24
Zone-2	157596	2.1336	336246825	37
Zone-3	469870	2.1336	1002514632	109
Zone-4	602181	2.1336	1284813382	140
Total	1333262	-	2844647803	310

One Bio-dome can treat about 25000litres/day of wastewater. So as per the above data, minimum number of domes required to treat the river Machchhu has been estimated. Figure 8 shows the preferred location of domes. The yellow points shows the location of Bio-domes. Even the pollution entrance points are also shown in the image.

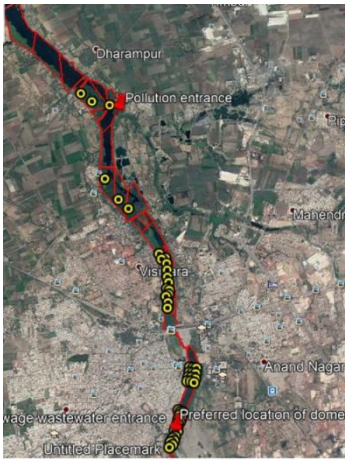

Fig. 8 Dome location

VII. CONCLUSION

The study shows that the current pollution levels are very high in river and hence eutrophication in river has taken place which has led to dying of river. The eutrophication is spread over the 12 kms stretch of river. The technique of using Bio-Dome to treat the river was experimented with and it was found that the Bio-domes are very effective in treating river water. Use of Bio-dome in Machchhu river can be highly useful in rejuvenating the river.

VIII. ACKNOWLEDGMENT

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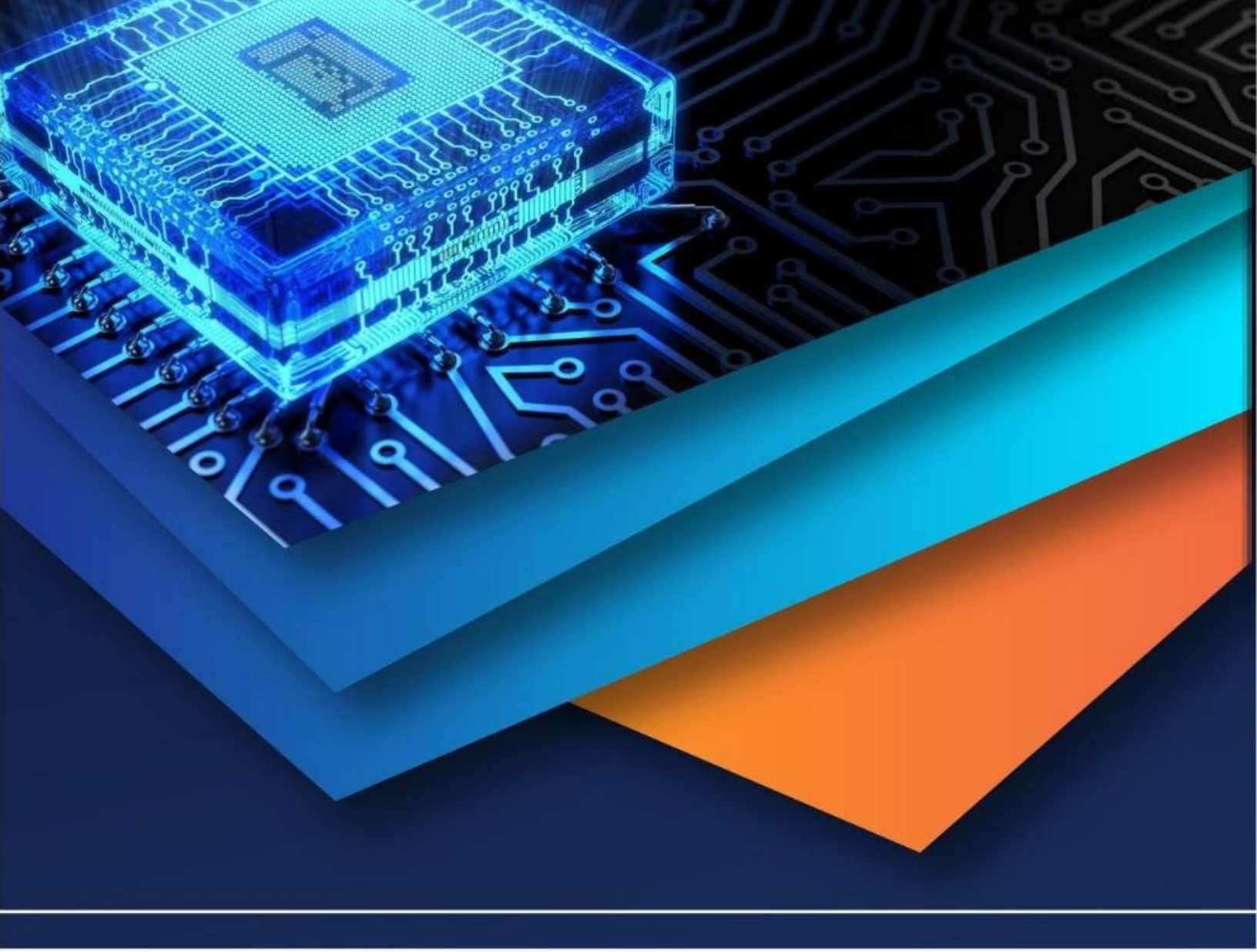

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