Conservation of Natural Ecosystem of Mithi River

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Abstract— After the heavy floods of 2005 in Mumbai city, based on Chitale Committee report recommendations, MMRDA and MCGM were instructed to take necessary actions along the Mithi river shores. Accordingly de-silting, removal of encroachment (not fully), widening, deepening, rock removal, and river training works by construction of RCC retaining walls and gabion walls were executed for a length of 11.68 Km. The other recommendations regarding conservation of urban ecosystem, and restoration of hydrological system of small rivers, ponds and soaking areas are still unattended. The ground reality is encroachment along the shores have not been evacuated completely and thus overflow waters of Powai and Vihar lake has turned into black water.

According to the baseline parameters of Mithi water, it is polluted black water with toxic metal substances contamination and high level of nitrogen. This has an adverse effect on the flora and fauna of Mithi. The sewer system is not adequate and sufficient due to unsewered slums which adds load on the river water level with several open-air channels sanitation risks. In addition to it due to unloading of oil tanks and toxic metallic substances black stinge occurs in the water. To bridge the gap found in existing scenario many alternatives are listed in the chapter. The scope for present work is to analyse the existing data of water quality of Mithi and based upon it to work out feasibility of construction of diversion head works to channelize the black water to local STPs and ETP for tertiary treating the water for recycle and reuse to fulfill the water demand. Also other solutions are to avoid dumping of solid waste directly in course of river by barricading existing roads or bridges having direct access to shores or course of river and recommendations,

Index Terms—BOD, Toxic substances, STP, Tertiary Treatment, Sludge Treatment.

I. INTRODUCTION

The Mithi is a river on Salsette Island, the island of the city of Mumbai, India. It is a confluence of tail water discharges of the Powai and Vihar lakes. The river is seasonal and rises during the monsoons. The overflowing lakes also contribute to the river flow which is stopped by a dam in other times. The river originates from the overflow of Vihar Lake and also receives the overflows from the Powai Lake about 2 km later. It flows for a total of 17.84 km before it meets the Arabian Sea at Mahim Creek flowing through residential and industrial complexes of Powai, Saki Naka, Kurla, Kalina, Vakola, Bandra-Kurla complex, Dharavi and Mahim. The river has an average width of 5 m in the upper reaches, has been widened to 25 m in the middle reaches and up to 70 m in the lower reaches after the 26 July 2005 deluge (944 mm in 24 hr on 26 July 2005). It is also less well known that the Mahim bay area, where Mithi River meets Arabian Sea is a nominated bird sanctuary where migratory birds come for nesting. This part is full of mangroves. When the river was not as polluted as it is today, it used to serve as an important storm water drain for Mumbai but as it has been used as a sewer over the years, its importance as a storm water drain has reduced and on the contrary, it poses as a hazard during high tide bringing polluted water into the city.

The river has been polluted by dumping of raw sewage, industrial waste and municipal waste into the river. Besides this, illegal activities like washing vessels, animals and oily drums, discharge of unauthorised hazardous waste are also carried out along the course of this river. Cattle sheds in some areas contribute animal waste. Barrel cleaners, scrap dealers and others dump sludge oil, effluent and garbage in the river. The organic waste, sludge and garbage dumping has reduced the carrying capacity of the river. The water with mixture of sewage and industrial waste is a threat to marine life. The river bed is full of sludge, garbage and vegetation growth like water hyacinth in many parts.

II. LITERATURE REVIEW

A. Storm Water Scenario of Mumbai

The Mithi River flows through the city of Mumbai and forms a principal channel to discharge storm water and sewage. This Sound Practice pertains to the widening and deepening of the Mithi river and other city drains in a scientific and well planned manner. This is intended not only to increase their discharge capacity but also to prevent flooding in low-lying areas adjoining the river by reducing gradients of the Mithi river in its’ upper reaches.
Following the damage caused by severe floods in Mumbai in 1985, the BRIMSTOWAD Project was initiated by the Municipal Corporation of Greater Mumbai (MCGM).

Engineers and Researchers, under this project, studied the storm water drainage system of Mumbai in detail and submitted a report in 1993 to MCGM giving suitable recommendations, but they largely remain unimplemented.

Mumbai was again hit by a more disastrous flood in 2005, which necessitated a fresh study on increasing storm water drainage capacity of the Mithi river and other city drains. Central Water and Power Research Station (CWPRS), Pune – Central Government’s Principal Hydrological Research Institute, conducted 1-D Mathematical Model and Desk Studies for mitigating floods of the Mithi river and submitted its report with suitable recommendations in January, 2006.

MCGM and Mumbai Metropolitan Region Development Authority (MMRDA), which is a government body responsible for development of areas surrounding lower reaches of the Mithi river, have accepted almost all the recommendations and have chalked out a plan to implement them in two phases. The first phase has been completed in June 2006. The second phase is proposed for the period from October 2006 to June 2007.

The Storm Water Drainage (SWD) system of Mumbai comprises a hierarchical network of roadside surface drains (about 2000 km length, mainly in the suburbs), underground drains and laterals (about 440 km length in the island city area), major and minor channels (200 km and 87 km length, respectively) and 186 outfalls, which discharge all the surface runoff into rivers and the Arabian Sea. Of the 186 outfalls, there are 107 major outfalls in city, which drain to Arabian Sea directly, 4 at Mahim creek and 4 at Mahul creek. There are 29 out-falls in western suburbs draining directly into sea while 14 drain into Mithi river which ultimately joins Mahim creek and 4 at Mahul creek. There are 29 outfalls into Arabian Sea, tidal variation has a major effect on the river system.

The old SWD system is capable of handling rain intensity of 25 mm per hour at low tide. If the rain intensity is more than 25 mm per hour and high tide occurs, there is always a possibility of water logging in some parts of the city. Since the discharge of all the storm water and treated sewage is into the Arabian Sea, tidal variation has a major bearing on the system of storm water drainage (SWD) resulting in flooding and water logging during heavy rains and recession of water during low tide.

B. Heavy Metal Pollution in Mithi River of Mumbai

Although the river has attracted tremendous attention after 26/7 flood in Mumbai, the pollution level of the river has remained neglected issue. The metals which have been studied extensively in recent decades are: Cd, Hg, Zn, Cu, Ni, Cr, Pb, Co, V, Ti, Fe, Mn, Ag and Sn. Some metals that have received more attention are Hg, Cd, and Pb, because of their highly toxic properties and their effects on the environment and the living organisms.

Metals are separated into the essentials and non-essentials in classes A and B, and in a borderline class[2]. Class A metals: Calcium (Ca), Magnesium (Mg), Man-ganese (Mn), Potassium (K), Sodium (Na), Strontium (Sr) Class B metals: Cadmium (Cd), Copper (Cu), Mercury (Hg), Silver (Ag) Borderline metals: Zinc (Zn), Lead (Pb), Iron (Fe), Chromium (Cr), Cobalt (Co) Nickel (Ni), Arsenic (As), Vanadium (V), Tin (Sn). Previous short term study conducted by Maharashatra Pollution Control Board shows the presence of cyanide, consistent high COD, oil and grease found at this station indicating some chemical activity in that area. Unauthorized encroach-ments by illegal industrial units, scrap dealers and oil mixing business at CST road near Kalina, have further resulted in discharge of solid waste, organic waste, industrial waste, heavy metals, oils and tar in the river. This sampling point is surrounded by many small scale industries including recyclers, barrel cleaners, workshops and other units. This area has thick density of population. Illegal activities like wash-ing of oily drums have resulted in discharge of unauthorized hazardous waste which is carried out along the bank of this river. Development of Bandra-Kurla Complex has resulted in diversion and unnatural turn along the Mithi River at few places thereby affecting natural flow of the river and seriously affected the drainage. This part of the river is a dumping ground for garbage and it is reflected in higher values of suspended solids. The organic waste, sludge and garbage dumping has reduced the carrying capacity of the Mithi River.

C. BRIMSTOWAD Project

The BRIMSTOWAD Project (initiated in response to 1985 floods and is the currently available Master Plan for Greater Bombay Storm Drainage) prepared for MCGM in 1993, had suggested an increase in the storm water drainage for the Mithi river catchments, but the recommendations largely remained unimplemented. Only about 15% of the recommendations were carried out by MCGM. Some of the reasons for nonimplementation of the project recommendations were lack of financial resources, institutional hurdles as a assortment of agencies were involved with regards to procedural formalities for permission and execution of specific components, ownership of the water bodies, shifting of utilities, other issues with regards construction of pumping stations at outfall locations, and encroachment removal issues, rehabilitation and relocation costs, and implementation issues. Report on Model Studies on the Effect of Proposed Reclamation in Mahim Creek by Central Water and Power Research Station (CWPRS), Pune, conducted in 1978, formed the basis for Bandra Kurla Complex (BKC), which is a special economic region developed along the banks of Mithi river downstream and was severely affected from flooding of
the Mithi river in 2005, development by MMRDA. In recent years more concern has been expressed by individuals, professionals, and institutions of the Government of India, and the Government of Maharashtra for improving the condition of Mithi river.

D. Maharashtra Nature Park at Mahim

Situated near Dharavi, Asia's largest slum, Maharashtra Nature Park comes across as a breath of fresh air. This educational park was the brainchild of Shanta Chatterji, a busy corporate lawyer and the chairperson of World Wildlife Fund (WWF). Thus developed the 37 acre Mahim Nature Park, which today stands testimony to the 12 long years of hard work put in by her and her team. The park was opened for school children in 1992. Two years later they began allowing general public to visit the park. Every year, around 1.5 lakh people visit this park, which has 580 species of plants, houses 123 species of birds (as recorded), more than 78 types of butterflies, 22 varieties of reptiles and amphibia and more than 30 species of spiders. The MNP has about 27 acres of functional area, most of which was a garbage dump earlier. The entire creek area behind the park was used as a dumping ground back in the 1970s. But by the 1980s, some of this area was declared as a bird sanctuary; soon enough, three decades later, MNP is one of the success stories of the city where nature has once again flourished. The MNP has recorded close to 300 varieties of plants, 115 species of birds and quite a large number of insects. It is like a little green haven in the middle of the choked, polluted city. The forested area pretty much cuts down the vehicular sound that comes from the Bandra-Sion link road, right adjacent to one side of the park. You will find yourself in a tranquil state once you enter the park.

III. STUDY AREA AND METHODOLOGY

A. Study Area and Work Identification

The Further study and methods for making the black water of Mithi river into clear potable water needs to be explored and this gap can be bridged by methods for remedial measures, contamination control and conservation of natural ecosystem mentioned below. Mithi River flows through the city of Mumbai and forms a principal channel to discharge storm water and sewage. Contamination Control by increasing the sewerage network in unsewered areas of Mumbai Suburbs. Collection of Solid Waste by MCGM and penalising the persons disposing the waste and waste water. Conservation of Green Area on the banks of the river by legal binding of Landuse pattern by the planning authorities. To implement SCADA in order to introduce remote control monitoring of the system. Beautification and landscaping along the banks of river with the intention to avoid future encroachments. Strategic cost management by analysis of financial models to achieve cost benefit projects by developing as tourist spot, water sports and boating facilities and can also have surveillance on the illegal dumping of solid waste due to public access by travelling in waters of Mithi. To construct bandharas or weirs or holding ponds on upstream side of river and reuse the water and desilting the silt and debris. The barricading with chain link fencing parallel to existing retaining walls at banks of Mithi prone to slums, scrap dwellers and direct access road and bridges will arrest the dumping of solid waste directly in the river. To install STPs along the banks by recycling the raw sewage for non-potable for reuse.

B. Data Analysis of Water Samples of Mithi

The characteristics of sewage is essential in planning, design and operation of treatment and disposal facilities and in the engineering management of environmental quality. The present investigation deals with study of physio-chemical parameters content in water samples. The samples of Mithi river water were collected from Jan 2014 to Feb 2015 from different locations of river to analyse water quality. The samples were collected from Sakinaka Pg. Stn., Near Sakinaka Pg. Stn, Near Kurla Pg. Stn. and Near Mahim Causeway and tested at MCGM laboratory at Dadar.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Sakinaka Pg.Stn. (Point 1)</th>
<th>Near Sakinaka Pg.Stn (Point 2)</th>
<th>Near Kurla Pg.Stn (Point 3)</th>
<th>Near Mahim Causeway (Point 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.2</td>
<td>7.6</td>
<td>7.5</td>
<td>8.8</td>
</tr>
<tr>
<td>BOD mg/L</td>
<td>124</td>
<td>102</td>
<td>69</td>
<td>84</td>
</tr>
<tr>
<td>Total Suspended Solids mg/L</td>
<td>184</td>
<td>166</td>
<td>133</td>
<td>146</td>
</tr>
</tbody>
</table>

Fig. 1: Sampling Points on Mithi River (Google image-20-08-2015)
### Table 2: Treated Sewage Standards

<table>
<thead>
<tr>
<th>Parameters</th>
<th>After secondary treatment</th>
<th>After tertiary treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOD 5 (mg/L)</td>
<td>≤10</td>
<td>≤5</td>
</tr>
<tr>
<td>COD (mg/L)</td>
<td>≤100</td>
<td>≤50</td>
</tr>
<tr>
<td>TSS (mg/L)</td>
<td>≤20</td>
<td>≤5</td>
</tr>
<tr>
<td>Total Nitrogen (mg/L)</td>
<td>≤10</td>
<td>≤10</td>
</tr>
<tr>
<td>Total Phosphorous (mg/L)</td>
<td>≤1</td>
<td>≤1</td>
</tr>
<tr>
<td>pH</td>
<td>6.5 – 8.5</td>
<td>6.5 – 8.5</td>
</tr>
<tr>
<td>Turbidity (NTU)</td>
<td>≤10</td>
<td>≤2</td>
</tr>
<tr>
<td>Residual Chlorine (mg/L)</td>
<td>≤1</td>
<td>&lt;0.3 – 0.5</td>
</tr>
</tbody>
</table>

### D. Basic criteria for selection of waste water treatment process

One of the most challenging aspects of a sustainable Waste Water Treatment system design is the analysis and selection of the treatment processes and technologies capable of meeting the requirements. The process is to be selected based on required quality of treated sewage. For instance, effluent quality, process complexity, process reliability, environmental issues and land requirements should be evaluated and weighted against cost. A treatment system is essentially a combination of several unit operations and unit processes, each one for removal or reduction of particular pollutant.

In general process for treatment of domestic sewage involves:

- **Primary Treatment (Screening, Oil & Grit Removal)**;
- **Secondary Treatment (Aerobic Biological Treatment and Secondary settling tank)**;
- **Sludge thickening followed by Anaerobic Sludge Digestion and Sludge Dewatering**;
- **Tertiary Treatment (Chemical coagulation with Disinfection using NaOCl)**;

### E. Treatment processes

The following alternative processes are considered which appear to be suitable for this STP. All the processes are essentially variations of the Conventional Activated Sludge Process, which consists of an aerated biological reactor followed by secondary sedimentation and recycle of the settled sludge back to the biological reactor. Process description for various technologies is as follows:

1) **Extended Aeration (EA)**: The extended aeration process is similar to the effluent than MBBR and 47% less than MBR.

2) **Moving Bed Bio Reactor (MBBR)**: The MBBR is an aerobic attached growth process which uses cylindrical shaped polyethylene carrier elements for biological growth.

3) **Sequential Batch Reactor (SBR)**: The SBR is a fill and draw type of reactor system involving a single complete – mix reactor in which all steps of the activated sludge process occur.

4) **Membrane Bio Reactor (MBR)**: MBR technology is the combination of a high rate, activated sludge biological process with ultrafiltration (UF) membranes for solids separation.
F. Evaluation and selection of process technology

The evaluation is based on criteria such as capital cost, O&M cost, space requirements, power cost, complexity of process and performance reliability. For biological treatment, SBR was selected after comparative study with other processes. The SBR is a fill and draw type of reactor system involving a single complete – mix reactor in which all steps of the activated sludge process occur. For Waste Water Treatment with continuous flow, at least 2 basins are used so that one basin is in the fill mode while the other goes through react, solids settling and effluent withdrawal modes. A SBR goes through a number of cycles per day; a typical cycle may consist of 1.5 hr fill and aeration, 0.75 hr settling and 0.75 hr for withdrawal of supernatant. MLSS remains in the reactor during all cycles, thereby eliminating the need for separate secondary sedimentation tanks. Decanting of supernatant is accomplished by decanter mechanism. The HRT for SBRs generally range from 16 to 22 hrs. based on influent flow rate and tank volume used. Aeration may be accomplished by jet aerators or coarse bubble diffusers. Separate mixing provides operating flexibility and is useful during the fill period for anoxic operation. Sludge wasting occurs normally during aeration period. The complete operation is PLC controlled.

IV. RESULTS AND DISCUSSIONS

This eco-friendly scheme will not only improve the ecosystem of the Mithi river due to tertiary treatment of water but also conserve fresh water from present sources of supply to Mumbai city. Also the problem of flooding and disposal of storm water directly into the sea will be reduced as the sewage is reused. Thus the concentration of sewage water will reduce due to pumping of sewage from Mithi to proposed sewage treatment plant and the storm water dilute the balance flowing water and backwashing in the river due to overflow from Powai and Vihar lakes. It will result in sustainability of flora and fauna in the ecosystem of river. It will also save energy because any alternate water source (more than 100km far distance) would have cost implications required for pumping, storage, treatment and transmission.

The following results are achieved:

1) The life cycle cost of tertiary treatment followed by Ultra filtration system which includes capital cost, O&M cost and repair cost for SBR is 27% less than Extended Aeration, 12% less than MBBR and 47% less than MBR.

2) Power cost of Extended Aeration is more compared to MBBR & SBR and for MBR it is highest i.e.44% more than SBR.

3) Also space requirement for SBR is 15% less than Extended Aeration and same as MBBR.

V. CONCLUSION

1. SBR technology is economical from both capital cost and O & M cost point of view and generates good quality of effluent with combination of Tertiary treatment in comparison with EA and MBBR.

2. Proposed project of 50MLD is a high end project and the treated waste water quality required for reuse for gardening, flushing, cooling towers, fire demand, road washing, etc. will add to existing water supply to fulfill the demand.

3. Capital Costs for STP with Extended Aeration, Sequential Batch Reactor and MBBR is almost same whereas for STP with MBR is more.

4. Power cost of Extended Aeration is more compared to MBBR & SBR and for MBR it is highest.

5. Operation & Maintenance is higher for MBR as compared to three alternatives.

6. Area requirement for MBR is less as compared to that required for other alternatives. Further Tertiary Treatment is not required for MBR.

7. MBR technology is good and generates high quality of effluent but the capital cost and O & M cost is very high. Membrane life is also short 5 – 7 years and membranes needs to be replaced after and interval of time which has high periodic cost.

8. SBR technology is economical from both capital cost and O & M cost point of view and generates good quality of effluent with combination of Tertiary treatment in comparison with EA and MBBR.

9. As per the above observation SBR followed by Ultrafiltration is the more suitable option for Tertiary treatment.

10. Proposed project is a high end project and the treated wastewater quality required will be of good quality to reuse for gardening, flushing, etc.

11. Considering area requirement, operating flexibility, cost comparison, better quality of Effluent and reuse of treated wastewater; it is proposed to provide SBR technology followed by Ultrafiltration.

ACKNOWLEDGEMENT

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