International Journal of Biotechnology and Food Science
Vol. 1(3), pp. 56-64, September 2013
ISSN: 2384-7344
Research Paper

In-situ bioremediation for treatment of sewage flowing in natural drains

S. K. Jain[1] • A. B. Akolkar[2] • M. Choudhary[2]

[1]International Institute for Environmental Management and Research, A-7 In Toran Garden, A. B. Rd, Indore-11, India.
[2]Central Pollution Control Board, Delhi, India.

*Corresponding author. E-mail: sanatenvirotech@rediffmail.com.

Abbreviations: BOD, Biochemical oxygen demand; **COD,** chemical oxygen demand; **TDS,** Total dissolved solids; **TSS,** total suspended solids; **ETP,** effluent treatment plant; **STP,** sewage treatment plant; **CFU,** colony forming units.

Accepted 21st August, 2013

Abstract. The study is aimed to treat sewage flowing in open drains by application of especially developed microbial consortium – a bioremediation method. The objective of the study is that sewage may be stabilized in drains thereby giving relief to the citizens from exposure of obnoxious harmful gases and unhygienic situations which prevail in the vicinity of open drains, and to reduce concentration of water polluting parameters like biochemical oxygen demand, chemical oxygen demand, total dissolved solids, total suspended solids including odour control. The study has been carried out at Indore in Khajarana-RR-A.B. road drain in a stretch of 9.55 km as a model project using probiotics consortium without changing the basic structure of the drain or flow pattern, with a stress on economic-viability by adopting non- mechanized/ non-electrical processes so that unskilled staff could carry out the treatment process. A critical examination of Data for 12 months has shown reductions in odour of more than 98%, BOD of 75 to 80%, and COD of 70% under natural conditions.

Keywords: In-situ, bioremediation, sewage, natural drain, treatment.

INTRODUCTION

Wherever people live, waste products are produced as a result of their activities. These can be solid, liquid or gaseous and may substantially affect the health either directly (e.g. by pathogens, odour nuisance, unaesthetic appearance, etc) or they may cause major damage to natural resources through soil, water and air.

Ever since wastes have become trouble-some and man has tried to dispose them off in natural resources. In the past nature disposed off such wastes since the population of men was not much and carrying capacity of natural resources was enormous. Now it is vice-versa. Therefore, the problem of pollution has become a great dogma.

In the interest of public hygiene, public health and national economy these wastes, especially the community sewage, have to be disposed off in a hygienically, unobjectionable way, at costs that are justified from the economic point of view. In so doing, particular attention has to be paid to obtain secondary use or recovery or conversion into products which can well be utilized.

Environmental Acts adopted in various countries in the world, states that:

> Further development of the National Economy and the Management of the National Environment call for towns and villages to effectively utilize or harmlessly dispose off waste products and care has to be taken that the Living conditions of citizens, the landscape and public health are not impaired by waste products.

Thus, it is expressly stressed that the necessary facilities for the efficient reuse and harmless disposal of community sewage should be planned and provided.

In order to improve the demand of water need for both – industrial sector and domestic, and for the sake of environmental protection, greater importance must be attached to reutilization of by-products or recovery of water from wastewater for industrial use during the treatment of community sewage and / or the revival of polluted water bodies.

This study explores the possibility for *in-situ* treatment of polluted water body by eco-friendly technology for cleaning the polluted drain water for various uses, achieving the UNEP's goal and reviving the natural resource as well.

Magnitude of the problem

In 142 class 1 cities in India, there is lack of adequate sewage collection and treatment system. Majority of cities have no facilities for sewage and treatment of community sewage. In rural areas, the condition is still worst.

Due to inadequate sewage disposal, it invariably gets mixed with the open/natural water resources leading to water pollution (Death of River/Fresh water Resources) as is observed at Indore (Death of Khan and Saraswati Rivers).

It is a universal truth that wherever people live, pollution is generated. It is mainly generated in the form of community sewage. This needs a proper treatment and disposal. Such facilities are lacking in the countries like India, and hence most of the rivers in this country are either polluted or even converted into sewage drain, such as - Khan and Saraswati rivers at Indore and Mula-Mutha river at Pune. Such conditions of rivers have arisen due to discharge of untreated community sewage into rivers which have exceeded the carrying capacity of rivers, or in other words destroyed the self purification mechanism of rivers.

An improper management of such wastes creates environmental problems, because it contains large amount of carbohydrates, proteins, fat, mineral salt and other chemical compounds. The content of high organic matter in the wastewater can be used as a source of energy for the growth of microorganisms (Betty and Winiarti, 1990). Contaminated systems are causing impacts on plants, microorganisms, aquatic organizations and life support functions, such as immobilisation, mineralization and nitrification, that is ultimately affecting human health as well as health of ecosystem (Batayneh, 2012).

Bioremediation is an option that offers the possibility to destroy or render harmless various contaminants using natural biological activity. As such, it uses relatively low-cost, low technology techniques which generally have a high public acceptance and can often be carried out at site (Vidali, 2001). Bioremediation stimulates the growth of certain microbes that use contaminants as a source of food and energy (EPA, 2012). Kensa (2011) in an article "Bioremediation: an overview", states that bioremediation is an ecologically sound and state-of-the-art technique that employs natural biological processes to completely eliminate toxic contaminants. It may be any process that uses microorganisms, fungi, green plants or their enzymes to return the natural environment altered by contaminants to its original condition.

By definition, 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 (Rani et al., 2007) to degrade or to detoxify substances hazardous to human health, aquatic and terrestrial life and/or environment.

In literature most of the works on Bioremediation is done in laboratory scale (Monica et al., 2011), ETPs/STPs (Ahluwalia and Goyal, 2007; Jain, 2006; Singh et al., 2010), or land and ground water (Mani and Kumar, 2013; Chakraborty et al., 2012; Chatterjee et al., 2012; Achal et al., 2012b). Celia and Franklin (1997), in 'Bioremediation: Today and Tomorrow' have cited 140 references showing its applicability to mines, soil, groundwater, organic and metal contaminants, leaching and engineered bioremediation; but none on sewage drains or polluted rivers. They further state that technologies for surface water remediation are not nearly as well developed as those for soil or even ground water. Similar views are expressed in MoEF, Govt. of India Report (2011) and Mandal et al. (2012).

Now, there is an urgent need to develop techno-economical solutions for revival of such dead rivers to meet growing demands of water and for the survival of mankind in future on this beautiful planet "Our Mother Earth".

Technology needs

To achieve this goal, the only solution is to treat the community sewage at generation point most techno-economically in a decentralized system, that is, by dosing eco-friendly microbial population *in-situ* (Jain 2011).

To control the odour in the Nala or drains or channels, especially developed eco-friendly microbes can be dosed *in-situ* which do not allow the formation of either H_2S (Hydrogen sulphide) or methane – constituents of odour and anaerobic putrefaction, instead converts all organic matters into carbon dioxide (CO_2) through the process of fermentation. The latter is utilised by photosynthetic organisms present in the consortium. In short, *bioremediation* technology has thus revolutionized sewage and wastewater treatment. Probiotics (eco-friendly and efficient microbes) have been used worldwide for more than 10 years in sewage treatment plants in many countries including USA, Japan, Australia,

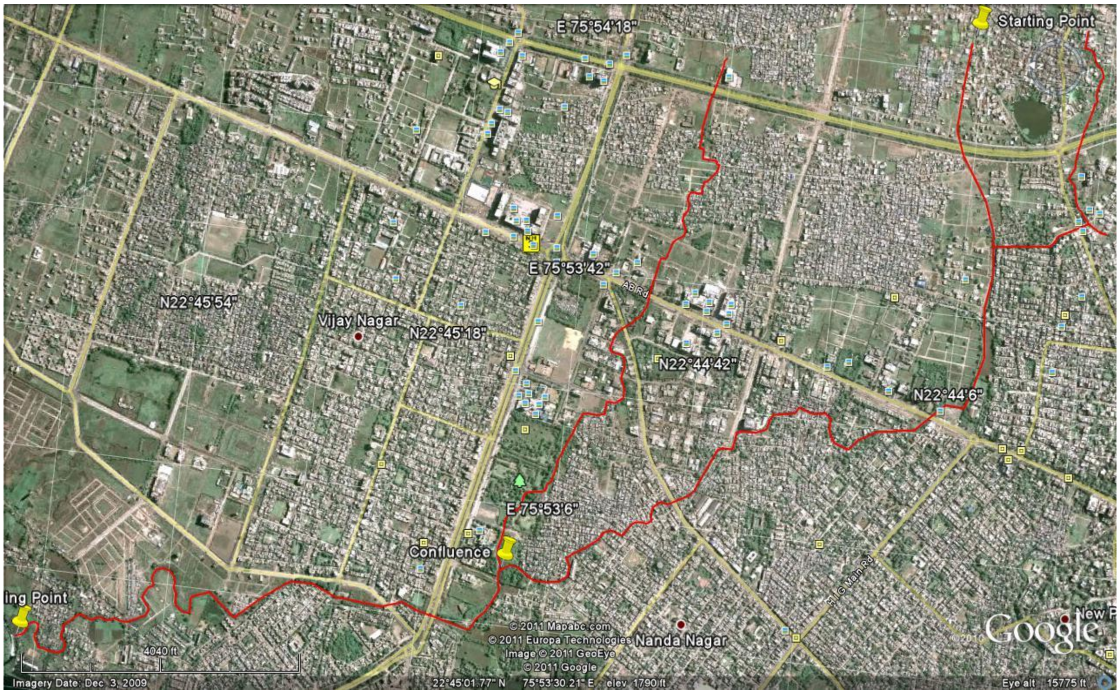

Figure 1. Map showing origin, merging and confluence of Khajarana-Ring Road-A. B. Road Drains with River Khan.

Thailand, Vietnam, Pakistan, India etc. Its spectacular performance in curbing pollution and treatment of effluent has made it the natural choice for environmentalists, municipalities and industry alike (Jain, 2006).

Objective of the research

The R&D study proposed is to treat sewage flowing in open drains by application of biological methods- Bioremediation using suitable Microbial Consortium. The objective of the study is:

1. To reduce concentration of organic pollutants in water body and to record an improvement in water quality by analysing pollution indicative parameters like BOD, COD, pH, TDS, TSS and Chlorides.
2. To observe reduction in odour and reduction of bottom sludge.
3. The study is to be carried out without changing the basic structure of the drain or flow pattern.
4. This study is stressed on economic-viability based on non-mechanized / non-electrical processes so that un-skilled staff could carry out the treatment process.

MATERIALS AND METHODS

Description of the project area

There are mainly two natural drainage crossing Agra-Bombay road on eastern side of Indore town. Both these natural drainage – meant for carrying storm water; but get loaded with domestic sewage and thus serve the purpose of sewage disposal. Since these are passing through the part of eastern sector of Indore town, carry about 20 MLD of domestic sewage emanating from 2 to 3 Lakhs population living in newly developed colonies and old habitation of town living around these natural drainages (Figure 1). Thus this natural drain covers a total of 9.55 km distance up to confluence with Khan River. The total catchment / basin of these drains is around 5.4 sq.km with a circumference of 16 km resembling almost a rectangle with little East-West protrusions.

Survey conducted from start point to Agra-Bombay road, covering a stretch of 2.6 km, gave an idea of flow of domestic sewage in these drains. At the start point, flow is very little; but further downstream the flow of sewage gets increased since more than 10 newly developed colonies-Private and Sch. No. 93 and 59 of Indore Development Authority pour domestic sewage in these (having average population ranging between 6000 to 15000 people).

A total of 8 dosing stations (Figure 2) have been identified to dose the consortium of probiotic population. These stations (from upstream to downstream of drain) are: Khajarana, Ring Road, Utkarsh Vihar, Anuragnagar, Gurudwara, Bhamori Pul, GSITM college-Sukhalia and Nyaynagar.

The drain water samples have been collected throughout 12 months covering all the three seasons, viz.-summer, rainy and winter from Gurudwara, Bhamori,

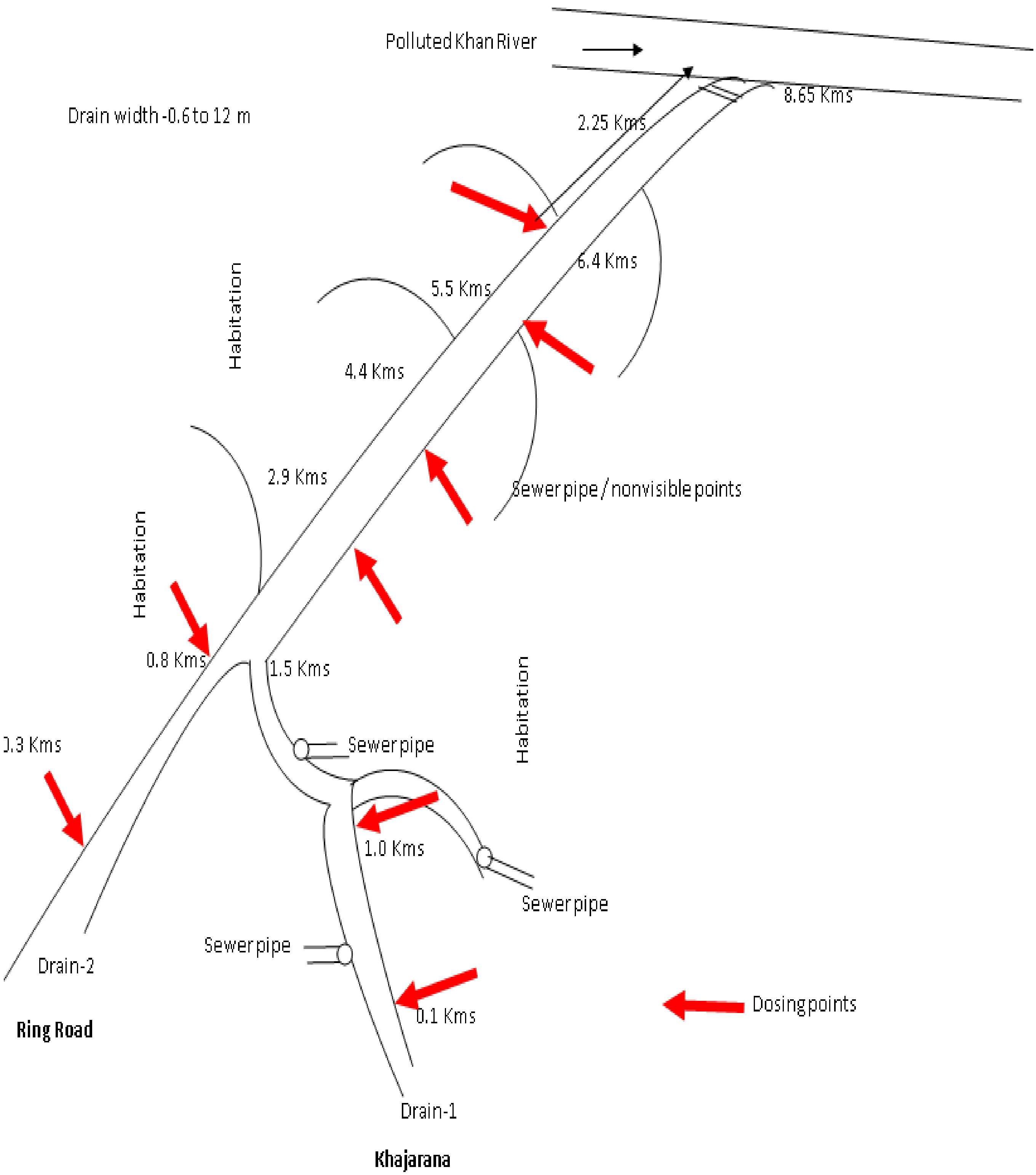

Figure 2. Schematic diagram showing dosing points on drains at Indore.

Sukhaliya and 100 m upstream before confluence with river Khan. Also, samples from 2 drains - Palasia drain and raw sewage from Utkarsh vihar drain have been collected for the sake of comparison. Samples collected periodically are analysed for various Parameters – BOD, COD, TDS & TSS by Regional Laboratory MPPCB,

Table 1. Monitoring results of drain water quality (before start of bioremediation).

Station	pH	TDS[1]	TSS[2]	Cl[3]	BOD[4]	COD[5]
Gurudwara	7.57	879	396	425	320	590
Bhamori	7.79	2217	491	175	290	530
Drain 100 M before confl. into Khan	7.52	815	647	350	410	650
Khan 50 M DS of drain confluence	7.59	814	210	425	210	370

1: Total dissolved solids; 2: Total suspended solids; 3: Chlorides; 4: Biochemical oxygen demand; 5: Chemical oxygen demand. Date of Sampling: 04/02/2011. Except pH, all values are expressed in mg/L.

Table 2. Monitoring of drain water quality (after start of bioremediation).

Station	pH	TSS	BOD	COD
Gurudwara	7.2	355	110	270
Bhamori	7.8	778	105	300
Sukhaliya Pul	7.3	1066	115	320
Drain 100 M before confl. into Khan	7.5	294	70	270

Date of sampling: 25/04/2011 (After 45 Days of Dosing) Bioremediation Stations. Except pH, all values are expressed in mg/L.

Indore following standard methods as mentioned in APHA, AWWA, WEF (2005).

Activation of microbial consortium

The dormant culture was opened and activated by taking 1 L of dormant culture, 20 g micronutrients and 49 L of filtered drain water in a container (in 1:50 ratio) in PVC drum. After screwing the cap tightly, it was kept for activation and multiplication. After 12 h, it was dosed daily. In the start daily dosing was 80 L up to 60 days, then 60 L for next 3 months and thereafter 40 L. Dosing was done through an e-micro-acti-dozer (mechanical dosing), through PVC tanks (for gravity dosing) 24 hourly and also by manual spraying through spray pumps twice in 24 h in 3 points. At each dosing point 200 L of activated culture was dosed inclusive of 20 L of manual spraying.

The source of microbial consortium used in this study is Sevalgen developed by MSI Biotech, India since this consortium was used earlier by Jain (2011) in sewage treatment. EM was also used earlier in sewage treatment (Jain, 2006); but it had limitations. Hence, a consortium containing co-enzymes (oxido-reductase group with proteolytic enzymes) and bacterial population belonging to hydrolytic, photosynthetic, flourscent, *Bacillus* sp., phosphate solubilizers, nitrifiers and denitrifiers, carbohydrate degraders, hydrocarbon degraders is used which has the ability to bioremediate the polluted drain water.

RESULTS AND DISCUSSION

A quantitative estimation of drain water has also been carried out through a 90° 'V' notch near Sukhalia (recording about 90% discharge as downstream colonies are also pouring its sewage in this drain in downstream of 'V' notch). A maximum flow of 1400 cum/h during noon time and minimum flow of about 700 cum/h is recorded during early morning hours.

Prior to dosing of the microbial consortium, the drain water quality was analyzed in M. P. State Pollution Control Board's Regional Laboratory (Table 1, Figure 3a, b, c and d).

From Table 1, it is evident that the drain is highly polluted and carries almost pure sewage with an obnoxious odour spreading in nearby areas.

After the dosing of microbial consortium, it was observed that the BOD and COD of this drain decreased gradually with a reduction in obnoxious odour. The quality of drain water recorded during various months is presented in Tables 2 to 9, Figures 3a, b, c and 4.

For comparison purpose, the quality of raw sewage and drain not under treatment was recorded in Table 3.

Tables 2, 3, and 4 indicate that *in-situ* bioremediation treatment of drain has positive impacts in controlling the odour nuisance and also in the reduction of pollution load. The BOD has almost reduced by 45% after 6 weeks of dosing. In general, it was observed that odour was reduced in the drain under treatment as compared with other drains, viz. Palasia Drain on A. B. Road and Utkarsh Vihar (raw) in the same locality.

Further reduction in odour and BOD and COD values has been recorded during the following months, which are presented in Tables 5 and 6.

After this sampling, the rains started with heavy showers. Its dilution effect is observed and recorded in Tables 7 and 8.

The results in Tables 7 and 8 indicate the effect of

Table 3. Water quality of drains not under dosing/bioremediation.

Station	pH	BOD	COD
Palasia nala Deonagar	7.3	220	1500
Utkarsh Vihar (Raw swg)	7.4	215	550

Date of sampling: 12/05/2011. Except pH, all values are expressed in mg/L.

Table 4. Water quality at bioremediation stations.

Station	pH	BOD	COD
Gurudwara	7.8	120	340
Bhamori	7.90	125	460
Sukhaliya	7.91	135	530
Drain 100 M before confl. in Khan	8.21	75	170

Date of sampling: 20/05/2011. Except pH, all values are expressed in mg/L.

Table 5. Date of sampling: 07/06/2011.

Station	pH	BOD	COD
Gurudwara	7.10	65	150
Bhamori	7.02	80	300
Sukhaliya	7.17	110	210
Drain 100 M before confl. in Khan	7.34	42	140

Table 6. Date of sampling: 06/07/2011.

Station	pH	BOD	COD
Gurudwara	7.53	84	330
Bhamori	7.42	96	340
Sukhaliya	7.51	116	380
Drain 100 M before confl. in Khan	7.31	76	300

Table 7. Date of sampling: 09/08/2011.

Station	pH	BOD	COD
Gurudwara	7.33	26	78
Bhamori	7. 20	26	70
Sukhaliya	7.31	28	80

Table 8. Date of sampling: 26/08/2011.

Station	pH	BOD	COD
Gurudwara	7. 21	28	70
Bhamori	7.14	24	60
Sukhaliya	7.31	28	80

dilution due to rainy water. However, the Palasia drain, which was not being treated, showed higher values of the pollutants (Table 9).

It is also evident that there is good reduction in polluting parameters, viz. BOD and COD, as compared with the data recorded during same period in other drain (not

Table 9. Water quality in Palasia drain.

Station	pH	BOD	COD
Palasia Drain (Not under treatment)	7.28	72	228

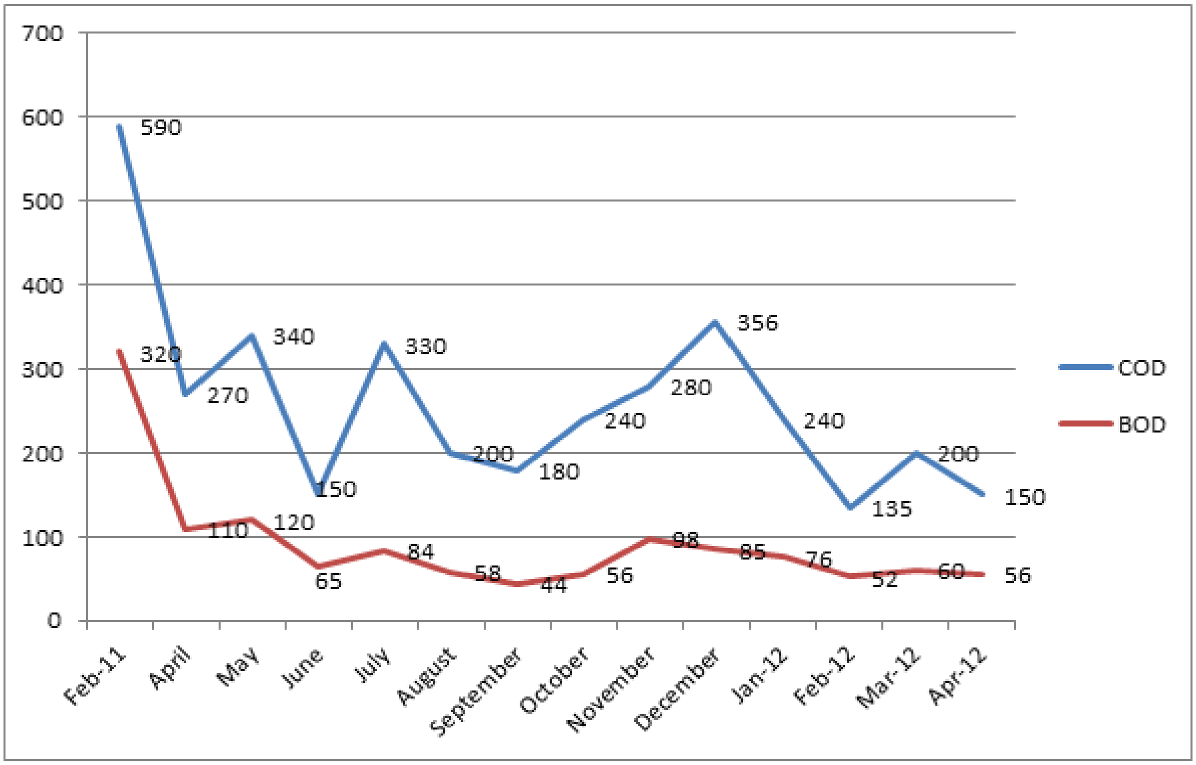

Figure 3a. Monthly variations in BOD (mg/L) and COD (mg/L) at Gurudwara (LIG).

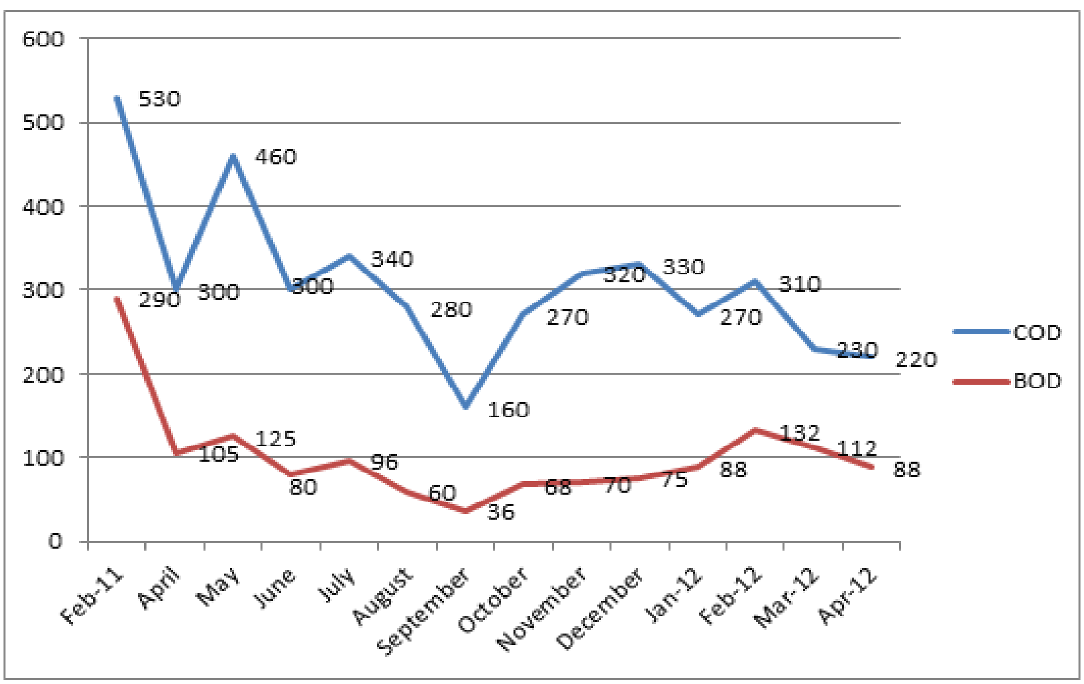

Figure 3b. Monthly variations in BOD (mg/L) and COD (mg/L) at Bhamori Pul.

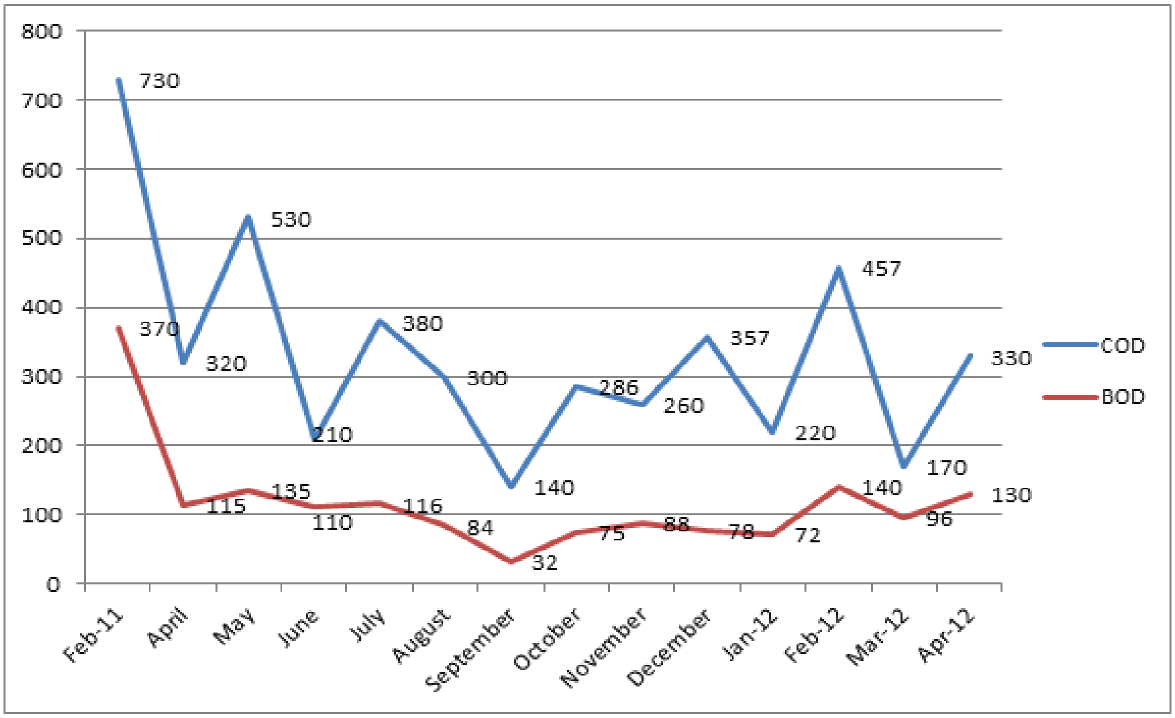

Figure 3c. Monthly variations in BOD (mg/L) and COD (mg/L) at Sukhaliya.

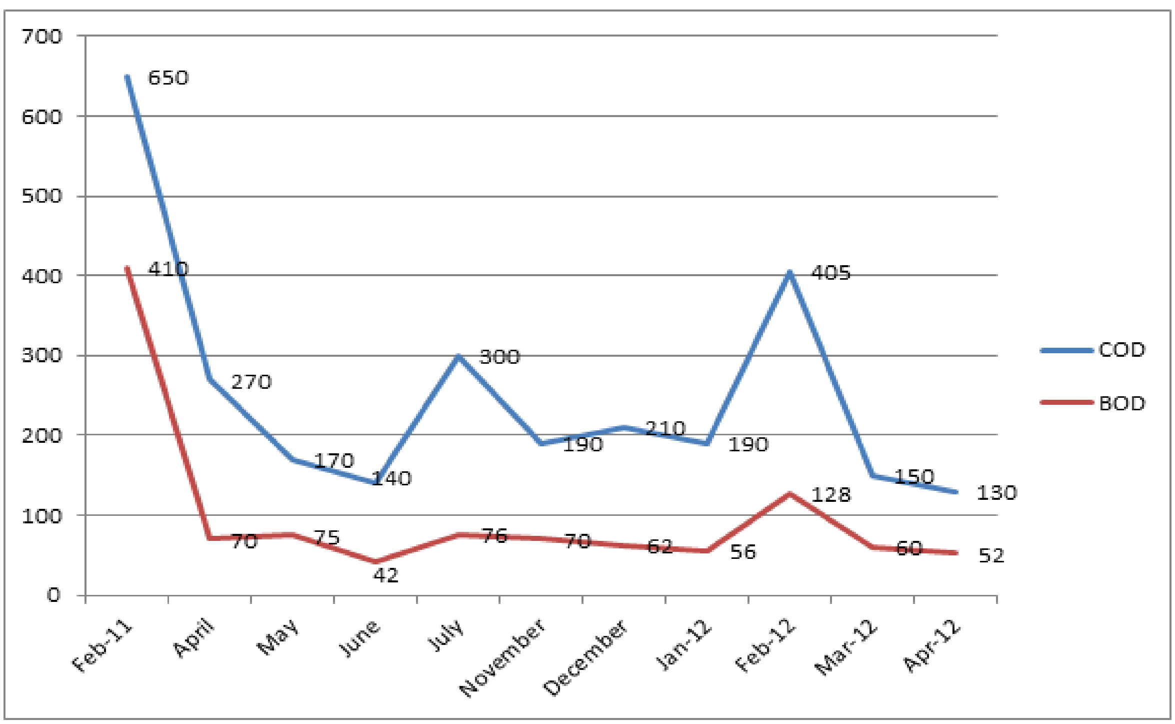

Figure 4. Drain before confluence with Khan River (100 m US).

under treatment) since dilution factor is common in both these drains. Monthly variations recorded in various locations are indicated in Figure 3 a, b and c. Figure 4 indicates up to 80% reduction in BOD before confluence with Khan River.

Jain (2006) had earlier reported that probiotic consortium plays an important role in the reduction of pollution load, helps to curb the odour nuisance in the area and is very helpful in boosting the growth of naturally occurring beneficial microbial flora in the natural drains polluted by sewage and in the Revival of Aquatic/Freshwater Ecosystems.

In the laboratory and field study, it was recorded that growth of microbes vs COD has an inverse relationship. Under field conditions, the cross-over point is 280×10^{6} CFU/ml while in laboratory, it is found as 340×10^{6}/ml, showing net difference of 60×10^{6} which can be attributed to regeneration of naturally occurring beneficial microbes (Report-Project on in-situ treatment of sewage in natural A. B. Road drains meeting Khan river at Indore, M. P., 2012).

Conclusion

The study on *in-situ* bioremediation treatment of storm water drains polluted by sewage was undertaken in one drain at Indore sponsored by CPCB, Delhi. In this study, covering three seasons- winter, summer and rainy seasons, the data obtained is reported from the drain under treatment and also drain without treatment. The latter was for the sake of comparison. It was found that the microbial consortium plays an important role in the reduction of pollution load, helps to curb the odour nuisance in the area and is very helpful in boosting the growth of naturally occurring beneficial microbial flora in the natural drains polluted by sewage. The methodology/technology evolved can be implemented in other drains for *in-situ* bioremediation treatment of drains/channels polluted by sewage and to prevent pollution in river/to restore good quality of water in Indian Rivers, that is, Revival of Freshwater Ecosystems.

This technique can be viewed to be more beneficial and effective than the *ex-situ* technique since *in-situ* bioremediation is a technique of remediation that employs living microorganisms in the place where the pollution occurred. At a comparison of costs between conventional methods and bioremediation, it should be kept in mind that in case of *in-situ* bioremediation costs for transport and excavation (laying of sewer lines) cease. In terms of sustainability, bioremediation has priority, because it leads to real reduction of pollutants in wastewater and not only storage or displacement of pollutants and leads to revival of ecosystem in a natural way. Although the methodologies employed are not technically complex, considerable experience and expertise is required to design and implement successful bioremediation program, due to the need to thoroughly access a site for suitability and to optimize conditions to achieve a satisfactory result.

ACKNOWLEDGEMENTS

Authors are thankful to Prof. S.P. Gautam chairman, member secretary and staff of Central Pollution Control Board, Delhi for financial support and to M. P. Pollution Control Board for their laboratory support and other helps rendered during this study.

REFERENCES

Achal V, Pan X, Zhang D (2012b). Bioremediation of strontium (Sr) contaminated aquifer quartz sand based on carbonate precipitation induced by Sr resistant *Halomonas* sp. **Chemo-bioremediation 89:764-768.**

Ahluwalia SS, Goyal DD (2007). Microbial and plant derived biomass for removal of heavy metals from wastewater. Bioresour. Technol. 98(12):2243-2257.

APHA, AWWA, WEF (2005). Standard methods for the Examination of Water & Wastewater. Ed. 21.

Batayneh AT (2012). Toxic (aluminum, beryllium, boron, chromium and zinc) in groundwater: health risk assessment. Int J. Environ. Sci. Technol. 9:153-162.

Betty SL, Winiarti PR (1990). Penanganan Limbah Industri Pengan.Penerbit Kanisins, Yogyakarta p.148.

Celia B, Franklin MJ (1997). Healthy Environments for Healthy people : Bioremediation Today & Tomorrow. Environ. Health Perspect. 105(1):1-20.

Chakraborty R, Wu CH, Hazen TC (2012). Systems biology approach to bioremediation. Curr. Opin. Biotechnol. 23:1-8.

Chatterjee S, Singh L, Chattopadhyay B, Datta S, Mukhopadhyay SK (2012). A study on the waste metal remediation using floriculture at East Calcutta Wetlands, a Ramsar site in India. Environ. Monit. Assess. 184:5139-5150.

EPA, US (2012). A citizaen's guide to bioremediation. 542:F-12-003.

Jain SK (2006). Advancing Frontiers of Ecological Researches in India, ed. By Kandya & Gupta, published by BSMP Singh, Dehradun, India. pp. 459-471.

Jain SK (2011). Water Today-Special Issue-Advantages of Centralised, Decentralised Wastewater Treatment, November 2011 pp. 48-53.

Kensa MV (2011). Bioremediation: An Overview. J. Ind. Pollut. Control 27(2):161-168.

Mandal AK, Sarma PM, Paul JC, Channashettar VA, Bina S, Lal B, Datta J (2012). Large scale bioremediation of Petroleum hydrocarbon contaminated waste at Indian Oil Refineries: Case Studies. Int. J. Life Sci. Pharm. Res. 2:114-128.

Mani D, Kumar C (2013). Biotechnological advances in bioremediation of heavy metals contaminated ecosystem: an overview with special reference to phytoremediation. Int. J. Environ Sci. Technol. 13:299-308.

Monica S, Karthik L, Mythili S, Sathiyavelu A (2011). Formulation of Effective microbial consortia and its application for sewage treatment. J. Microbial. Biochem. Technol. 3:51-55.

MoEF (2011). A state-of-the-art report on bioremediation, its applications to contaminated sites in India. Ministry of Environment & Forests, Paryavaran Bhawan, New Delhi 90 pp. Web http://moef. nic.in/downloads/public-information/BioremediationBook.pdf

Rani B, Choopera SL, Maheshwari R (2007). Cleaning up of Pollutants by Phytoremediation: A novel approach for Sustainable Development. J. Water Land use manage. 7(1):71-81.

Singh A, Kumar V, Shrivastava JN (2010). Green Biotechnology of EM in bioremediation of wasrewater. Geobios 37:231-237.

Vidali M (2001). Bioremediation: An overview. Pure Appl. Chem. 73(7):1163-1172.