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An ecological study of Indian open drain sewage and its treatment

Ajay Singh, SK Patidar, Vikramaditya Sangwan*

Department of Civil Engineering, NIT Kurukshetra, India
*Corresponding author's e-mail: emailaditya@icloud.com

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Abstract. The disposal of a large volume of untreated and partially treated domestic wastewater is causing pollution of various water sources. Sewage treatment involving conventional wastewater treatment technologies is costly. In the present study, in-situ treatment of sewage using a commercially effective microbial consortium was investigated in two community open drains of Chanarthal village in Haryana state of India. The pH, turbidity, BOD, and COD were determined in accordance with standard methods. The optimum dose for treatment in the batch study was 1ml/L, and the optimum time for treatment was 5 days. The batch study results were used for continuous in-situ treatment study performed in drains over a period of six weeks. The turbidity, BOD, and COD removal were 60.1, 82.1, and 64.7% in the batch study and 40.1, 61.1, and 56.4% in the continuous in-situ treatment study. It was also observed that a higher dose of microbial consortia gives the same performance as low doses at a later stage of the study.

Keywords: In-situ Treatment, Sewage Treatment, Bioremediation, Effective Microorganisms.

1. Introduction

The constitution of India stipulates many rights for Indian citizens, and the right to safe drinking water is one among them (Biswas, 2007). The sharp ascend in the population, reckless urbanization, and speedy industrialization have led to unexpected levels of stress on natural resources, especially water and its quality (Gaikwad et al., 2014). In earlier times, mother nature used to take care of the waste generated by human beings, for the population was minimal, and there was an abundance of natural resources, including that water. But now this trend has reversed. Moreover, the menace of pollution, especially water pollution, has become a major concern (Jain et al., 2013). The wastewater generated from domestic activities is usually termed sewage, and it constitutes 99.9% of water and 0.1% of solids. This domestic wastewater contains both organic and inorganic pollutants. Thereby, it becomes imperative to treat this domestic wastewater so as to minimize the untoward environmental impacts. It is a well-known fact that India has an acute shortage of facilities for treating and channelizing domestic wastewater. Taken together, the cities in India generate 61,754 MLD of domestic wastewater while the treatment provided is only for 22,963 MLD, leaving a gap of 38,791 MLD (63%) (ENVIS, 2017). Untreated community sewage disposed of in natural water resources leads to water pollution, and hence most of the rivers in the country are either polluted or have converted into sewage drains due to the destruction of the self-purification mechanism of water resources (Jain et al., 2013). Before being released into the environment, the wastewater is subjected to a rigorous treatment in the treatment plants so as to remove the impurities and toxic substances. Nevertheless, it is a costly affair. Another way out is that the domestic wastewater can be treated by employing natural ecological mechanisms (Iyer & Mastorakis, 2009). The effective micro-organism technology was incarnated by Professor Dr. Teruo Higa at University of Ryukyus, Okinawa, Japan in 1970's (Sangakkara, 2002). The most commonly known biological clean-up of domestic wastewater includes the activated sludge, which is a heterogeneous mix of microorganisms. Formulated microbial consortia involves a broad selection of the microbial population. The effective microbial consortia may be put in drains for in-situ cleaning of domestic wastewater and to curb pollution of receiving water bodies (Jain et al., 2013). The main focus of present study was on in-situ treatment of domestic wastewater flowing in open drain using commercial effective microbial consortia. The specific objective of study was to determine optimum dose of microbial consortia through batch study and then in-situ treatment of sewage flowing in open drain using microbial consortia.

2. Material and Methods

2.1. Details of Experimental Study Drains

Two community drains in Chanarthal village near NIT campus were selected, one for experimental study (ED) and other as reference drain (RD). Both drains carry the domestic wastewater and no measures were taken to alter the existing condition of drains. The layout and cross-sectional details of experimental drain were collected and experimental study was conducted in a stretch of 300 m length. A cipolletti weir was installed in the drain for discharge measurement.

2.2. Microbial Consortia

A commercial microbial consortium "Bio-Treat" was purchased from EM Solutions Enterprises, New Delhi. For batch experiments in laboratory, wastewater was collected from Chanarthal village drain.

2.3. Activation of Microbial Consortia

The dormant microbial consortium was activated by mixing 250 ml culture with luke warm solution containing 0.5 kg jaggery and 4.25 L of water to make a solution of 5 L. It was left intact for 5–6 days in an air tight bottle in shade. The bottle was opened for 2 min daily to release the gases formed. The microbial growth was observed with the help of measuring absorbance of culture at 600 nm wavelength (Hall et al., 2013). Activated culture was used after 6 days and before 12 days.

2.4. Batch Study

The batch study was carried out in laboratory to check the treatment capability of commercial microbial consortia and to find the optimum dose of microbial consortia. 800 ml of wastewater was taken in 1 L plastic bottles and varying doses of activated culture was mixed. Control was also kept for comparison. Then pH, turbidity, TSS, BOD and COD were determined at beginning and after 1, 3, 5, 7 and 9 days. Microbial counting was also done for activated microbial consortia, control and 1 ml/L dosed sample at beginning and after 3 and 9 days. The microbial count at beginning, 3 days and 9 days were $36 \cdot 10^6$, $32 \cdot 10^8$ and $91 \cdot 10^6$ CFU/ml, respectively.

2.5. In-situ Treatment Study

Continuous study was carried out in selected drain at Chanarthal village. According to timing of tap water supply in the area, samples were collected daily at 5 and 11 am in the morning to assess variation in wastewater quality parameters. A micro dosing system with multiple valves of varying discharge was fabricated for gravity dosing of microbial consortia at single point in the drain. Daily 5 L of microbial consortia solution was prepared and stored for 6 days in a container. 6 containers were kept for this purpose. Micro dosing system was installed and valves were open for 18 hours from 11 to 5 am, which provided a total microbial culture flow of 250 ml/h. 0.5 L of microbial consortia was also sprayed daily at 11 am along the stretch of the drain. Thus, total of 5 L of microbial consortia solution was dosed daily in the drain. Temperature of wastewater at the time of sample collection was also recorded. The initial characteristics of sewage in experiment drain was determined by collecting and analyzing sewage samples during two weeks period before addition of microbial consortia for in-situ treatment. The efficiency of in-situ treatment due to microbial consortia in terms of turbidity, BOD, COD removal was assessed based on initial average characteristics before microbial consortia addition and average characteristics observed in last two weeks of continuous study.

2.6. Analytical Techniques

The wastewater samples were analyzed for pH, turbidity, BOD and COD for characterization of wastewater, optimum dose determination in batch study and assess effect of commercial microbial consortia in in-situ treatment in open drain. The pH, turbidity, BOD and COD were determined in accordance with standard methods (APHA, 2005).

3. Results and Discussion

3.1. Batch Studies

The variation in pH, turbidity, BOD and COD with time as observed during batch study are shown in Fig. 1. Initially reduction in pH were observed at higher dose. However, pH was increased with time continuously for all doses similar to that of control and it attained a constant value for all doses. The variation in pH in dosed samples was similar to control, which indicate that added microbes were functioning similar to the naturally present micro-organism in the drain.

Effects of lower doses were negligible on turbidity, whereas higher dose of microbial consortia initially increased turbidity corresponding to dose, because microbial consortia itself has very high concentration of micro-organism making highly turbid culture solution. Variations at lower dose were erratic and at higher doses slight increase in turbidity was recorded. At 1 ml/L dose, turbidity was found similar to control.

Initially BOD and COD of wastewater were increased very rapidly corresponding to added higher dose of microbial consortia, due to presence of substrate in culture. After 1 day, it became same for lower doses as that for control but higher dose took more than 3 days to match the value of control. On subsequent days, it was observed that lower doses do not contribute to sufficient reduction in BOD and COD whereas higher doses gave similar reduction. Based on results, the observed optimum dose was 1 ml/L. The BOD and COD reduction was rapid up to 5 days and thereafter no significant reduction was observed.

The results of batch study show similar reduction as found in studies of Monica et al. (2011), Shrivastava et al. (2012, 2013), and Gaikwad et al. (2014).

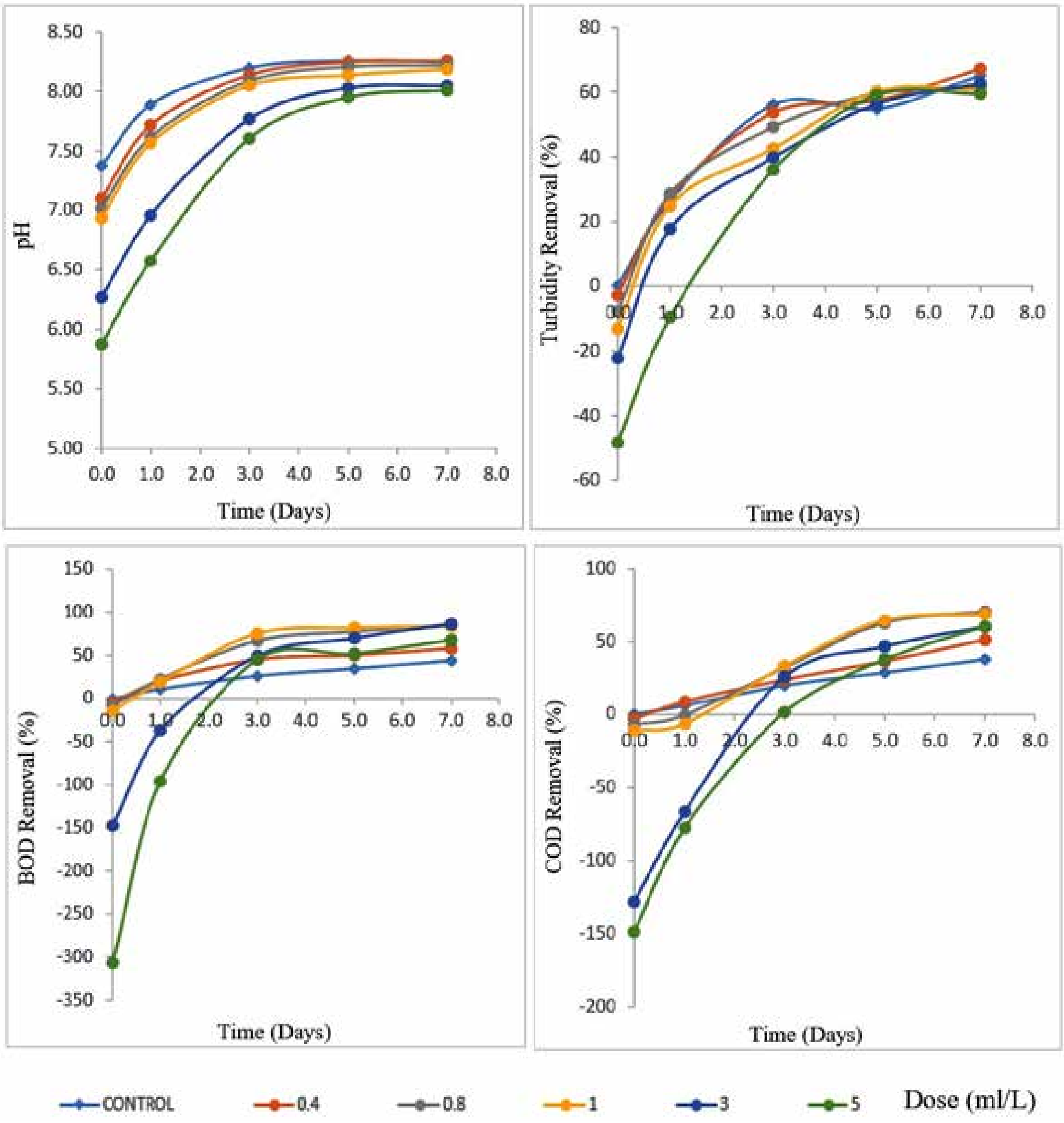
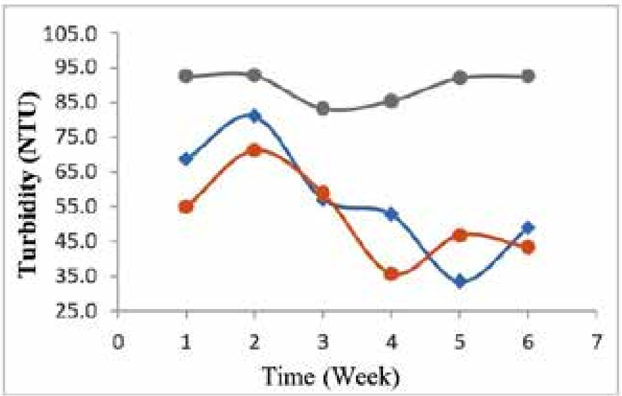


Figure 1. Variation of pH, Turbidity, BOD and COD with Time in Batch Study

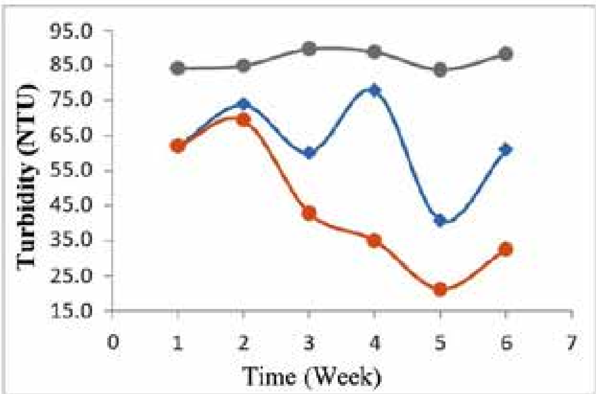
3.2. In-situ Treatment Study

The variation in turbidity, BOD and COD with time as observed during continuous treatment study performed in open drain are shown in Figure 2.

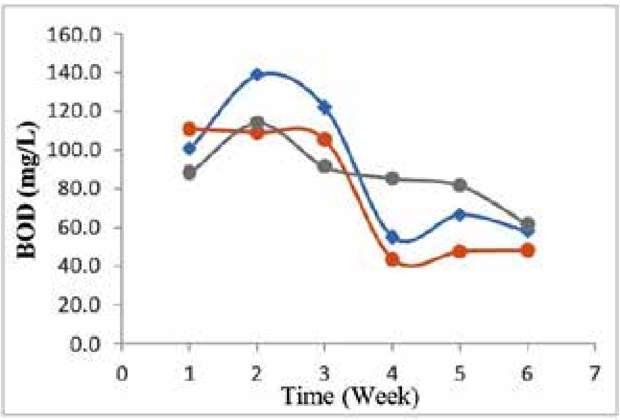
Turbidity of ED (experiment drain) outlet and ED weir were decreased over the duration of treatment at 11 am, but at 5 am reduction was less. It was also observed that reduction at ED outlet is much higher than ED weir at 11 am.



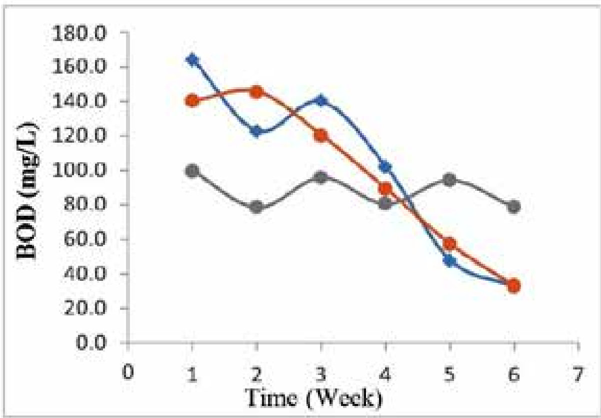
(a) **Turbidity** at 5 AM



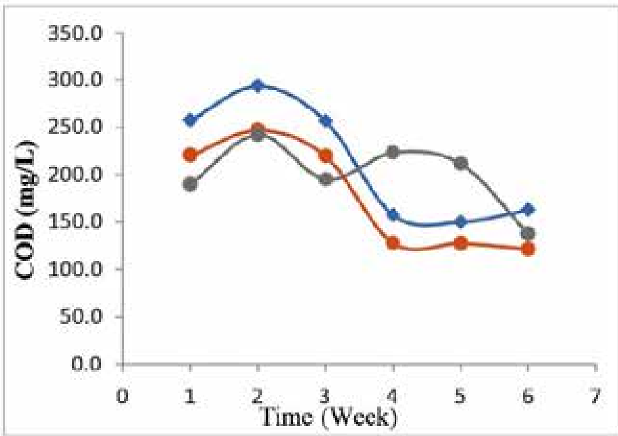
(b) **Turbidity** at 11 AM



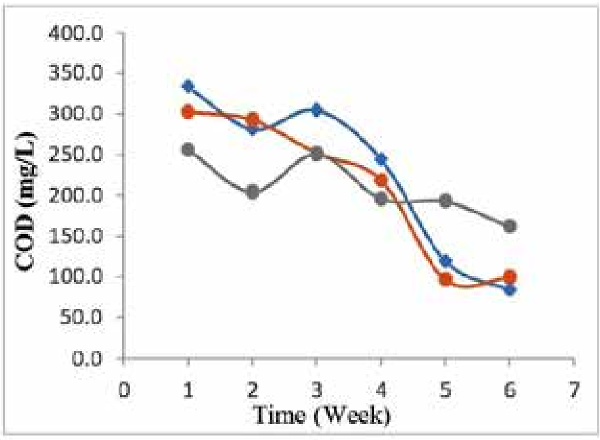
(a) **BOD** at 5 AM



(b) **BOD** at 11 AM



(a) **COD** at 5 AM



(b) **COD** at 11 AM

Figure 2. Variation in Turbidity, BOD and COD with time in Continuous In-situ Treatment Study

BOD was reduced significantly after application of effective microbial consortia. The BOD removal was relatively higher at 5 am in the experiment drain as compare to 11 am. Also, higher BOD removal was observed in 2nd week after microbial consortia addition at 5 am as compare to similar removal in 4th week at 11 am. This was due to low flow and longer hydraulic retention time available at 5 am.

COD was reduced significantly after application of effective microbial consortia. The COD removal was relatively higher at 5 am in the experiment drain as compare to 11 am. Also, higher COD removal was observed in 2nd week after microbial consortia addition at 5 am as compare to similar removal in 4th week at 11 am. This was due to low flow and longer hydraulic retention time available at 5 am. The results found are similar to Jain et al. (2013).

4. Conclusions

In the present study, use of commercial microbial consortia for in-situ treatment of sewage flowing in open drain was investigated. Based on the results presented following findings/conclusions emerged from the present study.

- Optimum dose for treatment was found as 1ml/L based on batch study and optimum time for treatment was observed as 5 days.
- In batch study, turbidity removal efficiency at optimum dose was 60.1% and in continuous treatment study, maximum removal efficiency of turbidity was recorded as 40.1%.
- TSS removal efficiency at optimum dose was 63.5% in batch study.
- BOD removal efficiency at optimum dose was 82.1% in batch study and maximum removal efficiency was 61.1% in continuous treatment study.
- COD removal efficiency at optimum dose was 64.7% in batch study and maximum removal efficiency was 56.4% in continuous treatment study.
- Low dose of microbial consortia does not provide enough microbial growth, and it results in low removal efficiency.
- Higher dose of microbial consortia itself increases the value of turbidity, BOD and COD in the beginning and take more time for treatment. It was also observed that higher dose gives same performance as for low dose at later stage of study.

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