Control Of Major Pollutants In River By Bioremediation: A Case Study - River Mutha - Pune.

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Abstract

River plays a very vital role in social, cultural and economical development of any region. The rivers flowing through Pune are getting polluted due to activities related to humans, industries. The BOD, DO, Ph, Turbidity, microbial count etc are so high that it is not suitable for irrigation or domestic purpose despite treatment at various STPs. Inadequate treatment of sewage, contaminate rivers downwards and water bodies, wells, groundwater in the vicinity.

Control over river pollution can be achieved by some definite strategies including surveys, systematic study of river basins, and characterization of contaminants, analyzing water parameters and finalizing action plan.

The present work is in accordance with chemical characterization of river Mutha-Pune. This study includes water quality characterization, finding major pollutants submerging through point and non point sources, GIS plotting of river stream for digitization of river stream showing pollutant concentration and their behavior for spread and finally a control strategy Bioremediation.

The study also helps to understand the possible scenario of river water quality in the absence of certain category. The above case study also emphasizes that Indian cities needs to revive and sustain rivers.

1. Introduction

Mutha river has a prime importance in the economy of area aside. River bank attracts developers for residential, commercial and industrial developments whereas it already has been enriched with agricultural lands. The tremendous development along the riverside has resulted in polluting river water stream as it is very common to discharge waste water as well as garbage into the river.

The area under investigation has

Residential building along river bank - discharges their septic tank effluent, storm water and sewage.

Agricultural lands - discharges the pesticides and chemical fertilizers into the river.

Industries: Along the river most of the industries are the manufacturing units. Some of them process cement, metal, silica sand and other are Small Scale Industries dealing with electronic devices, chemical industries dealing with detergents, caustic, bottling plants, battery works etc. The effluent from these industries is let out in the river directly.

Municipal sewer: The sewage from municipal sewer line is also directly connected to the river. The common *Nala* collecting all storm water, domestic sewage, industrial water–treated/untreated is directly discharged without any processing into the river. This *Nala* is having length of about 10-12Km, and is carrying large amount of untreated and contaminated water.

After detailed chemical characterization of river water at selective points it has been observed that Bioremediation is one of economic and feasible method to control river pollution aerobically.

Bioremediation is the use of living organisms, primarily microorganisms, to degrade the environmental contaminants into less toxic forms. It uses naturally occurring bacteria and fungi or plants to degrade or detoxify substances hazardous to human health and/or the environment. The microorganisms may be indigenous to a contaminated area or they may be isolated from elsewhere and brought to the contaminated site. Contaminant compounds are transformed by living organisms through reactions that take place as a part of their metabolic processes. Biodegradation of a compound is often a result of the actions of multiple organisms. When microorganisms are imported to a contaminated site to enhance degradation we have a process known as bio augmentation.

Present work will deal with chemical characterization of river water, and control over major pollutants - heavy metals (Mercury, Lead, arsenic and Zinc), chlorides, phosphates and nitrates by bioremediation.

2. Preliminary Observations.

The flowing rivers are getting polluted due to human activities and effluents from industries. Mutha River one of the prime water sources for Pune city is getting contaminated because of urbanization, industrialization and population along bank. Presently no treatment is being adopted before discharging the waste water into the river.

Hazardous effect on river ecosystem - River ecosystem is of prime importance in environmental ecosystems. There are around 170 different species that exists in the river which maintain a very good environmental balance through food chain and food web. This ecosystem not only consists of aquatic life but also ecosystems along river bank.

In case of Mutha River the temperature of river water is objectionable. Effluent stream carries higher nitrates, sulfates and heavy metals to some extent. All this badly affects the river ecosystems and needs to be controlled.

Health hazard to human being – Water is the life for human being. Human beings always prefer not only pure but clean and hygienic water source. At the same time water is one of the prime reasons for many communicable diseases. The potable water should be as per WHO standard and free from any kind of contaminants.

In case of Mutha River the industrial effluent stream is directly introduced into the Mutha River. The stream water has been found with higher

temperature, acidic, excess total solids and contaminated with heavy metals like mercury, lead & zinc.

As this contaminated water is being utilized by civilians it may harm the human health leading to skin diseases, cancer, eye irritation, allergies etc.

Health hazard to livestock – It is also observed that the same contaminated water is being utilized by civilians for their cattle cleaning, sweeping, drinking and bathing purpose.

As these cattle are used for dairy purpose the milk quality will definitely get affected because of intake of polluted water. It has been observed that the livestock are also falling sick due to polluted water.

3. Methodology

Water quality parameters are means to describe the chemical, physical and biological characteristics of water usually in respect to its suitability for particular purposes[2]. The qualitative parameters derived from water samples were collected at various locations along the urban stretch of Mutha River (approx. about 11Km) **(Fig. I)**. Fifteen (15) sampling stations were fixed starting from Khadakwasala dam downstream. Water samples were collected from these stations. The water samples were tested in the laboratory for different physical, chemical and bacteriological parameters.

Figure 1- Study area

a. **Sampling of stream water:** For systematic study of river water quality it is essential to have proper sampling.
b. **Characterization of stream water:** Chemical characterization of stream water is carried out to determine contamination. Chemical characterization also helps to design pollution control mechanism. As this river is receiving different types of pollutants chemical characterization need to be done.
c. **Plotting GIS map showing different parameters like Ph, TSS, heavy metal content etc. -** The study will incorporate plotting of GIS maps for the different chemical parameters and also pollutant contaminations.
d. **Pollution Control strategy:** Bioremediation is one of the effective methods to control the water pollution aerobically.

   Bioremediation is the use of living organisms, primarily microorganisms, to degrade the environmental contaminants into less toxic forms. It uses naturally occurring bacteria and fungi or plants to degrade or detoxify substances hazardous to human health and/or the environment. The microorganisms may be indigenous to a contaminated area or they may be isolated from elsewhere and brought to the contaminated site. Contaminant compounds are transformed by living organisms through reactions that take place as a part of their metabolic processes. Biodegradation of a compound is often a result of the actions of multiple organisms. When microorganisms are imported to a contaminated site to enhance degradation we have a process known as bio augmentation.

   In case of river pollution control microorganisms which catalyze process of oxidation need to be introduced.

The parameters are total suspended solids (TSS), total dissolved solids (TDS), turbidity, biochemical oxygen demand (BOD), Chemical Oxygen Demand (COD). The above parameters revealed the overall health condition of river. The aforesaid polluting parameters are mainly present in the Mutha River (Kanase et al. 2005). So, much attention and emphasis has been laid towards the quantification of wastewater generation, its prevention from mixing directly to river and partial biological treatment. Above-mentioned parameters were derived for assessing the Mutha river urban watershed health assessment. The qualitative parameters deal with only with the nature / characteristics and not the volumes / quantities of the themes under consideration.

Total Suspended Solids (TSS)

Total Suspended Solids (TSS) represents the total suspended solids / nondissolved in water (Kanase et al. 2005). Total Suspended Solids (TSS) maps were derived from random samples collected from Mutha River. Total Suspended Solids (TSS) zones were derived from fifteen random samples collected from Mutha River.

Total Dissolved Solids (TDS)

TDS means the total concentration of dissolved minerals (or salts) in water (Kanase et al. 2005). Total Dissolved Solids (TDS) maps were derived from random samples collected from Mutha River. Total Dissolved Solids (TDS) zones were derived from fifteen random samples collected from Mutha River.

Turbidity

Presence of large amount of clay or suspended organic materials in water will make the

appearance of water as muddy or turbid. The turbidity depends upon the fineness and concentration of the particles present in the water (Kanase et al. 2005). Turbidity zones were derived from fifteen random samples collected from Mutha River.

Biochemical Oxygen Demand (BOD)

If sufficient oxygen is present in water, the useful aerobic bacteria production will flourish, which causes the biological decomposition of waste and organic matter and thus reducing the carbonaceous material from the water. The amount of oxygen required in the process, until oxidation gets completed is known as Biochemical Oxygen Demand (BOD). Polluted water will continue to absorb oxygen for many months and it is not possible to determine this ultimate oxygen demand. Hence the BOD of water during five days at 25° C is generally taken as the standard demand. If BOD of water is zero, it means that no oxygen is required and thus no organic matter is present (Kanase et al. 2005). BOD zones were derived from fifteen random samples collected from Mutha River.

Chemical Oxygen Demand (COD)

According to the American Society of Testing and Materials (ASTM), COD is defined as the amount of oxygen (mg / l) consumed under specified conditions in the oxidation of organic and oxidisable inorganic matter, corrected for the influence of chlorides. The chemical oxygen demand (COD) is a measure of the oxygen equivalent to that portion of organic matter present in the wastewater sample that is susceptible to oxidation by potassium dichromate. This is an important and quickly measured parameter for the streams, sewage and industrial waste samples to determine their pollution strengths (Kanase et al. 2005). COD zones were derived from fifteen random samples collected from Mutha River.

4. Significance of Bioremediation:

Avoids development and construction of specific waste treatment plant, thus reduces building, operation and maintenance cost of conventional plant:

Industrial waste water is being treated by industries themselves may be within their premises or through common effluent treatment plant. Both of these methods may cause expensive treatment units, their costlier operation and maintenance cost.

Pollution control by bioremediation will be the better alternative for such expensive plants and processes.

Bioremediation promotes an ecologically efficient and economically sustainable pollution control:

It is very essential to maintain the river ecosystem. The conventional methods adopted for industrial waste water treatment causes to disturb the aquatic life of river, if discharged in river. As the bioremediation is the process of degradation of contaminants by microbial activities, this process maintains food chain and ultimately an ecosystem.

Reduced operation and monitoring cost:

The method of bioremediation is economic one as there is very less operational and monitoring cost. The microbial culture once developed can be utilized for longer span of time.

Flow fluctuations, weathering conditions do not affect the process of bioremediation:

River stream largely fluctuate in pre monsoon, monsoon and post monsoon season. The fluctuation results to cause stagnation or turbulence of water bodies. Stagnation of water bodies causes to rapid increase in BOD and ultimately increases concentration of pollutants. Whereas turbulence developed causes rapid diffusion of pollutant within river stream.

Bioremediation in either case works effectively as there is microbial activity which is not affected due to type and nature of flow.

The development of microbial culture is carried out depends on the atmospheric conditions. The suitability is frequently checked and altered if necessary.

5. Laboratory Work:

For defining the exact method and strategies it is essential to run a pilot plant. The pilot plant consists of a fibre tank of dimension 1.5m X 0.30m X 0.30m with necessary plumbing fixture to regulate flow and overflow. The sample river water will be allowed to circulate in this tank.

Development of microbial culture – A necessary microbial culture developed depending upon the chemical characteristics of the river water. Same microorganisms will be allowed to grow in the tank.

Laboratory analysis:

Laboratory analysis is carried out for both pre-treatment stage and post treatment stage. In pre-treatment stage analysis the river water is tested for its chemical characterization. Based on these chemical constituents, the type of microorganisms that need to be developed is finalized.

In post treatment stage chemical analysis of river water has carried out, to check whether the treated water follows WHO standard.

Table No. 01: Field Test Results: Duration of sampling – 03.05.2012 to 22.10.2012

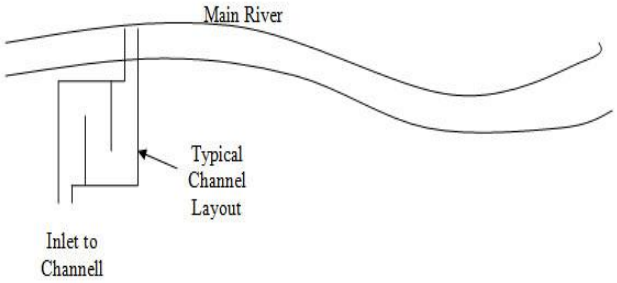
Zone	Peculiarity and details	No. of Samples analyzed	Preliminary analysis (Avg. Values)					
			BOD	DO	pH	COD	Lead	Chromium
	Permissible values		2-3 mg/l	5-6 mg/l	6.5-8.5	250 mg/l	0.05 mg/l	0.05 mg/l
Zone 1	downstream of khadakwasala Dam	6	29	7.1	6.2	360	Absent	Absent
Zone 2	Residential - Point source of domestic waste water; Behind Nanded City	6	36	5.5	8.0	436	Absent	Absent
Zone 3	Industrial - Point source of Industrial waste water; near Warje bridge	6	42	7.8	8.7	405	2.4	2.7
Zone 4	Aggricultural - Line source of Aggricultural chemicals, Pesticides; Vitthalwadi	6	41	6.5	8.6	457	1.2	1.3

Selection of microorganism's culture for bioremediation:

Bioremediation is the use of living organisms, primarily microorganisms, to degrade the environmental contaminants into less toxic forms. It uses naturally occurring bacteria and fungi or plants to degrade or detoxify substances hazardous to human health and/or the environment. The microorganisms may be indigenous to a contaminated area or they may be isolated from elsewhere and brought to the contaminated site. Contaminant compounds are transformed by living organisms through reactions that take place as a part of their metabolic processes. Biodegradation of a compound is often a result of the actions of multiple organisms. When microorganisms are imported to a contaminated site to enhance degradation ; process known as bio augmentation.

In case of river pollution control microorganisms which catalyze process of oxidation need to be introduced.

Dozing of Microorganisms:



Schematic lay out for in situ application of bioremediation.

Four microorganism's cultures are selected for trials. These cultures are with microorganisms having strong oxidizing capacity. These cultures need to be cultivated for six weeks. River water will be treated with these microorganisms and again chemical analysis will be carried out. This chemical analysis is essential to decide dosing of selected microorganisms.

In this process microorganisms used are –**Aerobic -** In the presence of oxygen. Examples of aerobic bacteria recognized for their degradative abilities are *Pseudomonas, Alcaligenes, and Rhodococcus.* These microbes have often been reported to degrade pesticides and hydrocarbons, both alkanes and polyaromatic compounds. Many of these bacteria use the contaminant as the sole source of carbon and energy.

In laboratory a mixture of species of *Pseudomonas* and *Rhodococcus* applied in predefined dosage.

The results obtained are tabulated in table No.2

6. Results and Conclusion:

Dosing rate is independent of pollution level as bacteria will multiply in the polluted water environment to its own optimum population level. Dosing is generally based on estimate water volume in the treatment zone or daily flow volume whichever is higher. Higher dosing rate is recommended at zones upstream than zones down stream as some bacteria upstream will flow to zones downstream.

For very slow flowing river with retention time more than 24 hours per zone, the dosing can be consolidated into few days per dosing to save labor cost. Alternatively, automatic continuous dosing is highly recommended if feasible.

The combination of biological parameters used in this study proved to be appropriate for monitoring remediation efficiency during bioremediation. The parameters studied reliably and consistently indicated bioremediation progress during treatment. The study also demonstrated that bioaugmentation was more effective in removing a variety of organic contaminants from the lake sediments as compared to biostimulation with aeration and nutrient

addition. The latter was significantly more effective than biostimulation with aeration only.

Table No. 02: Laboratory Test Results after bioremediation.

Zone	Peculiarity and details	No. of Samples analyzed	Preliminary analysis (Avg. Values)					
			BOD	DO	pH	COD	Lead	Chromium
	Permissible values		2-3 mg/l	5-6 mg/l	6.5-8.5	250 mg/l	0.05 mg/l	0.05 mg/l
Zone 1	downstream of khadakwasala Dam	6	7	7	6.2	260	Absent	Absent
Zone 2	Residential - Point source of domestic waste water; Behind Nanded City	6	6	5	6	330	Absent	Absent
Zone 3	Industrial - Point source of Industrial waste water; near Warje bridge	6	5	6	6,2	380	0.02	0.04
Zone 4	Aggricultural - Line source of Aggricultural chemicals, Pesticides; Vitthalwadi	6	6	6	6.4	410	0.02	0.035

6. Referances:

Md. Zeyaullah, Mohammed Atif, Badrul Islam, Azza S. Abdelkafe, P. Sultan, Mohamed A.ElSaady and Arif Ali.; Bioremediation: A tool for environmental cleaning**;** African Journal of Microbiology Research Vol. 3(6) pp. 310-314; June 2009.

WenpingCaoa, HouhuZhangb, YinmeiWanga, JiZhengPanc; Bioremediation of polluted surface water by using bio films on filamentous bamboo; The journal of ecosystem restoration; Vol.38 Issue 1; January 2012 ISSN:0925-8574.

Desale Prithviraj et al; Biosorption of Heavy Metals by Actinomycetes for Treatment of Industrial Effluents; UMT 11th International Annual Symposium on Sustainability Science and Management 09th – 11th July 2012, Terengganu, Malaysia;

Adebowale Adeniji; Bioremediation of Arsenic, Chromium, Lead, and Mercury; U.S. Environmental Protection Agency; Office of Solid Waste and Emergency Response; Technology Innovation Office; Washington, DC; www.clu-in.org; August 2004.

D.G. Kanase, S.D. Jadhav, R.W. Jawale, M.S. Kadam; : A Study On Some Physico - Chemical Characteristics Of Flowing Water Of Major Rivers In Pune City.