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Enhancing Effluent Clarity through Bioaugmentation in a Textile Wastewater Treatment Facility

Himanshu Ramesh Lamba[1]* and Emanuel M Tapu[2]

[1]BiOWiSH Technologies, USA

[2]CV Abatemen Karya Bersama, USA

ABSTRACT

This study highlights the outcomes of a bioaugmentation project carried out at prominent textile company based in Surabaya, Java, Indonesia. The primary focus of this study was to address challenges related to biological treatment efficiency of the wastewater treatment plant. Faced with persistent difficulties in attaining optimal biological treatment, the facility extensively depended on chemical treatment strategies to attain desired effluent clarity. Prior to Bioaugmentation, it was observed that the Total Suspended Solids (TSS) in the Clarifier Tank averaged about 300 mg/l. This observation indicated that only approximately 10-15% removal occurred following the biological treatment and settling process in the clarifier. The findings of this study highlights the efficacy of bioaugmentation in enhancing settling rates within the clarifier, thereby contributing to an overall improvement in the plant's operational efficiency.

***Corresponding author**
Himanshu Ramesh Lamba, BiOWiSH Technologies, USA.

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Introduction

The textile industry is a major source of wastewater, using substantial amounts of water in wet processing operations. The discharged wastewater contains various pollutants such as acids, dyes, and chemicals [1,2]. Globally, the textile industry is a significant water consumer, with discharged wastewater that is often highly polluted [3]. On average, medium-sized textile mills use around 200 liters of water per kilogram of fabric processed daily. Textile dyeing and finishing contribute to 17-20% of industrial wastewater, according to World Bank estimates [1]. Strict environmental standards necessitate adopting an eco-friendly textile industry model, addressing flaws throughout the entire production process [2]. The textile industry, described as a complex industrial chain, starts with harvesting or producing fibers, undergoes multiple processing steps, and often emits pollutants. A major issue is the industry's high-water consumption, resulting in heavily polluted wastewater [3]. Advanced water recovery systems are essential for managing complex textile effluents. This involves separating wastewater streams, using membranes, biological treatment, coagulation, and Advanced Oxidation Processes (AOPs). These methods enable the effective reuse of textile wastewater [3,4].

Biological treatment processes utilize the metabolic capabilities of bacteria to decompose both organic and inorganic compounds. Usually carried out in bioreactors with adequate aeration and agitation, these techniques have been in use for an extended period and undergo ongoing improvements. Chemical pretreatment is frequently utilized to transform biologically persistent pollutants [3]. Biological treatment provides a cost-effective and environmentally friendly option for treating textile effluents. Hence, numerous innovative efforts have been made to enhance biological reactor design and harness specialized microbes capable of degrading dyes [5].

Biological treatment uses microorganisms to break down organic pollutants, but some complex compounds resist degradation, compromising water quality. Bioaugmentation, the introduction of specialized microorganisms with the ability to break down resistant compounds, stands out as a cost-effective and eco-friendly alternative when contrasted with conventional physico-chemical methods. This approach not only offers an efficient means of addressing complex pollutants but also contributes to the sustainable and environmentally conscious management of wastewater, promoting a healthier ecosystem and reducing the overall environmental impact associated with water treatment processes [6]. The bioaugmentation technology implemented in this study combines beneficial microbes that are resilient to challenging environmental conditions and have the capability to address a wide range of complex organic compounds in wastewater.

Treatment Plant Design

The initial flow originates directly from the wastewater of the Laundry Processing Plant and enters the Equalisation (EQ) Tank. The laundering processes, which include water-washing and dual-phase washing, consume substantial amounts of water [7]. After EQ tank, it progresses through the treatment process, navigating the Moving Bed Biofilm Reactor (MBBR), Aeration tank 1 (AT1), Aeration Tank 2(AT2), Clarifier Tank(CT), Dissolved Air Floatation (DAF) system, and final treated effluent. DAF was implemented to enhance water clarity after the clarifier, and this treatment unit heavily depended on chemical consumption, averaging up to 1.5 tons per day of Polyaluminum Chloride (PAC), 10 kg/day of flocculant, and 100 kg/day of chlorine [8]. Operating a DAF system for one year incurs substantial electricity costs, with chemical expenses often being five or six times higher [8]. DAF, employing microbubble generation, offers an alternative for wastewater treatment. DAF has proven effective in treating various industrial effluents, removing organic solids, dissolved oils, and toxic organic chemicals [9]. The Moving Bed Biofilm Reactor (MBBR) system is recognized as an Advanced Wastewater Treatment that combines features from both Conventional Activated Sludge and biofilter processes, employing both suspended and attached biomass. While effectively treating the same wastewater volume as Conventional Activated Sludge systems, the MBBR system requires a significantly smaller footprint. Additionally, it seamlessly integrates into existing structures of Conventional Activated Sludge systems [10]. Return Activated Sludge (RAS) was maintained at 50% from the clarifier to the MBBR tank. The rate of Return Activated Sludge (RAS) is one of the operational factors influencing the characteristics of Activated Sludge (AS) in biological treatment [11].

Table 1: Volume for Each Unit in the Wastewater Treatment Plant

Treatment Unit	Volume (m^3)
Equalization Tank	504 m^3
MBBR Tank	504 m^3
Aeration Tank 1	504 m^3
Aeration Tank 2	504 m^3
Clarifier	400 m^3

The average daily flow of wastewater was 2000 m^3/day. Daily measurements on the Equalization tank included Total Suspended Solids (TSS), Turbidity, and pH. The average values for these three parameters in the Equalization tank are detailed in table 2.

Table 2: Average values of TSS, Turbidity and pH at the Equalisation Tank

Parameter	Unit	Average Values
Total Suspended Solids (TSS)	mg/l	350
Turbidity	NTU	300
pH		8.5

Materials and Methods

The bioaugmentation technology applied in this study is a proprietary composite biocatalyst comprising a novel consortium of metabolically cooperative microorganisms. It is composed entirely of natural, non-genetically modified materials. During the initial ten days, an initial dose of 2 kg/day of bioaugmentation feed was introduced into the MMBR Tank, followed by a reduced amount of 1 kg/day for the remaining duration of the second month. For the dosing process, the decided dose of bioaugmentation technology was mixed with approximately 100 liters of water in a drum and then applied directly into the MBBR tank on daily basis.

Results and Discussion

60% reduction in Total Suspended Solids (TSS) and 62% reduction in Turbidity (NTU) was observed within the first month of the bioaugmentation study, accompanied by a shift in pH to a neutral level. Figure 1 & 2 visually illustrates the noticeable contrast in wastewater clarity from the clarifier before and after the application of bioaugmentation technology. Plant operators noted that while it is common for the pH to fluctuate, the significant and immediate decrease in TSS and NTU was significant.

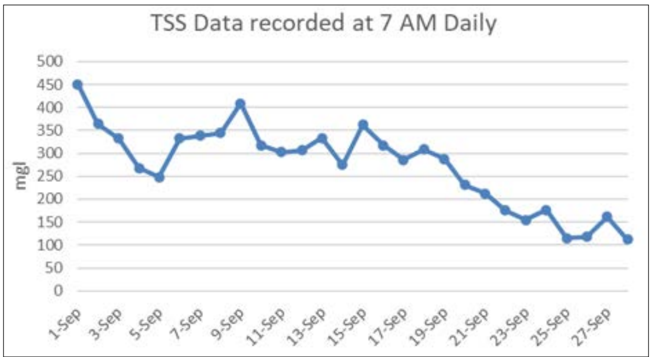
Table 3: Daily Monitoring data for TSS, Turbidity and pH during Bioaugmentation Program

Date	1-Sep	2-Sep	3-Sep	4-Sep	5-Sep	6-Sep	7-Sep	8-Sep	9-Sep	10-Sep	11-Sep	12-Sep	13-Sep	14-Sep
TSS at 7 AM	450.0	364.0	332.0	268.0	248.0	332.0	338.0	344.0	409.0	317.0	303.0	307.0	333.0	275.0
TSS at 2 PM	367.0	367.0	327.0	295.0	267.0	228.0	263.0	298.0	274.0	305.0	454.0	363.0	309.0	269.0
TSS at 8 PM	398.0	337.0	322.0	304.0	264.0	336.0	389.0	375.0	314.0	301.0	266.0	353.0	272.0	317.0
TSS at 2 AM	274.0	298.0	324.0	284.0	173.0	341.0	374.0	401.0	317.0	288.0	309.0	341.0	329.0	311.0
TSS Average	372.3	341.5	326.3	287.8	238.0	309.3	341.0	354.5	328.5	302.8	333.0	341.0	310.8	293.0
Turbidity at 7 AM	351.0	291.0	258.0	235.0	208.0	260.0	239.0	218.0	334.0	268.0	256.0	252.0	276.0	232.0
Turbidity at 2 PM	295.0	292.0	262.0	291.0	223.0	248.0	199.0	245.0	295.0	263.0	373.0	294.0	255.0	226.0
Turbidity at 8 PM	295.0	262.0	254.0	255.0	224.0	267.0	221.0	305.0	225.0	270.0	222.0	292.0	231.0	263.0
Turbidity at 2 AM	245.0	312.0	260.0	248.0	142.0	276.0	298.0	332.0	269.0	246.0	252.0	265.0	274.0	258.0
Turbidity Average	296.5	289.3	258.5	257.3	199.3	262.8	239.3	275.0	280.8	261.8	275.8	275.8	259.0	244.8
pH at 7 AM	8.8	6.8	7.2	8.1	8.4	9.0	8.8	8.8	9.0	9.0	8.7	8.7	8.6	8.5
pH at 2 PM	9.4	9.8	8.7	8.2	8.7	8.9	8.4	8.8	8.8	8.7	8.8	8.7	8.9	8.6
pH at 8 PM	8.7	8.7	8.6	8.7	8.7	8.8	8.8	8.7	8.8	8.7	8.8	8.8	8.7	9.0
pH at 2 AM	8.7	8.8	8.7	8.7	9.2	9.0	9.0	9.0	9.2	8.9	8.9	8.9	8.8	8.5
pH Average	8.9	8.5	8.3	8.4	8.7	8.9	8.7	8.8	8.9	8.8	8.8	8.8	8.7	8.7

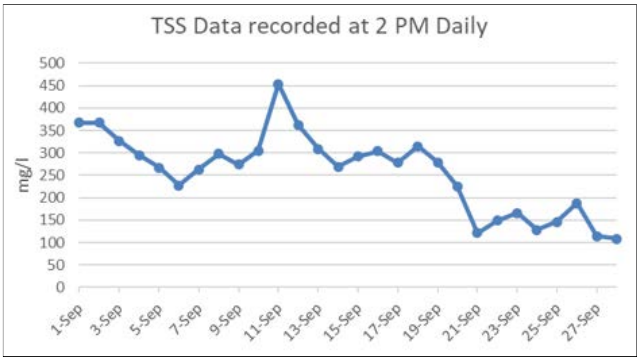
Date	15-Sep	16-Sep	17-Sep	18-Sep	19-Sep	20-Sep	21-Sep	22-Sep	23-Sep	24-Sep	25-Sep	26-Sep	27-Sep	28-Sep
TSS at 7 AM	362.0	317.0	286.0	309.0	288.0	231.0	212.0	176.0	155.0	177.0	115.0	118.0	162.0	112.0
TSS at 2 PM	292.0	304.0	278.0	315.0	279.0	226.0	121.0	149.0	166.0	128.0	146.0	188.0	114.0	108.0
TSS at 8 PM	311.0	307.0	296.0	300.0	295.0	224.0	146.0	157.0	159.0	125.0	251.0	290.0	139.0	125.0
TSS at 2 AM	324.0	283.0	349.0	315.0	297.0	246.0	215.0	150.0	151.0	138.0	205.0	192.0	122.0	132.0
TSS Average	322.3	302.8	302.3	309.8	289.8	231.8	173.5	158.0	157.8	142.0	179.3	197.0	134.3	119.3
Turbidity at 7 AM	228.0	268.0	238.0	261.0	237.0	198.0	129.0	155.0	139.0	161.0	99.0	109.0	142.0	105.0
Turbidity at 2 PM	240.0	252.0	227.0	270.0	231.0	186.0	141.0	127.0	140.0	115.0	126.0	165.0	102.0	112.0
Turbidity at 8 PM	257.0	256.0	245.0	234.0	244.0	182.0	124.0	136.0	130.0	124.0	215.0	181.0	127.0	119.0
Turbidity at 2 AM	234.0	238.0	285.0	257.0	235.0	213.0	135.0	139.0	137.0	127.0	178.0	170.0	115.0	114.0
Turbidity Average	239.8	253.5	248.8	255.5	236.8	194.8	132.3	139.3	136.5	131.8	154.5	156.3	121.5	112.5
pH at 7 AM	8.7	9.0	8.8	8.6	8.5	9.0	9.1	8.9	8.9	8.9	8.9	8.9	8.5	6.9
pH at 2 PM	8.6	8.6	8.7	8.8	8.6	8.7	8.8	8.6	8.8	9.3	8.7	7.6	7.5	7.5
pH at 8 PM	8.7	8.8	9.0	8.2	8.7	8.6	8.6	8.6	8.7	8.9	8.8	7.6	6.7	8.1
pH at 2 AM	8.9	8.8	8.8	9.0	8.7	8.7	8.8	8.5	8.7	8.8	8.7	7.6	6.9	7.0
pH Average	8.7	8.8	8.8	8.6	8.6	8.7	8.8	8.6	8.8	9.0	8.8	7.9	7.4	7.4

Figure 1: Influent and After Clarifier Wastewater prior to Bioaugmentation

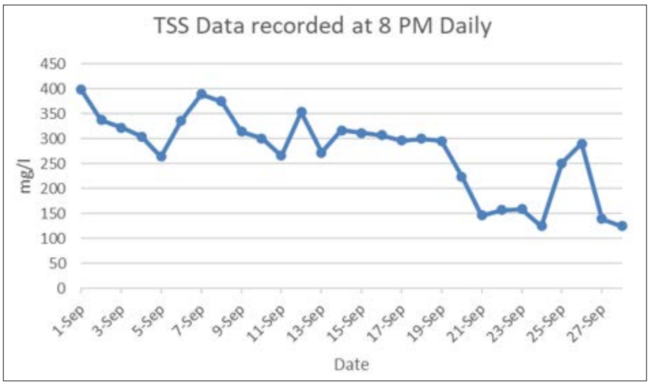
Figure 2: Influent and After Clarifier Wastewater after Bioaugmentation



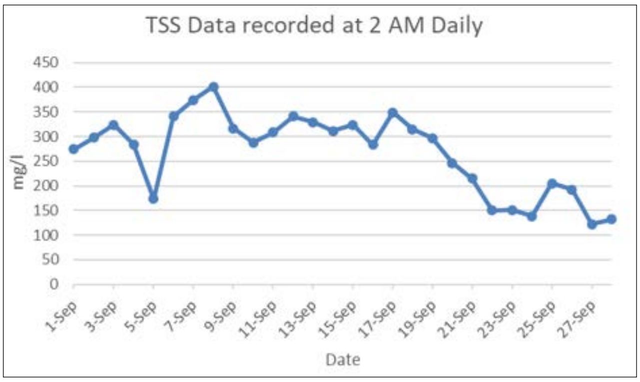
Graph 1: TSS (mg/l) daily data at 7 am



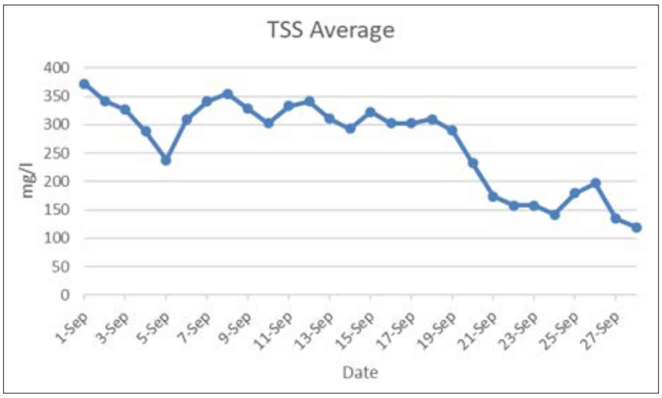
Graph 2: TSS (mg/l) daily data at 2 pm



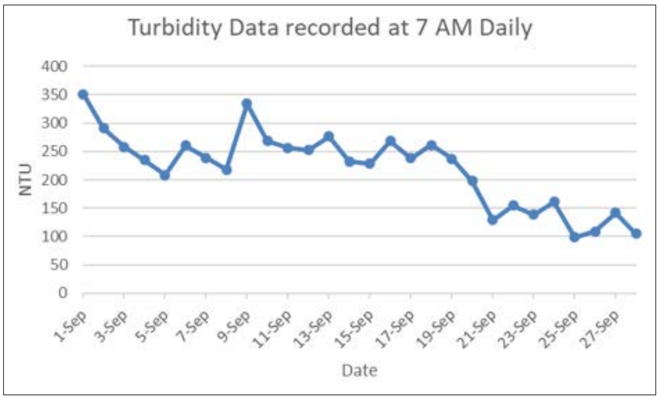
Graph 3: TSS (mg/l) daily data at 8 pm



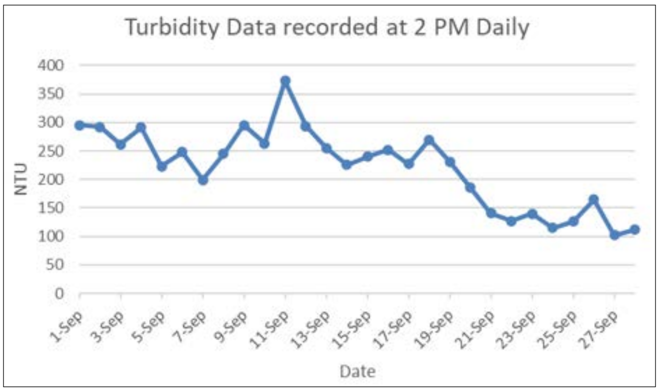
Graph 4: TSS (mg/l) daily data at 2 amam



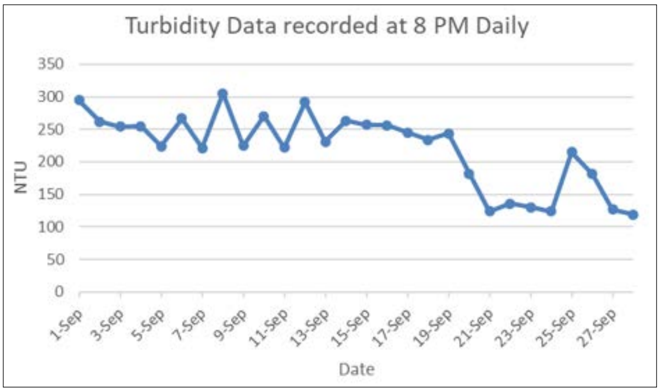
Graph 5: TSS (mg/l) Average during Bioaugmentation



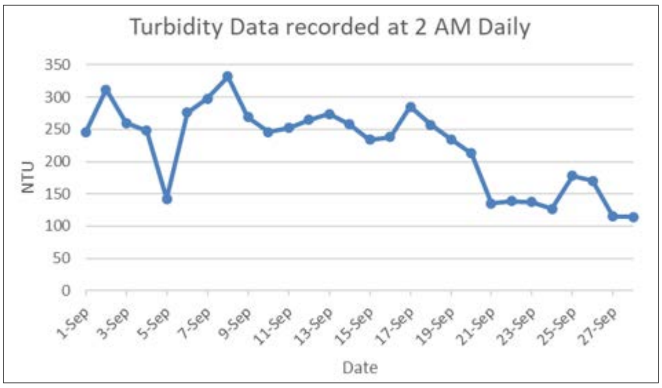
Graph 6: Turbidity (NTU) daily data @ 7 am



Graph 7: Turbidity (NTU) daily data at 2 pm

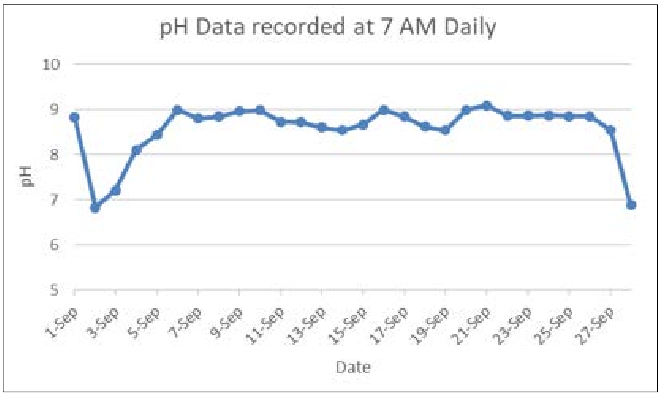


Graph 8: Turbidity (NTU) daily data at 8 pm

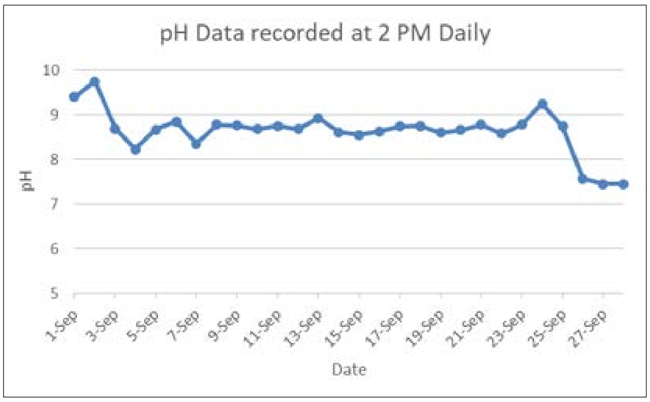


Graph 9: Turbidity (NTU) daily data @ 2 am

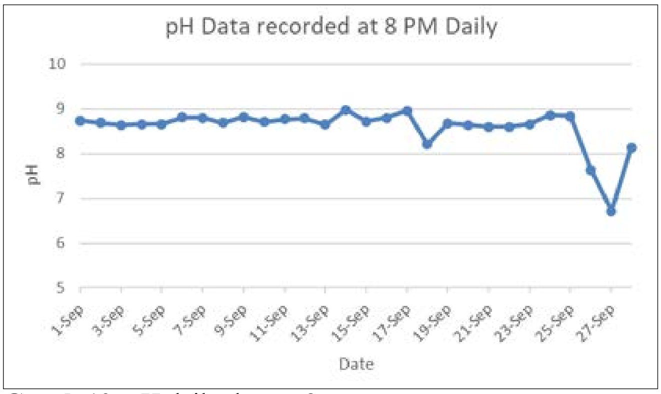
Graph 10: Turbidity (NTU) Average during Bioaugmentation



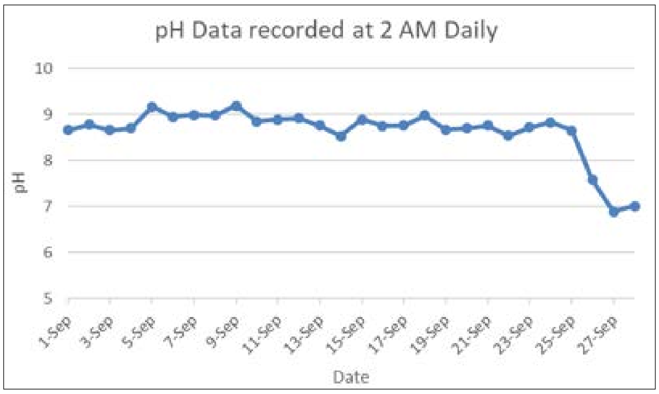
Graph 11: pH daily data at 7 am



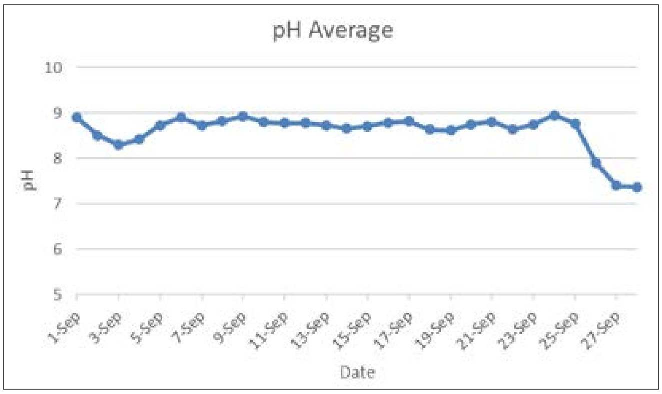
Graph 12: pH daily data at 2 pm



Graph 13: pH daily data at 8 pm



Graph 14: pH daily data at 2 am



Graph 15: pH daily data at 8 pm

Conclusion

The success of the bioaugmentation program at this site was evident in its immediate capacity to handle shock loads and swiftly recover from performance reductions in Total Suspended Solids (TSS) and Turbidity (NTU). The program's remarkable rapid response from active biology not only facilitated a quick rebound but also played a pivotal role in minimizing chemical dosage rates. This proved particularly beneficial during peak loading days caused by a demanding laundry schedule, thereby easing the process burden on the site operators. As a significant outcome, the operators concluded that the bioaugmentation technology utilized in this study showcased a remarkable ability to respond rapidly within the plant. This responsiveness was not limited to specific operational conditions, indicating the efficacy of the bioaugmentation approach across a broad spectrum of challenges. The research findings confirm that bioaugmentation emerges as a practical and effective solution for industrial wastewater environments encountering difficulties in achieving improved settling rates and addressing Total Suspended Solids (TSS) efficiency within the clarifier.

References

1. C R Holkar, A J Jadhav, D V Pinjari, N M Mahamuni, A B Pandit (2016) critical review on textile wastewater treatments: Possible approaches. Journal of Environmental Management 182: 351-366.
2. K Siddique, M Rizwan, M J Shahid, S Ali, R Ahmad, et al. (2017) Textile Wastewater Treatment Options: A Critical Review," Enhancing Cleanup of Environmental Pollutants 183-207 https://link.springer.com/

chapter/10.1007/978-3-319-55423-5_6
3. K Paździor, L Bilińska, S Ledakowicz (2019) A review of the existing and emerging technologies in the combination of AOPs and biological processes in industrial textile wastewater treatment. Chemical Engineering Journal 376: 120597.
4. Vikas Dinkar Gosavi, S Sharma (2013) A General Review on Various Treatment Methods for Textile Wastewater. Journal of Environmental Science, Computer Science and Engineering & Technology https://www.academia.edu/5829971/A_General_Review_on_Various_Treatment_Methods_for_Textile_Wastewater
5. A M Lotito, U Fratino, G Bergna, C Di Iaconi (2012) Integrated biological and ozone treatment of printing textile wastewater. Chemical Engineering Journal 195-196: 261-269.
6. A Nzila, S Razzak, J Zhu (2016) Bioaugmentation: An Emerging Strategy of Industrial Wastewater Treatment for Reuse and Discharge. International Journal of Environmental Research and Public Health 13: 846.
7. S Šostar-Turk, I Petrinić, M Simonič (2005) Laundry wastewater treatment using coagulation and membrane filtration. Resources, Conservation and Recycling 44: 185-196.
8. A Sulzer Brand (2014) 7 Ways to Reduce Chemical Use in a DAF System, FRC Systems. https://www.frcsystems.com/reduce-chemical-use-in-daf-system/
9. M Alves, Fabiano Nunes Capponi, Carlos Henrique Ataíde, S Barrozo (2021) Wastewater treatment using DAF for process water reuse in apatite flotation. Journal of Cleaner Production 308: 127285-127285.
10. A D Santos, R C Martins, R M Quinta-Ferreira, L M Castro (2020) Moving bed biofilm reactor (MBBR) for dairy wastewater treatment. Energy Reports 6: 340-344.
11. D N Khudhair, M Hosseinzadeh, H M Zwain, S M Siadatmousavi, A Majdi, et al. (2023) Upgrading the MBBR Process to Reduce Excess Sludge Production in Activated Sludge System Treating Sewage. Water, 15: 408.