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Effective microbial consortia to treat wastewater on site

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Abstract
It is an established fact that India faces major problem of sewage treatment and disposal due to paucity of adequate sewage treatment infrastructure. Conventional treatment techniques come with a lot of economical issues due to cost factor. An alternative economical substitution is the on site treatment of wastewater flowing into open drains. Onsite bioremediation offers treatment of sewage in the running battery of flow without displacing; and by employing microbial consortia in theaerobic and facultative environment to degrade sewage resulting into CO_2 and H_2O and reduce odour. In the present paper bioremediation based onsite sewage treatment technologies, effective microbial consortia and its application to treat wastewater are discussed and a summary of studies on the use of effective microbial consortia is also presented.

Keywords: Onsite or in-situ sewage treatment (IST); Bioremediation; Natural drain; Effective Microorganism (EM).

Introduction
Corollary of the fundamental right to life under article 21 includes the right to safe and drinking water (Biswas, 2007) [3]. Despite the seeming opulence of water on earth, as much as 42% (2.9 billion) of the world's population live in water-parched locations (Iyer and Mastorakis, 2009) [10]. In the past, nature disposed-off wastes since the population was less and carrying capacity of natural water resources was extensive. Now it is vice-versa. Therefore, the problem of pollution has emerged as one of the biggest challenges before human civilization (Jain *et al*., 2013) [11].
Sewage is the domestic wastewater comprising 99.9% water and 0.1% solids. The domestic sewage has a high amount of organic and inorganic pollutants (Elliot, 1986). So, the sewage has impact on the environmental. To protect the environment from its harmful effects, sewage treatment and disposal is sine qua non. But India has critical lack of infrastructure for treatment and disposal of sewage. Indian cities altogether generate 61,754 MLD of sewage and treatment facility is available only for 22,963 MLD without including sewage generated in informal settlements and in smaller towns (ENVIS).
These contaminated and polluted systems are causing negative impacts on aquatic organisms, plants, microorganisms and life support functions (Batayneh, 2012) [2]. The chemically treated water causes harmful effects due to toxic chemicals than the organisms which are originally present in the sewage (Khatab *et al*., 2015). Wastewater in a municipal sewage treatment plant undergoes a high level of treatment before getting into the environment, but it is costly. An alternative option is that polluted water may be cleaned up immediately by a suitable natural ecological system (Iyer and Mastorakis, 2009) [10]. In the present paper, bioremediation based in-situ or onsite sewage treatment (IST) technologies, effective microbial consortia and its application to treat wastewater are discussed and a summary of studies on the application of effective microbial consortia is also presented.

Bioremediation
Bioremediation is the application of natural biological activity to destroy or render innocuous multitude of contaminants present in the water. Bioremediation triggers the growth of microorganisms that use contaminants as the major source of food and energy (EPA, 2012) [6]. It uses naturally occurring bacteria and fungi or plants to break or to degrade substances hazardous to human health, aquatic and terrestrial life and/or environment (Rani *et al*., 2007).

In literature, most of the works on bioremediation is done in laboratory scale (Monica *et al*., 2011) or ETPs/STPs (Ahluwalia and Goyal, 2007) [1].

Onsite Bioremediation

In conventional treatment method, bacteria are used to separate the organic content of polluted water and produces sludge. The sludge can be a useful fertilizer or can be incinerated, disposed into ocean or landfill. The conventional sewage treatment processes are very costly to operate and maintain (Mazumder and Roy, 2000). Onsite bioremediation refers to "Treatment of sewage in the running battery of flow without displacing, and by employing microbial consortia in theaerobic and facultative environment to degrade sewage resulting into CO_2 and H_2O and reduce odour". Table 1 summarizes variousonsite sewage treatment techniques, which were also being tested by CPCB at various locations (NGRBA).

Table 1: Various Onsite Sewage Treatment Technologies

No.	Technology	Principle of Technology
1	Green-bridge	Waste water after screening is allowed to pass through a barrier of biological filter and also gets supplemented with nutrients. Embankments of the drain are planted to uptake nutrients. The entire technology is based on Biofilm and Constructed Wetlands.
2	Bio-Mimicking	This is based on bio-mimicry utilizing kinetic Bio-degradation. Operational constituents are mainly adsorption and degradation, aeration, filtration and sedimentation.
3	Effective microbial consortia	This technology allows co-existence of different strains of microbes blended together without outcompeting each other, their-by withholding the effects. The Technology adopted is bio-augmentation, in which addition of selected bacterial consortia in the treatment area is done to increase the beneficial count and thus encouraging faster degradation of organic matter.

Effective Microbial Consortia

The conventional biological treatment of sewage includes activated sludge, which is an arbitrary amalgamation of microorganisms. Naturally occurring microorganisms are the key components of wastewater treatment comprising protozoa, rotifers, bacteria, fungi, and other microbes. These organisms thrive on many of the complex compounds present in wastewater. Micro size, a very high surface area-to-volume ratio, and large contact interfaces with their ambient environment are some of the key and beneficial features of microorganisms as bioindicators of chemical pollutant stressors (Ramakrishnan, 2012).

Effective Microorganisms

Effective Microorganisms (EM) are the useful and naturally occurring microorganisms. These are not chemically synthesized. There is no genetic modification. The EM solution is the mixing of effective microorganisms in molasses at low pH. Originally, EM was developed to enhance the crop yield by positive tinkering of the soil activity (Higa and Parr, 1994) [9]. But later, it has found its key application in wastewater treatment (Okuda and Higa, 1995).

The EM secretes organic acids and enzymes which work on sewage and disintegrates complex organic matter into simpler ones. The antioxidant substances produced by EM stimulates the breakdown of solids and decreases the sludge volume (Higa and Chinen, 1998) [8]. Missouri River in Jefferson City, North America was polluted by runoff from industries and cities and generates foul odour. The application of EM for one month reduced the foul odour (Da Silva *et al*., 1997 [4]. Details of effective microorganisms used in various studies are summarized in Table 2.

Table 2: Details of Effective Microorganisms Used in Various Studies

SN.	Effective Microbes (MB) Used	Source of MB	Incubation and Activation Technique for Use	References
1	1. Lactobacillus 2. Saccharomyces 3. Aspergillus 4. Pseudomonas 5. Streptomyces	1. Curd 2. Dry yeast granules 3. Boiled rice 4. Oil spilled soil 5. Moist soil	1. De Man Rogosa Agar, 37 °C, 24 hours 2. Potato Dextrose Agar, 37 °C, 12 hours 3. Czapek's Dox Agar, 28 °C, 3 day 4. King's B Agar, 37 °C, 24 hours • EM consortia formation: Culturing individual MB together at optimal pH of 8, incubation period of 72 hours, temperature of 28 °C – 37 °C and molasses concentration of 1-3%	Monica *et al*., 2011
2	Bacillus subtilis, B. cereus, B. Fusiformis, B. Thuringiensis, Escherichia coli, Rhodopseudomonas Palustris, Rhodobacter Spheroides, Lactobacillus species	Microbiology Lab, Dayalbagh Educational Institute, Agra	• Incubation at 37 ºC for 24-48 hours in NAM solid medium • For Nanoparticles synthesis: further Incubation for 7 days in darkness at room temperature with 50 ml of nutrient broth containing 3.5 millimolar $AgNO_3$ solution	Shrivastava *et al*., 2012

Studies on Application of Effective Microbial Consortia for Treatment of Wastewater

A summary of various studies employing effective microbial consortia for the treatment of wastewater is presented in Table 3.

Table 3: Summary of Various Studies on Waste Water Treatment Using Effective Microbial Consortia

SN.	Wastewater Type	Scale and Location	Effective Micro-organisms (EM) Used and Treatment Time	Dosing Quantity and Technique	Removal Efficiency (%)	References
1	Domestic sewage from college campus	Lab study at VIT University, Vellore	▪ 5 microbial species isolated from different potential sources ▪ Consortia developed at optimal conditions used	▪ Dose from 1 – 10 ml/L; Optimum 3 ml/L ▪ 3.33 L filtered sample in containers	BOD 85; COD 82; TDS 55; TSS 91	Monica *et al*., 2011
2	Yamuna water	Lab Study at Agra	▪ 8 Bacteria's isolated from Yamuna water sample ▪ Mono and dual combinations of bacteria's used	▪ 50 ml/L bacterial culture used ▪ 250 ml sample in containers	▪ Mono Isolates: BOD 93.55; COD 73.90; ▪ Dual Isolates: BOD 91.90; COD 67.60	Shrivastava *et al*., 2013
3	Pre-autoclaved Complex waste-water from Common ETP	Lab Study at CSIR Nagpur	▪ 5 microbial species isolated from different potential sources ▪ Single strains and consortia used	▪ 50 ml/L bacterial culture used ▪ 1 L sample in containers	▪ Mono Isolates: BOD 58.55-77.31 COD 42.11-59.76 TSS 66.36-71.42 ▪ Consortia: BOD 94.02; COD 90.17; TSS 79.76	Gaikwad *et al*., 2014 [7]

Conclusion

The effective microbial consortia can be applied in drains for onsite treatment of wastewater and to prevent pollution of receiving water sources. In terms of sustainability, bioremediation has priority, because it leads to areal reduction of pollutants in wastewater and not only storage or displacement of pollutants and leads to are vival of the fresh water ecosystem in a natural way. The studies have shown that use of effective microbial consortia is very effective on alab scale and more field studies should be encouraged.

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