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Treatment of Textile Processing Effluent Using Bacterial Isolate and Activated Charcoal

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KEYWORDS

Effluent, BOD, COD, bioremediation, B. *licheniformis*, seed germination

ABSTRACT:

Textile industries consume a huge quantity of water for their processes and generate an almost equal quantity of wastewater. Effluent Sample of textile processing industry was collected and physicochemical analysis was performed as per the standard protocol of APHA 2017. The high value of Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and adverse effect on wheat seeds, this highlights effluent is a highly toxic and hazardous effect to the ecosystem. Bacterial isolate identified as *Bacillus licheniformis* was screened for various hydrolytic enzymes and explored for effluent treatment, it showed a reduction in BOD by 50% and COD by 53%. The bacterial treatment followed by physical treatment by activated charcoal, resulted in 97% and 98% reduction in BOD and COD respectively. After treatment, the toxicity assessment by seed germination was performed and 90% germination of the wheat seed was increased in comparison with untreated effluent. Textile wastewater has very high amount of organic compound which makes this effluent very toxic and hazardous to environment. The combination of biological and physical treatment method shows significant reduction in terms of BOD, COD and toxicity which makes this combined treatment method more appropriate for such type of effluent.

1. Introduction

The textile industry is one of the rapidly emerging industrial sectors in India. It contributes 5% to the country's total GDP and India is the 6th largest exporter of textiles globally. It uses different raw materials like cotton, woollen, and synthetic fibers [1]. The problem of the textile industry is the massive consumption of water which transform into highly loaded by different chemicals of wastewater [2]; this wastewater contains chemicals like acids, alkalis, dyes, hydrogen peroxide, starch, surfactants dispersing agents, and soaps of metals, organic and inorganic chemicals [3,4]. The textile industry is estimated to use more water than any other industry and, almost all wastewater discharged is highly polluted and thus has a serious environmental impact. The level of dissolved oxygen decreases continuously and is a serious issue concerning the aquatic ecosystem. The dissolved oxygen should be at least 5 mg/l for survival of aquatic life [5]. Average-sized textiles mills consume water about 200 L per kg of fabric processed per day [6,7]. According to the World Bank estimation, textile dyeing and finishing treatment are given to a fabric that generates around 17 to 20 percent of industrial wastewater [7].These effluents contain high amounts of fatty acids, proteins, carbohydrates, and other plant materials. The effluents are diversified, and majorly possess higher amount of organic compounds of biodegradable nature [8], but their high amount results in a severe impact on environment [9,10, 11,12, 13, 14, 15].

Textile industrial effluent having dyes and other chemicals adversely affect to aquatic as well as agriculture land. Because of some industrial unwillingness and profit-making attitude their wastewater treatment plant not even working, and some are suffering due to shortage of material, time, infrastructure, land, manpower, and capital consumption [16]. Textile wastewater treatment is majorly done in effluent treatment plants (ETP). This treatment plant follows a series of treatment processes that mainly focus on different water quality parameters such as pH, temperature, color, electrical conductivity (EC), alkalinity, acidity, total dissolved solids (TDS), total solids (TS), COD, BOD and some others parameter directed by local governmental regulations.

Several studies showed that COD, color, toxicity, and salinity are the major effluent pollution indicator parameters in textile effluents [17, 18]. The receiving environments have harboured massive diversity of microorganisms, adapted to the environment, and capable of utilizing and degrading the polluting molecules resulting from effluents. The higher COD than BOD suggests that there is a higher amount of biologically non-degradable components. This highlights the need for a combination of treatment processes; physical and biological to address the problem.

This study describes treatment of textile cloth processing effluent by a bacterial strain *B. licheniformis* GACE1 and filtration. Along with this, a combination of physical and bacterial treatment is also explored. The physicochemical parameters, BOD and COD were analyzed for untreated and treated effluent.

2. Method

Sample collection and bacterial isolation

The effluent was collected in pre-sterilized plastic bottles from the textile processing industry (Chikhali, MS, India). The collected effluent samples were brought to the laboratory, processed immediately, and stored at 4°C for further study. The diluted sample was inoculated on a nutrient agar medium. Further, the isolated colonies were screened for hydrolytic enzyme production; amylase, cellulase, protease, and lipase on their respective agar medium (data not shown) [19, 20, 21, 22].

Identification of bacterial isolate

The bacterial isolate was identified based on their morphological, biochemical, and molecular characteristics. The phylogenetic description was obtained using 16S rDNA nucleotide sequencing at National Centre for Microbial Resource (NCMR), National Centre for Cell Science, Pune (India). The total genomic DNA of isolate was obtained as per Sambrook et al., [23]. Subsequently, the 16S rRNA gene was amplified using a universal specific primer. The sequence obtained was compared with database sequences by using BLASTn available at NCBI(http://www.ncbi.nlm.nih.gov/BLAST). The closely related sequences obtained in the blast search were retrieved and used for phylogenetic tree construction using Molecular Evolutionary Genetics Analysis (MEGA11). The nucleotide sequence of the isolate has been submitted to the GenBank database.

Physicochemical characterization of the effluent sample

The effluent sample was characterized for various physicochemical parameters such as pH, temperature, color, electrical conductivity (EC), alkalinity, acidity, total dissolved solids (TDS), total solids (TS), sodium, potassium, carbonate, bicarbonate, chloride, ammonia, total phosphorus, COD, BOD were estimated using the standard methods [24]. Consequently, the analysis of untreated and treated samples was performed.

Preparation of inoculum

A loopful culture of the isolate was inoculated in pre-sterilized 100 ml nutrient broth and incubated for 24h at 37ºC. Two percent of this culture broth was used as inoculum for the bioremediation of effluent.

Treatment of textile effluent

Biological treatment

A total of 100 ml textile effluent was taken aseptically in 250 ml of the conical flask. Then two percent of 24h old culture from the nutrient broth was added to the effluent and kept on a rotary shaker at 120rpm for 48h. after biological treatment sample was subjected to physiochemical, BOD, and COD analysis

Physical treatment

The physical treatment used was filtration of the sample by using activated charcoal. For this purpose, 7cm height of charcoal was filled in the column (2X8cm size) and 0.5 cm glass wool beds at the bottom. The flow rate of the sample addition was 3 ml per min as per Patel and Painter [25], with some modifications, and removed with the same flow rate. After physical treatment sample was subjected to physicochemical characterization.

Combined treatment

The combination of both the treatment biological followed physical method was performed. As

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mentioned above, the biologically treated effluent by isolate GACE1 was subjected to physical treatment by activated charcoal.

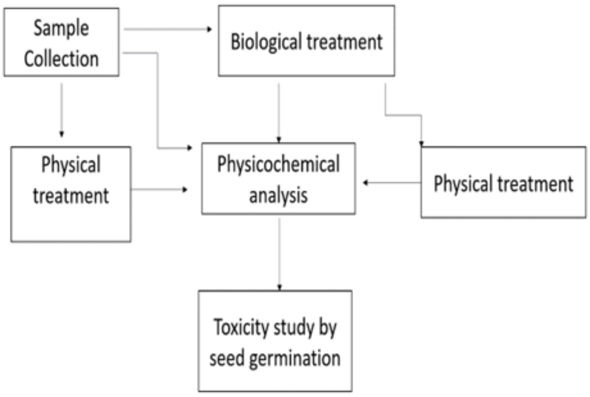

Figure 1: Outline of treatment and toxicity assessments.

Toxicity assessment

The seed germination assay was performed by the standard roll towel method [26], it was watered periodically with untreated and treated effluent. The wheat seeds were surface sterilized with 0.1% mercuric chloride for 5 min then rinsed with sterilized distilled water. Total 10 seeds were placed in one germination paper; the paper was rolled and placed in a sterilized Petri plate and plates were kept in the growth chamber. In this way three separate petri plates were used, every set watered by adding 10 ml of normal water, treated and untreated effluent sample on germination paper, after 48h observed for germination. The experiment was performed in triplicate, average values were used.

3. Results and Discussion

Isolation and identification of bacteria

The textile processing effluent contains a higher amount of bleaching agent, hypocloride, starch, natural pigments of fiber and fibers. This contributes to excess TDS, TS, BOD, and COD value. The bacterial isolate obtained capable to utilize starch and cellulose, isolate GACE1 confirmed as amylase, cellulase and protease producer selected for further study (data not shown here). The strain was identified based on morphological, biochemical, and molecular characteristics. The partial 16S rDNA sequence was obtained from National Centre for Microbial Resource, and submitted to GenBank (Accession no. OM977118). This comparison with the database sequences revealed99% similarity with *Bacillus licheniformis* (MT642946). The phylogenetic tree was constructed of neighbour-joining type with bootstrap value 1000. The biochemical and morphological characteristic along with the evolutionary tree based on 16S rDNA confirms the bacterial identification.

Physicochemical analysis of textile effluent sample

Treatment to textile processing effluent sample was given as per protocol mentioned in the method, after treatment, the sample was analyzed for physicochemical characteristics and the observation was shown in table no. (1). The high COD level of textile effluent shows that detergent, softeners, and other impurities on fabrics majorly contribute to increase COD level [27]. The combination of the anaerobic and aerobic method is typically implemented in real practice which uses an anaerobic process to treat textile wastewater of high chemical oxygen demand (COD), followed by the use of aerobic polishing treatment to treat the resulting textile wastewater of low COD. Generation of “methanogenic biogas” by an anaerobic process is possible only if the wastewater has a rather high COD, higher than 3 g/L, which is the case for designing wastewater containing more biodegradable organic compounds such as polyvinyl alcohol (PVA) or starch [28].

In this study, the textile effluent was treated differently, by physical and bacterial treatment. The physical treatment is majorly based on adsorption, there are some biological reports also suggesting adsorption for bioremediation [29]. But in this study no such adsorption found hence an additional treatment based on adsorption was done. The combination of bacterial and physical treatment was found more significant than separate treatment in terms of COD and BOD reduction i.e., 98 % COD and 97% BOD reduction. The biological methods for the complete degradation of textile wastewater have benefits such as: (a) eco-friendly, (b) cost-competitive, (c) less sludge production, (d) giving non-hazardous metabolites or full mineralization (e) less consumption of water(higher concentration or less dilution requirement) compared to physical/oxidation methods [30].

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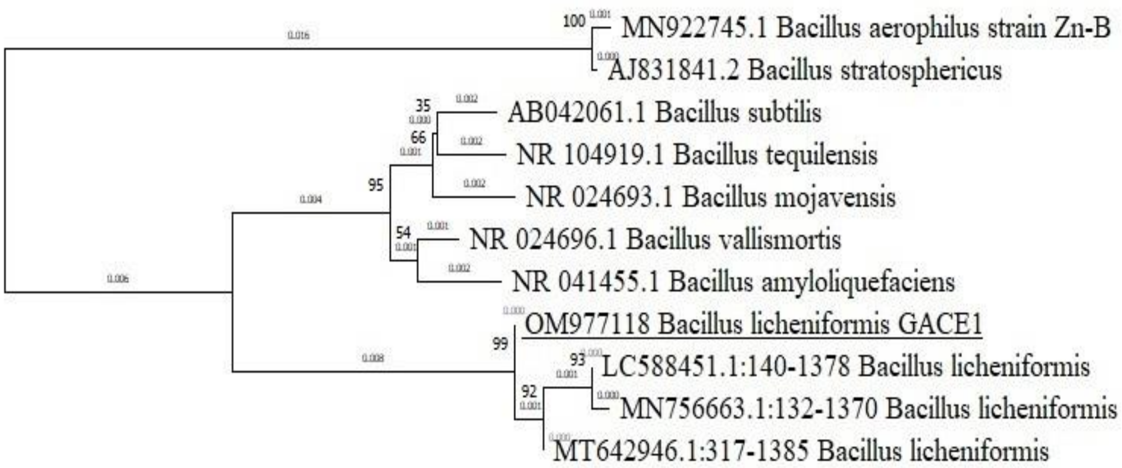

Figure 2: Phylogenetic tree of *Bacillus licheniformis GACE1*

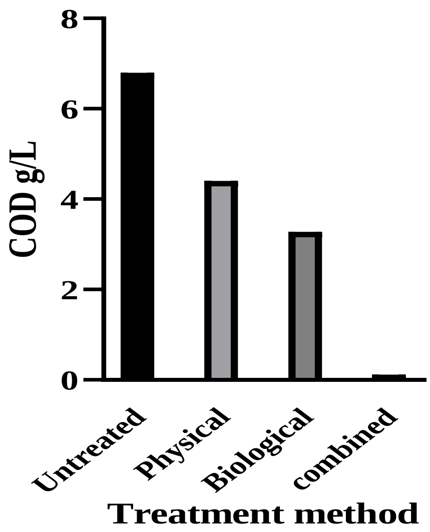

Figure 3: COD reduction of textile processing effluent with different treatment

There was no germination found in untreated effluent, this clearly highlights the extent of pollution and environmental impact. The industrial treatment schemes are thus designed to take care of this. Several studies showed that COD, color, toxicity, and salinity are the major effluent pollution indicator parameters in textile effluents [17, 18].The treatment alone by *B. licheniformis* GACE1 results in 53% COD reduction along with 66% seed germination. Whereas the combined, *B. licheniformis* GACE1 treatment and physical treatment by charcoal showed a significant increase in germination (90%)along with 98 % COD and 97% BOD reduction. The increased seed germination highlights the significance of the bacteria and physical process in reducing the unfavourable components (not detected in this study) thus making it suitable for germination.

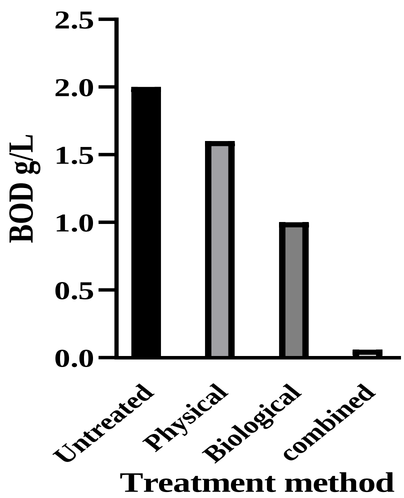

Figure 4: BOD reduction of textile processing effluent with different treatment

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Table 1: Physiochemical analysis of wastewater from textile processing industry

Sr. No.	Parameter	Before treatment	Physical treatment	Biological treatment	Combination treatment (Biological and Physical)
1	pH	9.0	8.1	7.5	7.5
2	Temperature (^{o}C)	25	25	25	25
4	Colour	Yellowish	Yellowish	Yellowish	Towards Transparent
3	EC(S/m)	1.567	1.22	1.503	1.123
5	Alkalinity(g/L)	1.700	1.59	1.61	0.98
6	Acidity(g/L)	0.375	0.290	0.300	0.200
7	TDS (g/L)	0.410	0.310	0.210	0.120
8	TS (g/L)	22.2	16.6	14.0	10.1
9	Total Hardness(g/L)	0.800	0.630	0.320	0.130
10	Sodium (g/L)	4.971	ND	ND	ND
11	Potassium(g/L)	0.438	ND	ND	ND
12	Carbonate(g/L)	1.26	0.71	0.74	0.36
13	Bicarbonate(g/L)	0.71	ND	ND	ND
14	Chloride(g/L)	4.624	ND	ND	ND
15	Ammonia (g/L)	0.00184	0.00182	0.00196	ND
16	Total Phosphorus (g/L)	0.00792	0.0079	0.0081	ND
17	COD (g/L)	6.8	4.4	3.279	0.12
18	BOD (g/L)	2	1.6	1	0.060

*ND- Not Detected

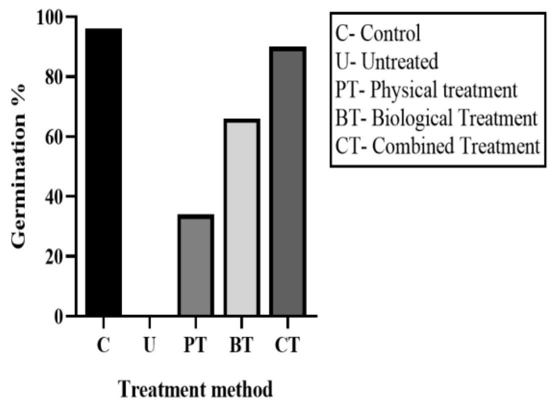

Fig. 5: Seed germination with water, Textile processing effluent-Untreated and various treatment methods.

[Values are the mean of germinated seeds of five experiments, significantly different from the control (seed germinated in water)].

Conclusion

The untreated or partially treated effluent has an extremely high organic content measured in terms of COD, further found to be a degradable organic matter. This has an adverse environmental impact evidenced by seed germination study. The treatment of this by a combined strategy, strain obtained in this (*B. licheniformis* OM977118), and a physical method (activated charcoal) significantly detoxifies and thus helps in appropriate treatment. This highlights suitability of the strain and physical method for the treatment of effluents of this type.

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