Aeration and In-Situ Bioremediation of Municipal Drains of Patna, India

[1]Priyanka Tomar,[2]Ramakar Jha, [3]A. R. Quaff
[1]*Research Scholar, National Institute of Technology Patna*
[2] *Professor, National Institute of Technology Patna*
[3] *Professor, National Institute of Technology Patna*

Abstract:-In India, it is essential to maintain the river ecosystem in its effective way. The aeration and bioremediation promote an ecologically efficient and economically sustainable pollution control in flowing water such as rivers, ponds, lakes, reservoirs and wetlands. This study looks at the levels of pollution and the processes underlying dissolved oxygen (DO) and biochemical oxygen demand (BOD), of Three major municipal drains in Patna, Bihar, India. Samples have been collected during April-June during the year 2022 from all the drains (a) at initial condition of wastewater without any prior treatment, (b) after use of aerators for reaeration, (c) after use of a biological product for bioremediation, and (d) after use of biological product for bioremediation and aerators for reaeration. The biological product PRIJOT for bioremediation has been tested for its applicability in water quality improvement for different conditions in all the three drains. The results indicate significant improvement for condition when aerators are used along with bioremediation process at different time and space domain.

Keywords: *BOD, COD, TSS, TDS, Bioremediation.*

1. Introduction

The term "treatment of sewage in the flowing water by employing microbial consortia in aerobic and facultative environment to degrade sewage" describes in-situ bioremediation. In-situ treatment (IST) is simple and easy-to-operate and does not require major modification of the drain. Naturally occurring Microbial consortia is used in the treatment process or activated to degrade sewage in flowing conditions without diverting the flow and no additional requirement of land or Power is involved. The technology is considered to be cost-effective, relatively cheaper than conventional treatment methods, easy to handle, not requiring skilled manpower to operate. In the process, the microbes are activated and allowed to multiply by adding or extra-cellular enzymes in presence of oxygen and available food in form of organic matter and sewage degradation takes place. During the inoculation period, intensive dosing is done in the site and after stabilization of the treatment, normal dosing is applied. The microbial dosing is done as per requirement assessed in terms of organic pollutants (microbial food) content in sewage.

The activated microbes consume organic mass and utilize the nutrients from the water body for their growth and multiplication; thus enhance the cleaning action of wastewater. The anaerobic as well as facultative bacteria play a vital role in treatment of sewage without causing any release of foul odour. In the process of treatment pollutants in terms of BOD, COD, TSS, TDS, heavy metals and toxic chemicals are reduced. Due to the action of the dominant microbial consortia, the harmful pathogenic bacteria like E.coli, etc are suppressed or eliminated from the treated water. (Tekere, M., 2019; Tomar et al., 2022; Vidali, 2001; EPA, 2012; Kensa, 2011; Rani et al., 2007; Coelho et al., 2015; Shan et al., 2009; Firmino et al., 2015; Karimi et al., 2015; Sheng et al., 2012, CPCB, 2020).

In urban cities of India, a large amount of wastewater is produced and discharged to the rivers without prior treatment. Almost 80% of water supply goes back into the ecosystem as wastewater (Kramer et al., 2022). Due to concentric development of the cities like Patna in Bihar, India and increased floating populations, the magnitude of the pollutant concentration in wastewater is found to be very high in municipal drains (Kaur et al., 2012; Singh and Jha, 2021; Singh and Jha, 2022). Moreover, it is found that the sewage water is being discharged into the river Ganga at Patna, Bihar without proper prior treatment. The contaminated systems are causing impacts on human health, microorganisms, aquatic life, flora and fauna and health of ecosystem (Batayneh, 2012). It is to be noted that in the interest of public hygiene, public health and national economy, the municipal wastewater, sewage water and industrial waste water are essentially required to be disposed-off properly only after treatment. Keeping this in view, it is essential to use reaeration and bioremediation process in drains to reduce the pollution.

2. The Study Area

In Bihar, northeastern India, the city of Patna is spread out along the Ganges River's south bank (Figure 1). The entire area of Patna is 250 km2, and the city's population is estimated to be there as of 2023 is 2,321,000. As shown in Figure 1, there are many drains in Patna and most of them are discharging wastewater in River Ganga without prior proper treatment.

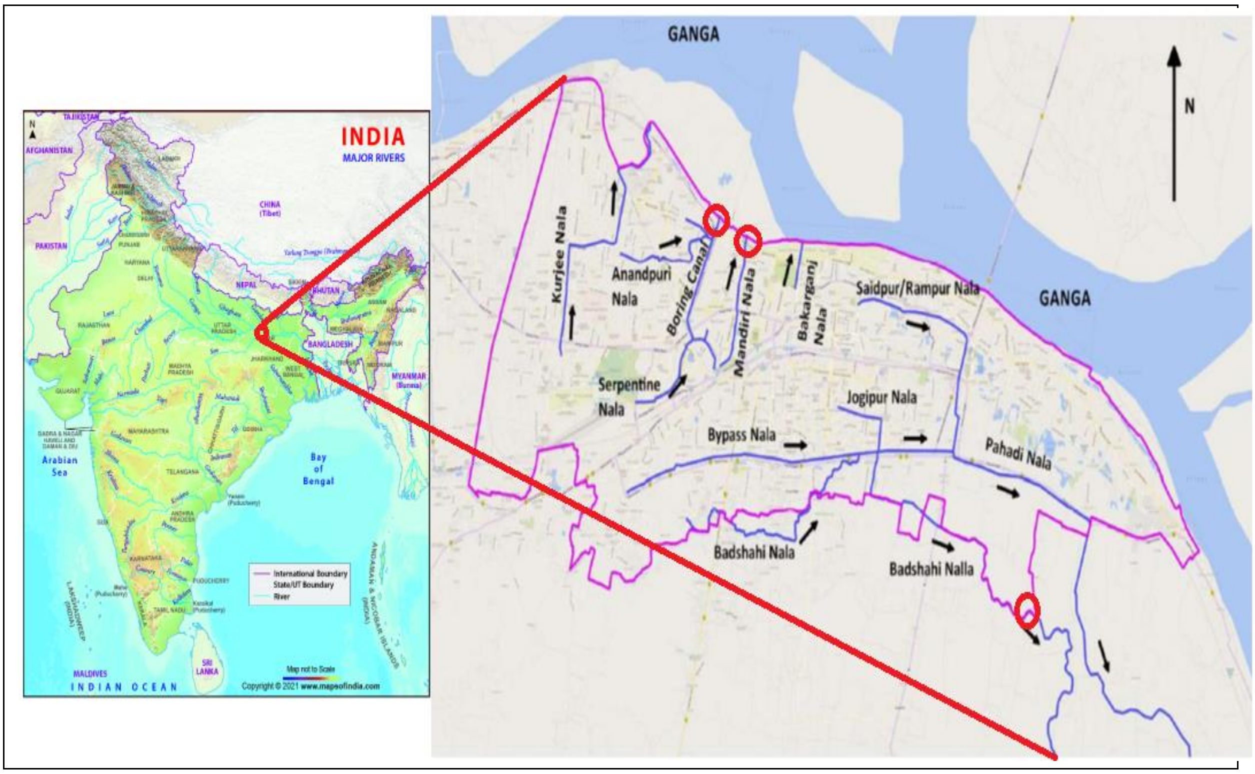


Figure 1: The study area and location of three drains considered in the present work

The weather in the area is generally uniform and subtropical. It has a moderate climate, with summers that are fairly hot and winters that are somewhat cold. Summertime temperatures range from 43°C to 30°C, while wintertime temperatures range from 21.4°C to 5°C. The summer months of April through July see record highs of 43°C in June and July. Rainfall is medium to moderate throughout the monsoon season, lasting from August and September into early October. Summertime brings a 100% increase in relative humidity.

The area is a portion of one of India's three primary physiographic divisions, the Indo-Gangetic alluvium, which divides the peninsular region on the south from the Extra-Peninsular region on the north. From Middle Pleistocene times, it has been known that granular filling of a huge depression with alluvial materials produced the level plain. The area has a monotonously flat relief and is a portion of the Ganga's flood plains. Quaternary alluvial deposits underlie the study area. On the Archaean basement, the Quaternary sediments deposited in an unconformable manner.

The study region's soil, terrain, and irrigation practices all have a major impact on the farming circumstances there. There are primarily four types of soils in the area: medium to heavy textured, acidic to slightly alkaline, and moderately well drained to poorly drained. From a farming perspective, only four types of soils—heavy clay (Kewal), loam (Domat), very light soil (Balsundri), and alkaline (Rehara)—can be classified as light to heavy in texture. Figure 2 depicts Patna's land cover and land use.

Table 1: The land use of Patna Metropolitan city

Land Use	Area (sq.km)	Percentage (%)
Residential	49.56	47.55
Commercial	4.65	4.46
Mix Use	3.52	3.37
Industrial	1.09	1.05
Public and Semi-Public	10.61	10.18
Open Space / Recreational	3.20	3.07
Transport / Roads	6.15	5.90
Airport	1.10	1.05
Brick Kiln	0.73	0.70
River / Flood Plain	3.49	3.35
Water Body	1.06	1.01
Vacant Land / Agriculture Land	18.40	17.66
Forest	0.67	0.64
Total PMC Area*	**104.22**	**100**

*Note: Total Area is subject to change based on cadastral information

For the analysis and water quality modelling samples were collected from 6 locations of each drain at a distance of 100m, 250m, 500m, 1000m, 2000m and 3000m at an interval of 15 days during April, May and June months of the year 2022.

3. Methodology

The following methodology was adopted as per APHA (24th Edition, year 2022):

- The sampling was done on bi-monthly basis (15 days interval) from 6 locations of Rajapur drain, Mandiri drain and Badshahi Nala.
- Grab sampling method was applied for collecting the samples. Samples were collected from each drain at a depth of ~0.5 m in Teflon bottles of 2L. The samples were transported and stored at 4 °C until analysis.
- On-site handheld equipment were used to analyze the temperature and pH levels of the water quality parameters.
- Samples for the determination of dissolved oxygen (DO) were gathered and stored on site in BOD bottles. To preserve the samples for metal analysis, they were acidified to a pH of less than two using pure HNO_3. The examination of dissolved oxygen was conducted using the Winkler-Azide method.
- Water samples were immediately kept and conserved within acid-cleaned polypropylene bottles during their frozen state using a transportable ice box in order to minimize the biogeochemical changes in accordance with normal procedure. Although in-situ tests are typically conducted using a single or combined meter submerged in the water to provide an estimate, samples were collected for additional research.
- Samples were collected from every sample station and put in containers with labels. After reaching the (Environmental Lab of NIT Patna), the samples were blended to homogeneity and an aliquot portion was obtained for laboratory examination on the remaining physical and organic parameters.

- Standard size aerators, which are used for aeration at various points in the drain, have a threaded male or female size of 15/16" or 55/64".
- The microbial consortium of the biological product PRIJOT having different microbial strains to remove BOD and reduce the CO_2 has been used to reduce the concentrations of organic pollutants in water bodies and improve the water quality Dosing of microbes in in-situ treatment has been used to controls the odour in drains.
- The microbial consortium of the biological product PRIJOT was activated for 24 hrs and dosing was done solutions to treat the domestic and industrial wastewater by microbial population.
- Using a PVC drum, 10 L of the dormant culture, 50g of micronutrient, and 1000 liters of filtered drain water, the dormant culture of biological product was opened and activated. Dosing was carried out using an e-micro-acti-dozer for mechanical dosing and PVC tanks for gravity dosing, 24 hours a day, with a daily cap of 500 liters. Every time, the same steps were taken to collect observations.

4. Results& Discussion

Different water quality data of pH, Temperature, BOD, and DO, have been collected from the drains and analysed in the laboratory. Figure 2, 3 and 4 shows the values of different water quality data at Rajapur, Mandiri and Badshahi drains. It is observed that due to unmeasurable pollution from different households, garbage disposed in drains and/or in the vicinity of drains and other non-point sources the Temperature and BOD is increasing from Zero distance to 3000m (3 Km distance).

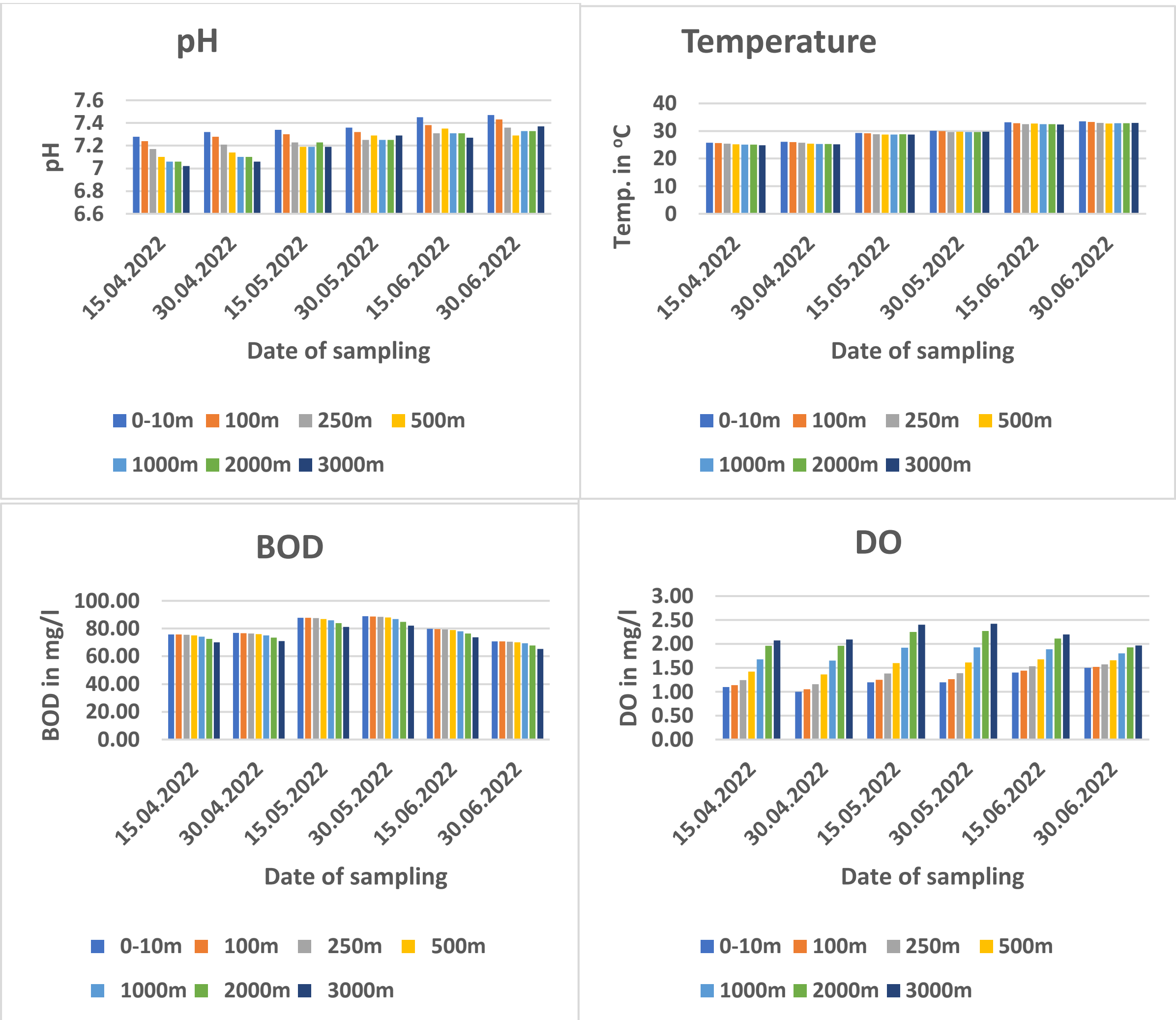


Figure 2: Water Quality of Rajapur Drain, Patna, India

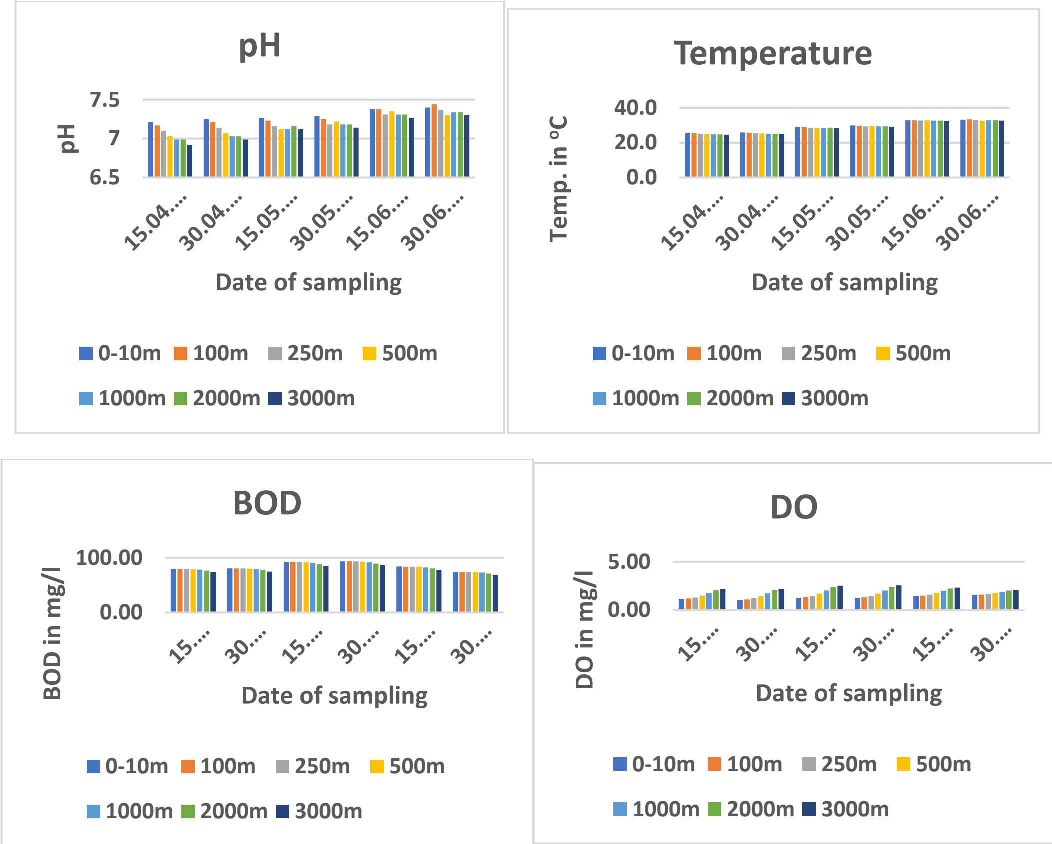


Figure 3: Water Quality of Mandiri Drain, Patna, India

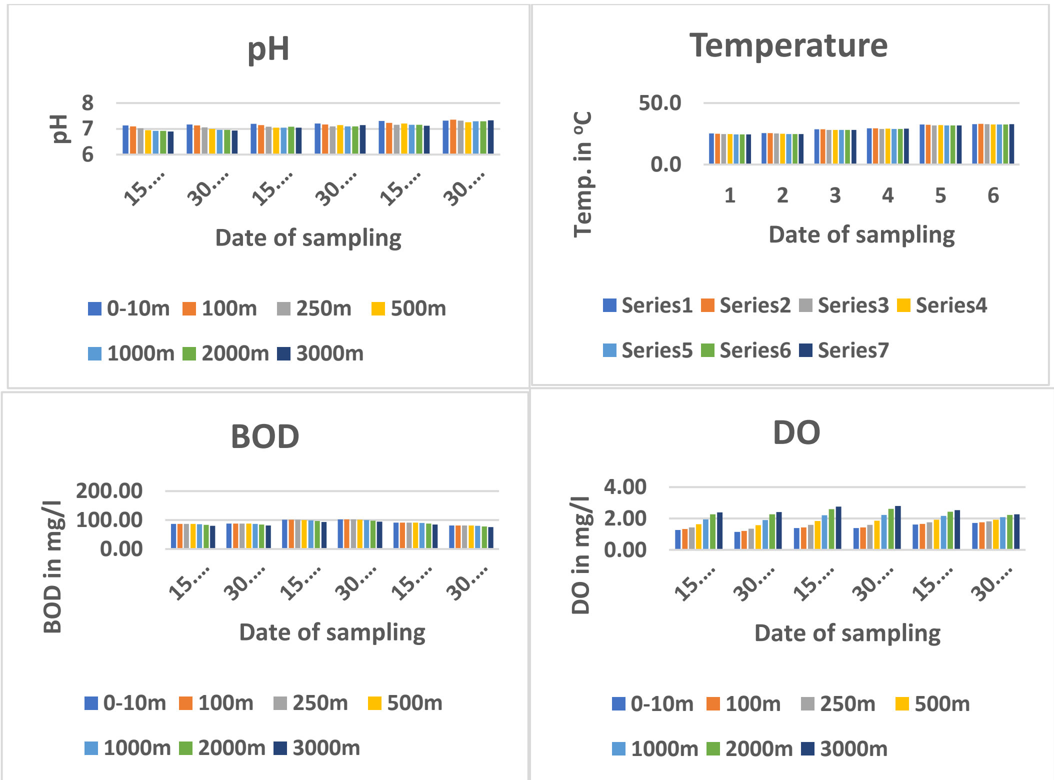


Figure 4: Water Quality of Badshahi Drain, Patna, India

Once, the data from drains were collected for natural condition, the Standard size aerators were used (a) at Zero distance, (b) at two locations (Zero distance and 1000m), and at three locations (Zero distance, 1000m and 2000m). The BOD and DO values are shown in Figures 5, 6 and 7.

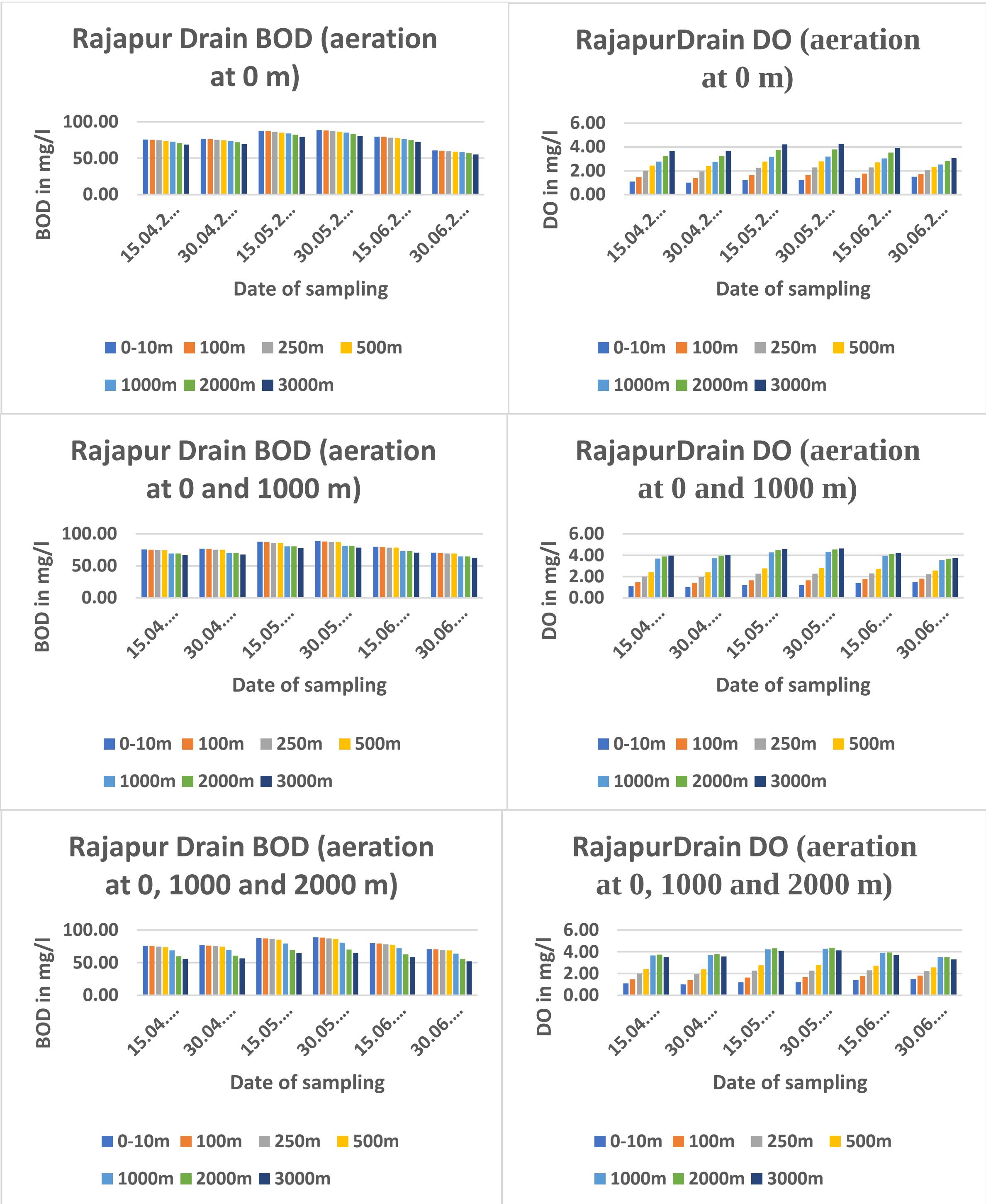


Figure 5: BOD and DO values at Rajapur drain with aeration at different distances

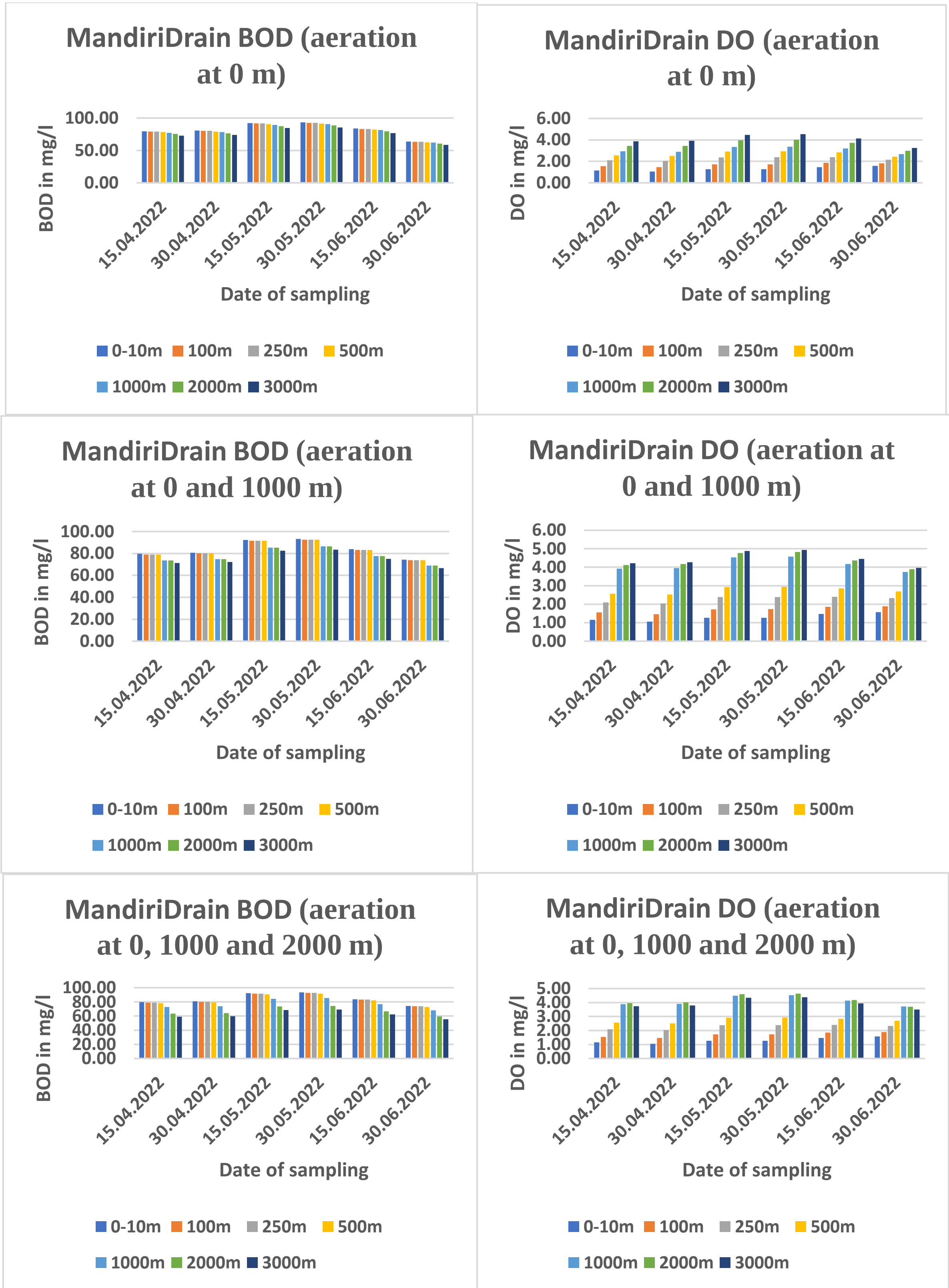
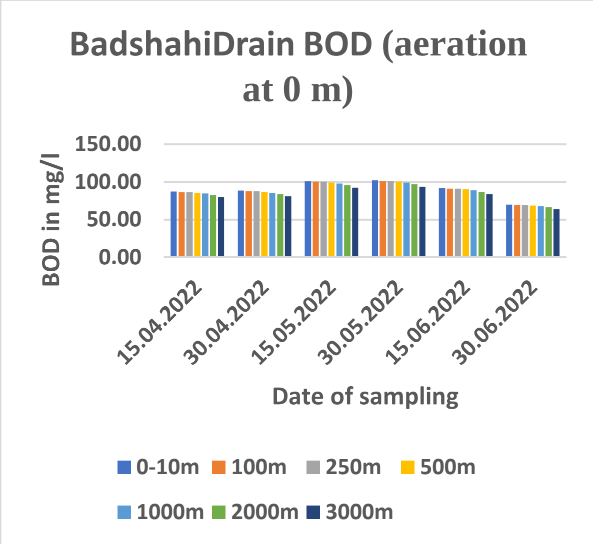
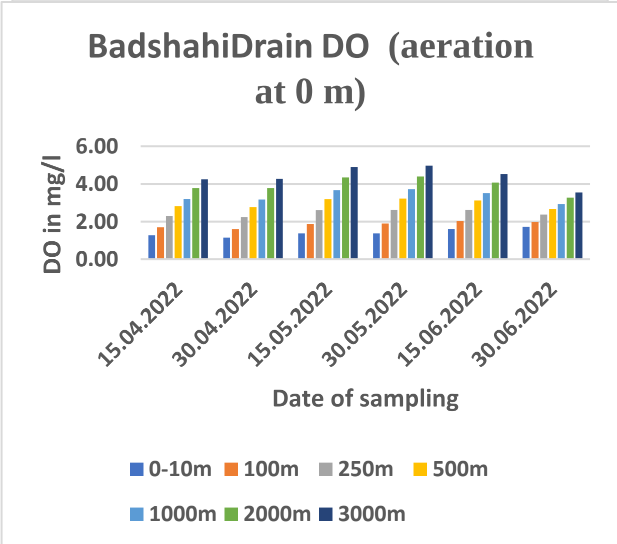
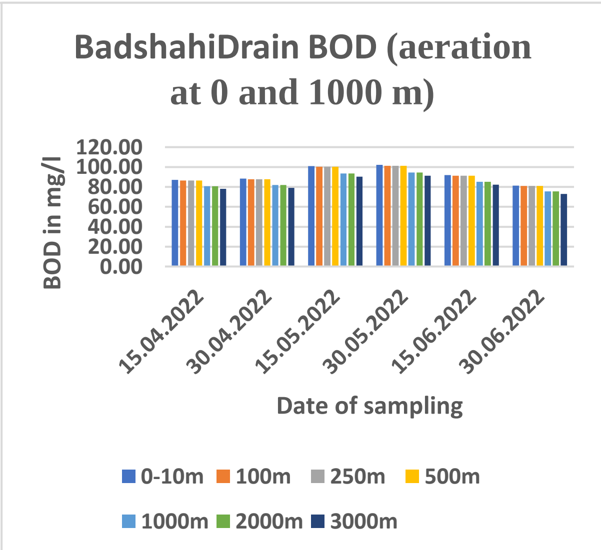


Figure 6: BOD and DO values at Mandiri drain with aeration at different distances


BadshahiDrain BOD (aeration at 0 m)
BOD in mg/l
150.00
100.00
50.00
0.00
15.04.2022
30.04.2022
15.05.2022
30.05.2022
15.06.2022
30.06.2022
Date of sampling
0-10m
100m
250m
500m
1000m
2000m
3000m


BadshahiDrain DO (aeration at 0 m)
DO in mg/l
6.00
4.00
2.00
0.00
15.04.2022
30.04.2022
15.05.2022
30.05.2022
15.06.2022
30.06.2022
Date of sampling
0-10m
100m
250m
500m
1000m
2000m
3000m


BadshahiDrain BOD (aeration at 0 and 1000 m)
BOD in mg/l
120.00
100.00
80.00
60.00
40.00
20.00
0.00
15.04.2022
30.04.2022
15.05.2022
30.05.2022
15.06.2022
30.06.2022
Date of sampling
0-10m
100m
250m
500m
1000m
2000m
3000m

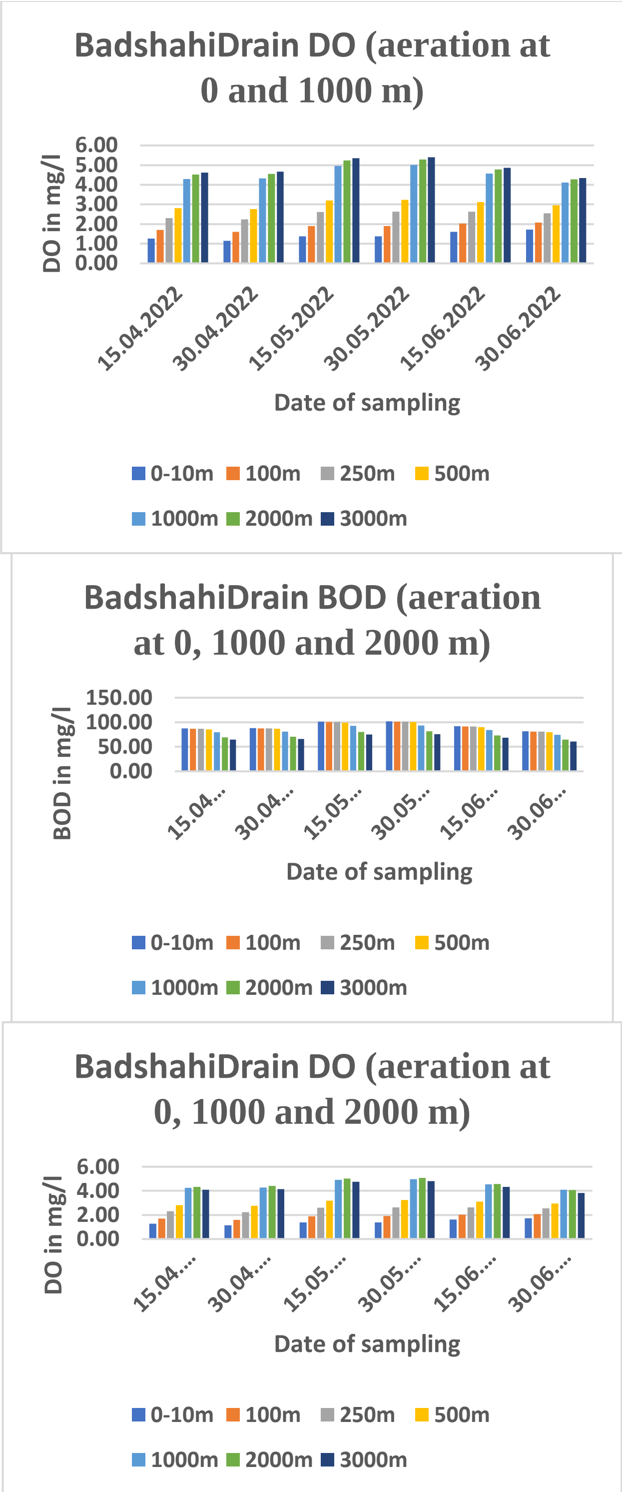


Figure 7: BOD and DO values at Badshahi drain with aeration at different distances

In the second set of experiments, the data from drains were collected for natural condition, and also by applying bio-remediation using product PRIJOT (a) at Zero distance, (b) at two locations (Zero distance and 1000m), and at three locations (Zero distance, 1000m and 2000m). The results of BOD and DO values are shown in Figures 8, 9 and 10.

Figure 8: BOD and DO values at Rajapur drain with Bioremediation at different distances

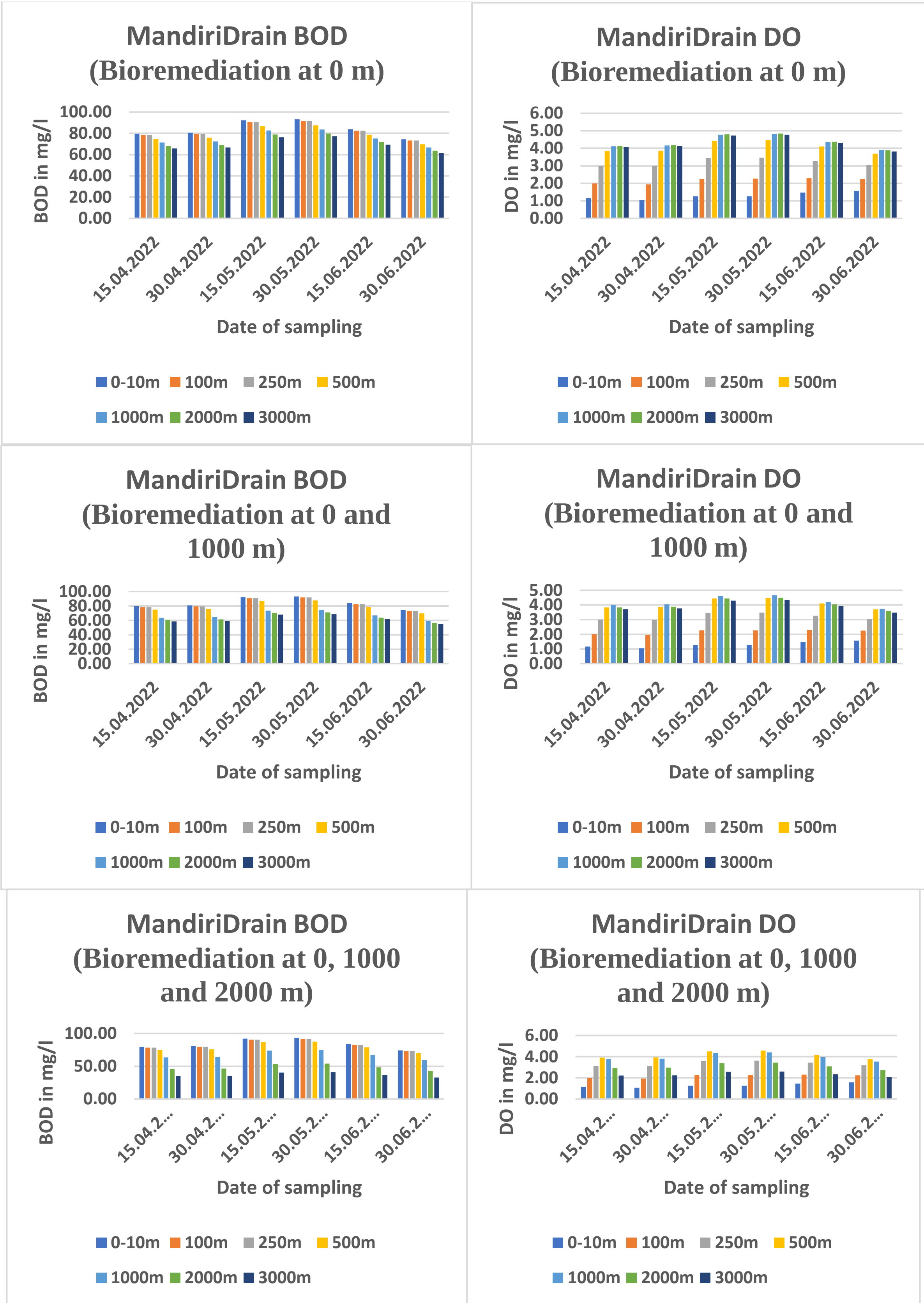
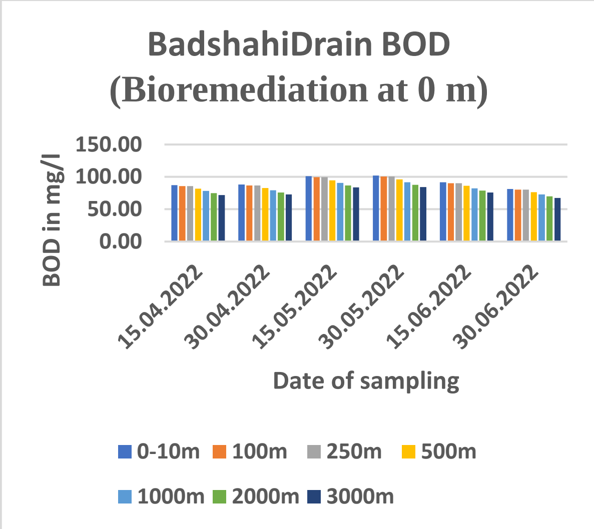
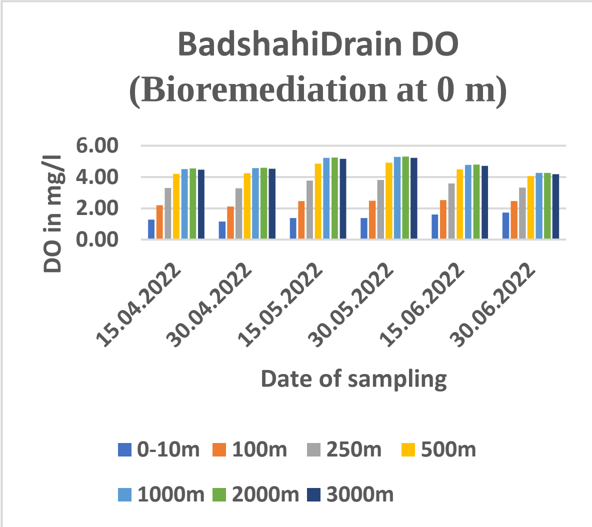
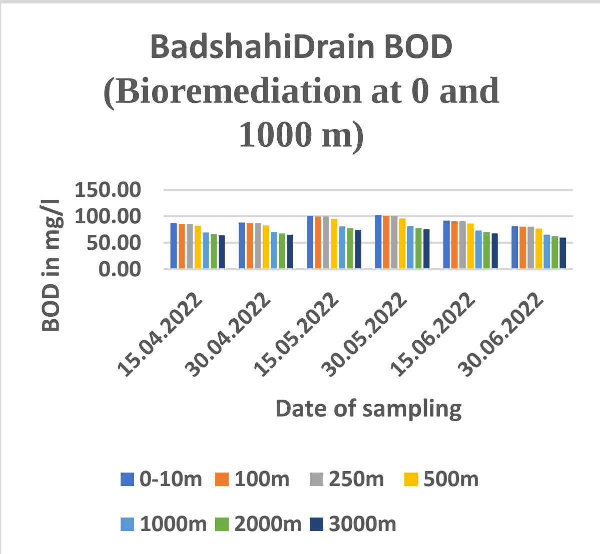


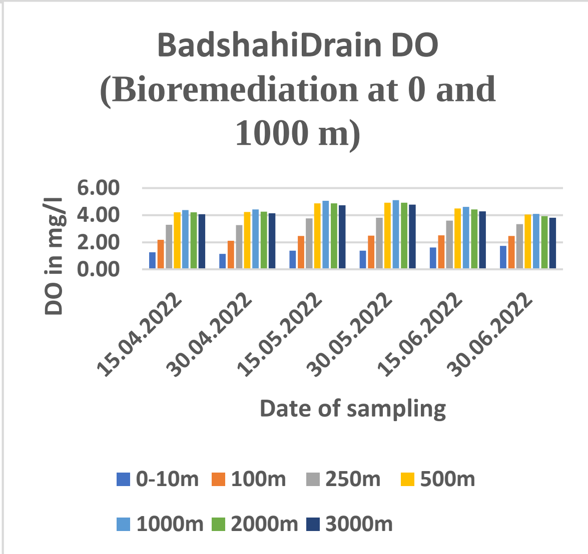
Figure 9: BOD and DO values at Mandiri drain with Bioremediation at different distances

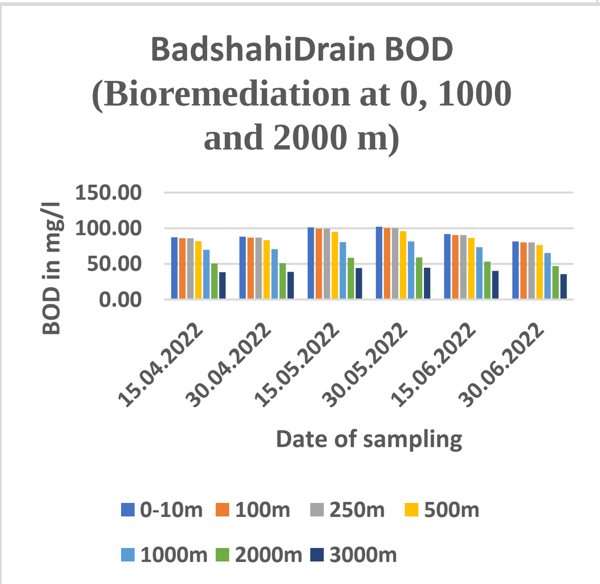
Tuijin Jishu/Journal of Propulsion Technology
ISSN: 1001-4055
Vol. 45 No. 2 (2025)











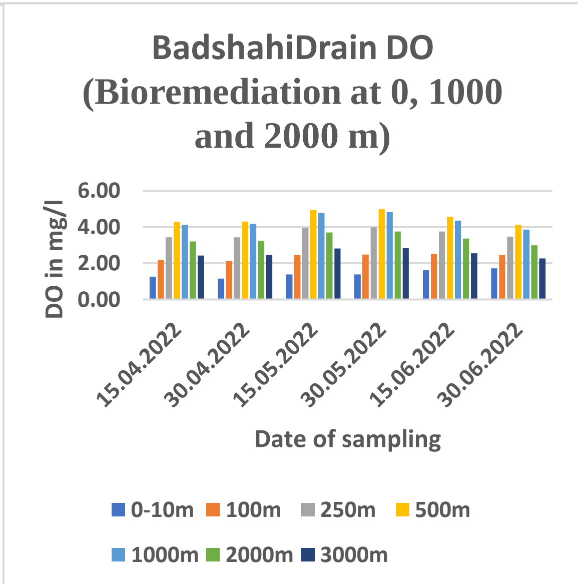
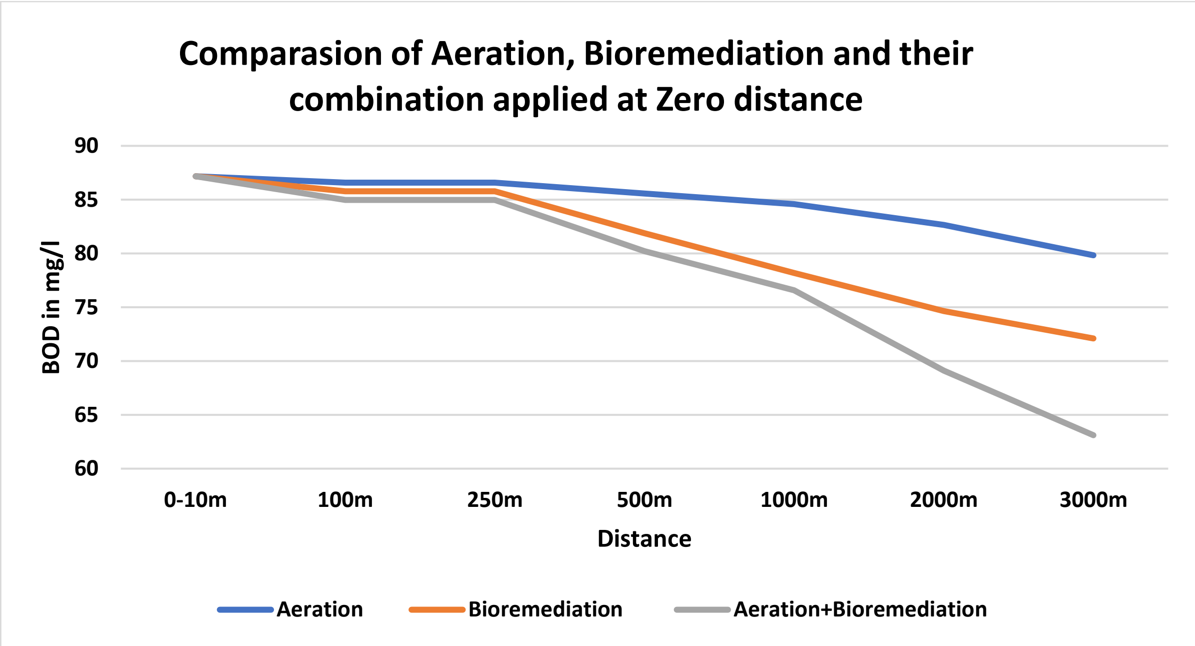
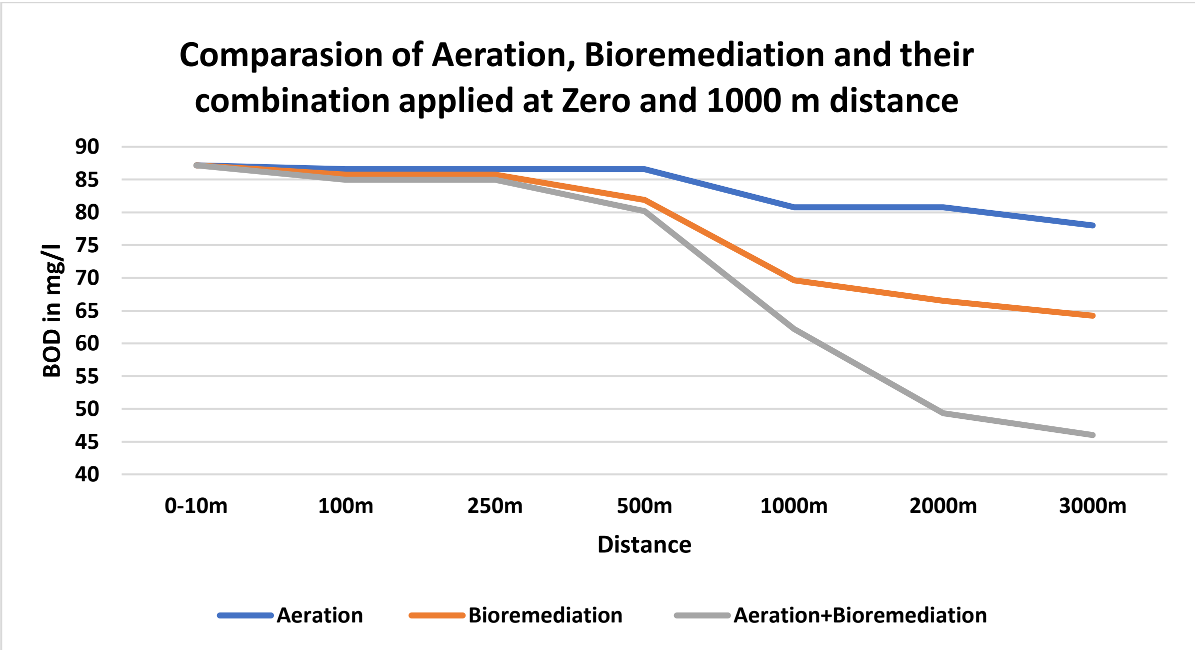


Figure 10: BOD and DO values at Badshahi drain with Bioremediation at different distances

After carrying out number of experiments, it has been observed that only reaeration at zero distance, at Zero +1000 m distance and at Zero+1000+2000 m does not reduce the BOD values Significantly. The bioremediation done reaeration at zero distance, at Zero +1000 m distance and at Zero+1000+2000 m reduces the BOD values and showing the significant reduction in BOD values. It is interesting to observe that combination of reaeration and bioremediation reduces the BOD values significantly and the BOD values goes below the 30mg/l every time, when the sampling was done. Figure 11 illustrates the comparison of results of BOD values obtained by different approaches.





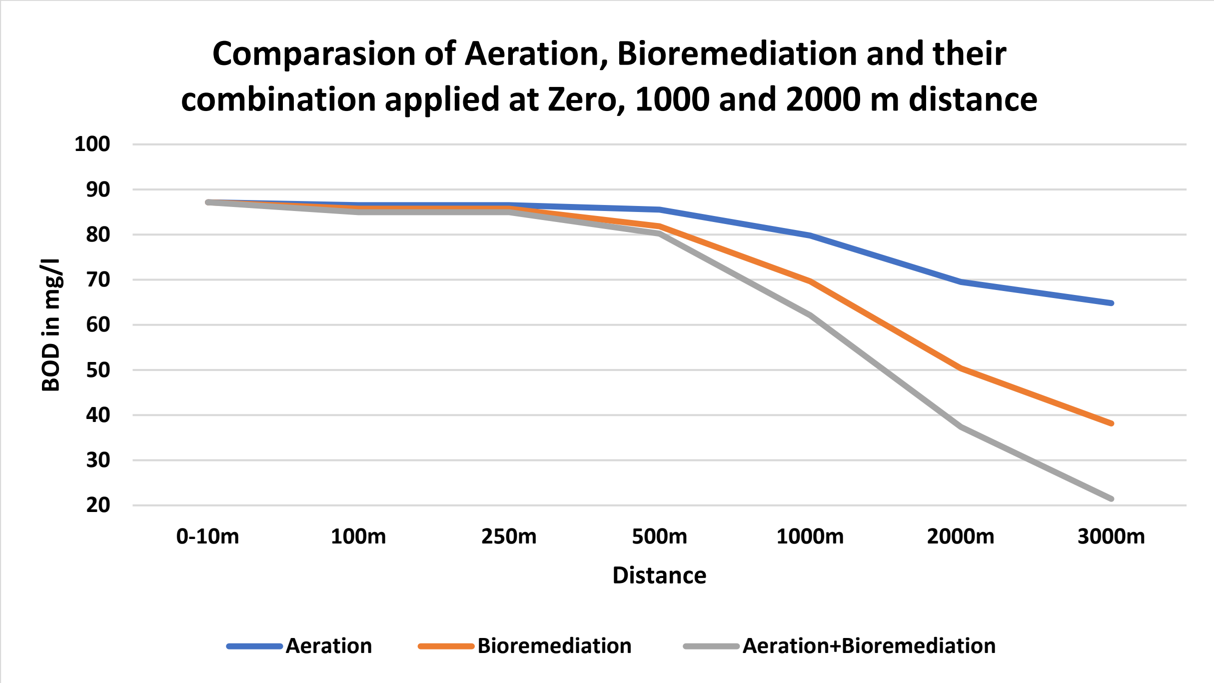
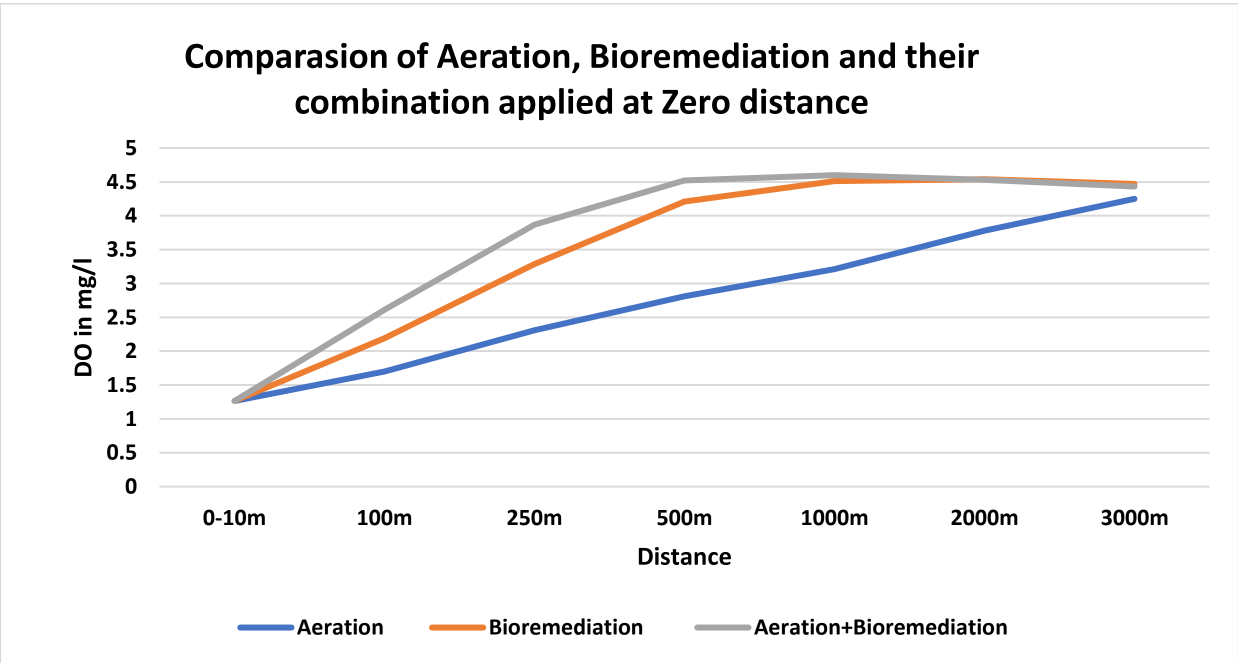
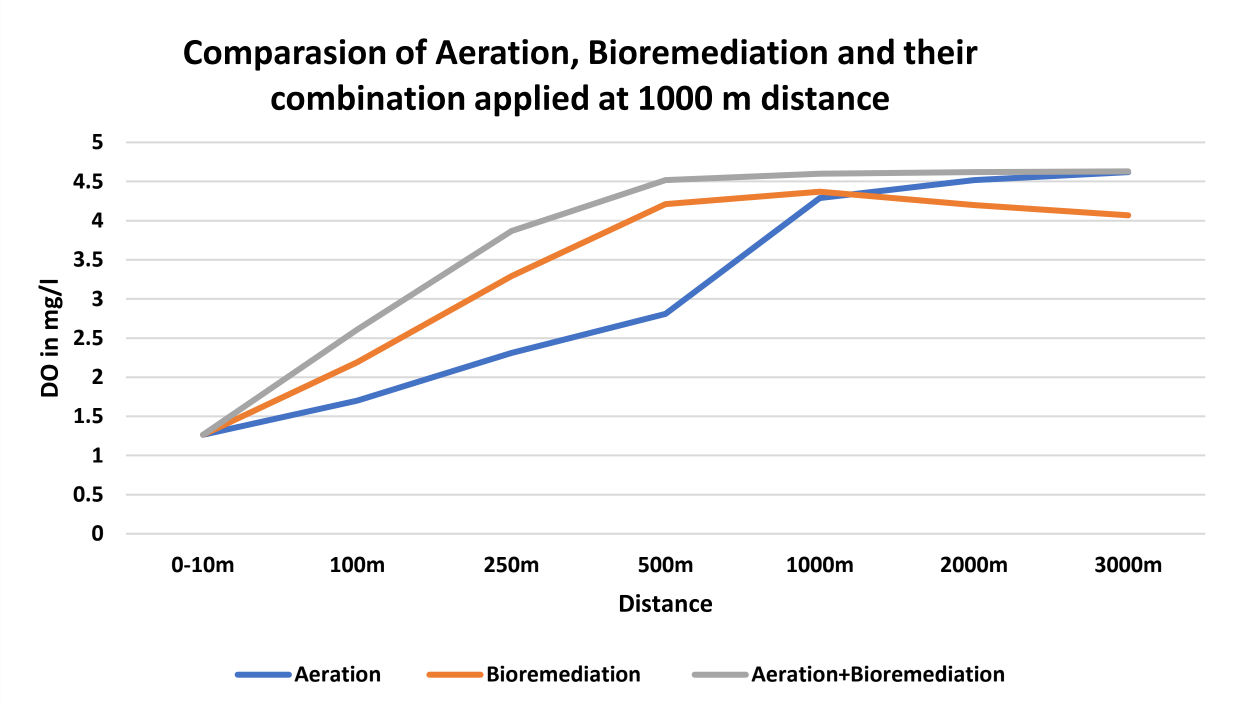


Figure 11: BOD Values with Aeration and Bioremediation process

It has been observed that only reaeration at zero distance, at Zero +1000 m distance and at Zero+1000+2000 m improves DO values. The bioremediation done reaeration at zero distance, at Zero +1000 m distance and at Zero+1000+2000 m improves DO values too. However, the combination of reaeration and bioremediation improves DO values significantly and the DO values goes above 4mg/l every time, when the sampling was done. Figure 12 illustrates the comparison of results of DO values obtained by different approaches.





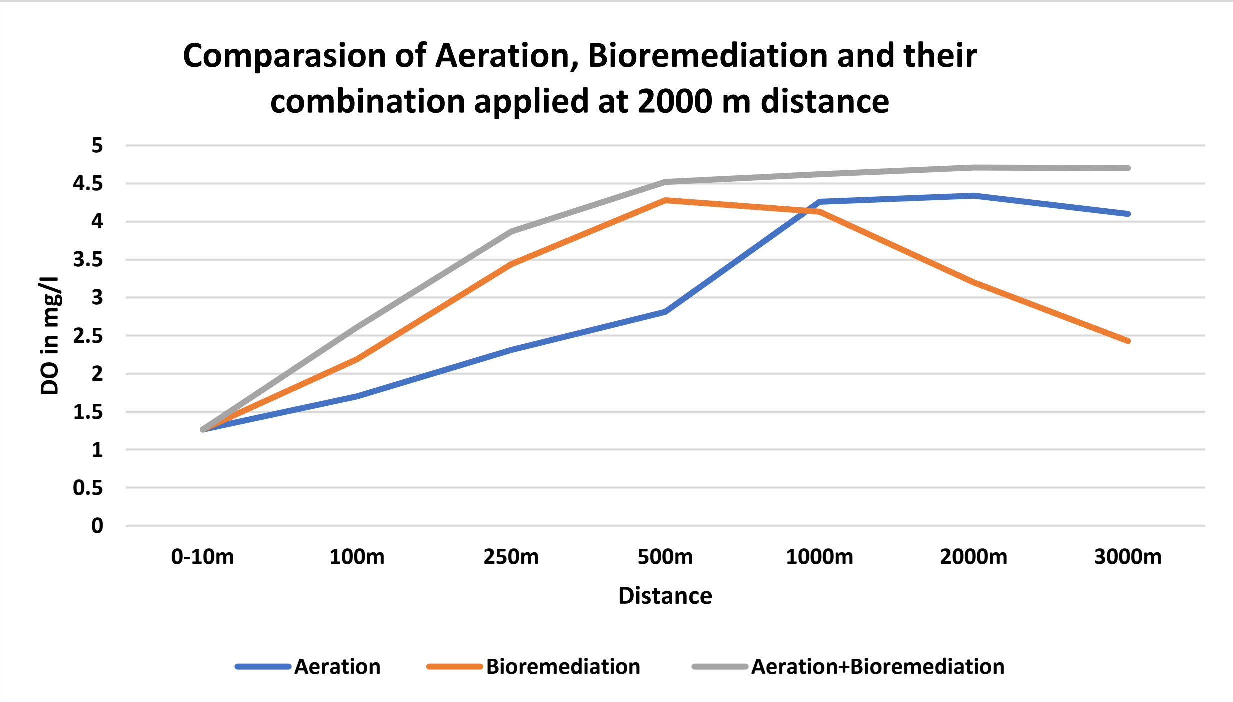


Figure 12: BOD Values with Aeration and Bioremediation process

Conclusions

The in-situ reaeration In the current project, bioremediation and its combination have been used to treat sewage in three municipal drains (the Rajapur, Mandiri, and Badshahi drains in Patna, India). Microbial consortia are employed in an aerobic and facultative environment to break down sewage. Samples have been collected during April-June during the year 2022 from all the drains (a) at initial condition of wastewater without any prior treatment, (b) after use of aerators for reaeration, (c) after use of a biological product for bioremediation, and (d) after use of biological product for bioremediation and aerators for reaeration. The biological product PRIJOT for bioremediation has been tested for its applicability in water quality improvement for different conditions in all the three drains. The results indicate that the combination of reaeration and bioremediation reduces the BOD values significantly and the BOD values goes below the 30mg/l every time, when the sampling was done. Also, the combination of reaeration and bioremediation improves DO values significantly and the DO values goes above 4mg/l every time, when the sampling was done. Figure 12 illustrates the comparison of results of DO values obtained by different approaches.

References

[1] APHA, 2022. Standard Methods for the Examination of Water and Wastewater, 24th Edition Batayneh, A. T. (2012). Toxic (aluminum, beryllium, boron, chromium and zinc) in groundwater: health risk assessment. Int J. Environ. Sci. Technol. 9:153-162.
[2] Coelho, L.M., Rezende, H.C., Coelho, L.M., de Sousa, P.A.R., Melo, D.F.O., Coelho, N.M. M., 2015. Bioremediation of polluted waters using microorganisms. Adv. Bioremed. Wastewater Polluted Soil 1–22.
[3] CPCB, 2020. In-Situ Bioremediation for Treatment of Sewage Carrying Drains Joining River Ganga - Performance Evaluation of Technologies and Development of Guidelines and Protocols 110032.
[4] EPA, 2012. Guidelines for Water Reuse. AR-1530 EPA/600/R-12/618 September 2012 2012
[5] Firmino, P.I.M., Farias, R.S., Barros, A.N., Buarque, P.M.C., Rodríguez, E., Lopes, A.C., dos Santos, A.B., 2015. Understanding the anaerobic BTEX removal in continuous- f low bioreactors for ex situ bioremediation purposes. Chem. Eng. J. 281, 272–280.
[6] Kramer, I., Bayer, Y., Mau, Y., 2022. The sustainability of treated wastewater irrigation: the impact of hysteresis on saturated soil hydraulic conductivity. Water Resour. Res. 58, 1–14. https://doi.org/10.1029/2021wr031307.
[7] Karimi, B., Habibi, M., Esvand, M., 2015. Biodegradation of naphthalene using Pseudomonas aeruginosa by up flow anoxic-aerobic continuous flow combined bioreactor. J. Environ. Heal. Sci. Eng. 13, 1–10. https://doi.org/10.1186/s40201- 015-0175-1.
[8] Kaur, R., Wani, S. P. 2012. Wastewater production, treatment and use in India. : Int. J. Mol. Sci. 16772–16786.
[9] Kensa MV (2011). Bioremediation: An Overview. J. Ind. Pollut. Control 27(2):161-168. Mandal AK, Sarma PM, Paul JC, Channashettar VA,
[10] 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.
[11] Shan, M., WANG, Y., Xue, S., 2009. Study on bioremediation of eutrophic lake. J. Environ. Sci. 21, 16–18. https://doi.org/10.1016/S1001-0742(09)60027-9.
[12] Sheng, Y., Chen, F., Sheng, G., Fu, J., 2012. Water quality remediation in a heavily polluted tidal river in Guangzhou, South China. Aquat. Ecosyst. Heal. Manag 15, 219–226. https://doi.org/10.1080/14634988.2012.687674.
[13] Singh, Kamakshi and Jha. Ramakar (2021). Changes in water quality of river ganga passing through urban cities with remote sensing and GIS support. Journal Ofxi'an University of Architecture & Technology JXAT Journal, 2021, 13 (10), 243-252.
[14] Singh, Kamakshi and Jha, Ramakar (2022). Changes in Water Quality of River Ganga Passing Through Urban Cities with Remote Sensing and GIS Support. Groundwater and Water Quality. Springer International Publishing. USA pp 335-346.
[15] Tekere, M., 2019. Microbial bioremediation and different bioreactors designs applied. Biotechnol. Bioeng. 1–19. https://doi.org/10.5772/intechopen.83661.
[16] Tomar Priyanka and Jha Ramakar (2022). In-Situ Bioremediation in a Natural Municipal Drain Discharging Effluent to River Ganga at Patna, India. JXAT, Volume XIV, Issue IX, 2022, 315-322.
[17] Vidali M (2001). Bioremediation: An overview. Pure Appl. Chem. 73(7):1163-1172.