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Research Article

Bioremediation of the Physicochemical Parametres of Challawa Textile Industrial Effluents in Kano, Nigeria

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Abstract

Release of untreated textile effluents, especially into water bodies contributes immensely in making the environment unhealthy, and thereby affecting entire life of humans, plants and other aquatic animals. This eventually affects the quality of water and limits its utilization. This study was carried out to determine some physical and chemical parameters of Challawa textile industrial effluent in Kano, Nigeria. Physicochemical characterization of textile effluents collected from Challawa industrial estates was carried out and the parameters considered in this study were Temperature, pH, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Dissolve Oxygen and Electrical Conductivity EC . Using morphological and biochemical characteristics, three (3) species of bacteria (*Pseudomonasearuginosa*, *Pseudomonasflourescens* and *Bacillusmegaterium*) were obtained from the central laboratory of Bayero University, Kano for their ability to degrade textile effluents and grow on minimum basal medium efficiently and rapidly. The biodegradation and decolourisations of the bacterial species were carried out for 5 days and the results were expressed in percentages with *Pseudomonasearuginosa* (99.60%), *Pseudomonasflourescens* and *Bacillusmegaterium* (89.00%) The results showed high rates of physicochemical parameters. Analysis of variance of the results revealed that, there was statistically significant differences ($p \leq 0.05$) in Temperature, pH and DO after bioremediation. While there was no significant difference in the reduction efficacy of BOD, COD and EC. The selected bacterial species represent a promising tool for application in bioremediation of textile industrial effluents and the biodegradation potential observed would increase the applicability of these microorganisms for treatment of textile effluents before disposal to appropriate channel.

Keywords: Bacterial species; Bioremediation; Challawa industrial estates; Physicochemical parameters; Textile effluents

Introduction

The continuing industrial development has led to a corresponding increase in the amount of wastewater generation leading to a consequential decline in levels and quality of the natural water in the ecosystem. Textile industries consume over 7 x 105 tons of dyes annually and use up to 1 litre of water per kg of dye processed and are one of the largest pollutants of the environment (Mutambanengwe et al., 2007). However, there is increasing concern on the impact in effective treatment of textile effluents as they introduce secondary pollutants during the remediation process which is quite costly to run, maintain, and clean up. Research on biological treatment has offered simple and cost effective ways of bioremediation of textile effluent. Microbial decolourisation and degradation is an environmentally friendly and cost-competitive alternative to chemical decomposition processes (Verma and Madamwar, 2003). Textile industries produce considerable amounts of effluent characterized by large amounts of suspended solids, high COD, fluctuating pH, high temperature, and a mixture of dyes (Robinson et al., 2001). Untreated textile wastewater can cause rapid exhaustion of dissolved oxygen if it is directly discharged into the surface water sources hence they are toxic to biological life. The high alkalinity and traces of

chromium, where it was employed in dyes, adversely affect the aquatic life as well as interfere with the biological treatment process (Babu et al., 2000; Robinson et al., 2001; Zaharah et al., 2004). Heavy metals beyond permissible limits cause direct toxicity to all living beings. There are physical and chemical methods, which in spite of costs, do not always ensure that the contaminants are completely removed (Hardman et al., 1993). Bioremediation is the use of organisms to break down and thereby detoxify dangerous chemicals in the environment; it employs both plants and microorganisms. The presence of dyes in the effluent poses a biggest problem since they are recalcitrant and toxic. A very small amount of dye can be visible in water, thus decreasing the transparency of the water which leads to inhibition of sunlight penetration and consequently photosynthesis. Both aerobic and anaerobic processes have been successfully used for degrading the textile effluent, but the best appears to be a combination of both. Most studies on metabolism of organic contaminants have been performed with bacteria especially in context of bioremediation (Glazer, 1997). Bacteria generally are easier to culture, grow and preserve than fungi and algea (Hardman et al., 1993). They are more amenable to molecular genetic manipulation. Bacteria such as *Pseudomonas* and *Bacillus* have been shown to degrade the azo- or reactive dyes from textile industry effluent in a process often referred to as bioleaching (Ashoka et al., 2000). Of all the technologies that have been investigated, bioremediation has emerged as the most desirable approach for cleaning up many environmental pollutants (Lovely, 2003).

Wastewater is generally hot and alkaline, with a strong smell and colour due to the consumption of a variety of dyes and other chemicals in the dyeing processes (Robinson et al., 2001). Discharge of such effluents into aquatic bodies can cause lowering of dissolved oxygen, threatening aquatic life and downstream water users. According to Robinson et al. (2001), Because of the high BOD, the untreated textile wastewater can cause rapid depletion of dissolved oxygen if it is directly discharged into the surface water sources. Therefore the effluents with high COD level are toxic to biological life.

The fate and transport of many anthropogenic pollutants are determined by not only hydrological cycles, but also physicochemical processes (Bhatt et al., 2000). Several works on water quality have focused on the physicochemical characteristics of waters. Growing populations may put stresses on natural waters by impairing both the quality of the water and the hydrological budget (Bhatt et al., 2000). The quality of given water body is governed by physical, chemical and biological processes, all of which inter play with one another and greatly influence productivity in water bodies. There is a great deal of investigations about fresh water quality (Gasim et al., 2006). Textile effluents are characterized by extreme fluctuations in many physicochemical parameters such as chemical oxygen demand, dissolve oxygen, biological oxygen demand, pH, temperature and EC (FEPA, 1991; Yusuf and Sonibare, 2004; Orisikwe 2009).

Materials and Method

This research involved sampling textile effluent at Challawa industrial area in Kano Metropolis. Some physicochemical analyses were carried out at the site before and after bioremediation. However, collection of selected bacterial species and biodegradation/decolourisation potential of bacterial were carried out for 5 days in the central Laboratory of Bayero University Kano, Nigeria. Kano lies on (Latitude 11°30 I N 8.30 I, Longitude 11.5°N 8.5°IE), in Northern Nigeria. Samples were collected from the discharge and drainage pipes of the site during the finishing step, chemical finishing, and mechanical finishing. Chemical finishing involves wet unit processes, while mechanical finishing involves dry unit operations, the former involves rinsing, washing, printing and dyeing processing which corresponding to the highest effluents volume discharge and hence the worsening environmental situation. Samples were collected in one litre (1L) plastic containers with screw caps from each point and transported in ice packs to central Laboratory, Bayero University Kano, for analyses within 24 hours of collection.

The pH was determined by placing a pH probe (Hanna instrument C-99- USA) into the sample in a 250 ml conical flask and allowed to equilibrate for 3 minutes and pH meter was read and recorded accordingly while temperature of the effluent was determined on the field by lowering a mercury thermometer (Hanna instrument C-99- USA) into the sample and allowed to equilibrate for 4 minutes and reading was taken to the nearest degree Celsius (°C). Electrical conductivity (EC) was determined by placing a conductivity probe (Hanna instrument C-99- USA) into the sample in a 250 ml conical flask and allowed to equilibrate for about 3 minutes and the electrical conductance in micro second per cm (µs/cm) was recorded. Dissolved Oxygen (DO) of the effluent samples was determined

using Jenway Model 9070 (Hanna instrument C-99-USA) waterproof DO-meter. The protective cap of the DO meter was removed from the probe. Membrane module was taken and held in the vertical position. The probe was calibrated prior to measurement with the appropriate traceable calibration solution of 5% sodium sulphate in accordance with the manufacturer's instruction. The probe was immersed into the effluent samples to be analyzed and the readings were recorded at the point of sample collection. In determination of Chemical Oxygen Demand (COD) Fifty (50 ml) of sample was taken into a refluxing flask and several boiling stones were added. Then 0.1 g $HgSO_4$ was added to the solution and 5 ml of concentrated $H_2 SO_4$ was also added to the solution. To ensure that $HgSO_4$ dissolved completely, the solution was swirled slowly while adding Sulphuric acid, then 0.1 g of Ag_2SO_4 was added to this solution and finally Potassium dichromate was added. Thorough mixing of the solution was ensured by swirling the flask in a water bath to prevent any volatile substances that may have escaped from the liquid state. The flask was then attached to a condenser and further cooling was carried out and 20 ml of Sulphuric acid was added to the solution in the flask continuing cooling and swirling to mix the solution. The solution was refluxed for 1 hour. A blank run (using 50 ml distilled water instead of sample) was simultaneously conducted with the same procedure after cooling; the solution was then transferred to an Erlenmeyer flask. The reflux flask was rinsed thrice, pouring the rinsing water to the Erlenmeyer flask. The solution was diluted to about 300 ml and about 8 drops of phenanthroline ferrous sulphate was added to the solution as an indicator. The solution was titrated against the Mohr's salt and the titre volume required for the colour change from blue-green to reddish blue was noted. Biochemical Oxygen Demand (BOD-5) was determined using DO HI9146 (Winkler) method of DO determination, Microprocessor Dissolved Oxygen Meter. The amount of sample to be analysed was measured, clean calibrated thermometer was placed into the sample; temperature was stabilized at 20°C ±1°C in the refrigerator. DO instrument was turned on for 30-60 minutes. After aeration, 1 ml each of the potassium phosphate, magnesium sulphate, calcium chloride, was diluted according to manufacturer's instruction. Dilution was placed at constant temperature to maintain the initial temperature until sample dilutions and analyses began. The initial and final (after 5 days ± 4 hours) DO concentration of was measured as (D1) of each sample and each dilution blank. Temperature was checked using air incubator with laboratory thermometer to ensure that the temperature has been maintained. At the end of 5 days ± 4 hours, BOD bottle was removed from incubator, and was poured off the water seal and ground-glass stopper, and final DO concentration (D2) was measured. The DO1 uptake (DO2 days - DO5 days) in the dilution water should not be greater than 0.2 mg/l and preferably not more than 0.1 mg/l. For each test bottle meeting the 2.0-mg/L minimum DO depletion and the 1.0-mg/L residual DO, calculate BOD5 as follows: The formula for calculating BOD is stated below. BOD5 (mg/l) = (APHA, 2005) Where, D1= DO diluted sample immediately after preparation (in mg/l) D2= DO diluted sample after 5 day of incubation at 20°C ±1°C (in mg/l) P= decimal volumetric fraction of sample used. Preserved bacterial species namely *Pseudomonasearuginosa*, *Pseudomonasflourescens* and *Bacillusmegaterium* were collected from the central Laboratory of the Bayero University, Kano.

Biodegradation of textile effluents using selected bacterial species, two separate flasks of 250 ml set up were mounted for each identified species. One was to examine the action of individual bacteria land second flask set up contained no bacterial inoculums and therefore saved as control. Inoculation was done in proportion as stated by Senan et al., (2004). The pH was adjusted to 7 ± 0.2 using sodium hydroxide and hydrochloric acid solution. Then, the flasks were sterilized at 121°C for 15 minutes. The sterilised flasks were inoculated under aseptic condition with 3 ml suspension of selected bacteria species into 250 ml Erlenmeyer flasks containing 200 ml of sterile effluents. The flasks were incubated on an orbital shaker at 200rmp for 10 days at room temperature. Samples were drawn at 48 hour intervals for observation. Three millilitre of the each sample solution was filtered and centrifuged at 5000 rpm for 20 minutes. Biodegradation/Decourisation of effluents was determined by monitoring the decrease in absorbance at the maximum wavelength of effluents (λmax. 523nm) by using a UV-Visible spectrophotometer (UV-1700 Pharmaspec, Shimadzu Made in China).

Results and Discussion

Physico-chemical parameters

The upsurge in the search for cost effective and environmentally sound alternatives to the conventional methods for dealing with wastes has been reported by Ugoji and Aboaba (2004). In this present study, the results of the physico-chemical characteristics of textile effluents indicated that, the effluents were highly polluted before bioremediation. This is in agreement with Olayinka et al. (2004); Awomeso et al. (2010), who reported high levels of pollutants from 7 sampled areas in Lagos contaminated by textile effluents.

The effluent discharged by this industry leads to serious pollution of groundwater and soil, which ultimately affects the livelihood of inhabitant of the area. In this present study pH of the effluent Table 1 samples were slightly alkaline when compared to acidic pH of the dyeing effluent in previous study (Al-ghouti, 2003). Electrical conductivity, was found to be 2577µs/cm, when compared with textile effluent in India, Pakistan and Lagos was above discharge limit of 670µs/cm, 787µs/cm l and 574 µs/cm respectively (Togo et, al. 2006). The decrease in photosynthetic rate reduces the DO level of wastewater by microorganism in the current sample. Electrical conductivity (EC) at different sampling 81 points generally higher; this might be connected with the release of effluents containing chemical salts during processing of dye in the textile industry. However, this may probably be due to high organic and inorganic compounds from various chemicals used during processing stages in textile industry. High temperature brings down the solubility of gases in water that ultimately expresses as high BOD and COD. High values 1622mg/l and 2743mg/l of BOD and COD respectively were noted prior to bioremediation in the present study in comparison to low values of BOD, (1501mg/l) COD (1234mg/l) in one effluent study by (Vandevivre et al. (1998) High BOD and COD levels are another indicator of an increased load of organic pollutants in the effluent.

pH	*Temp (°C)*	*COD (mg/l)*	*BOD (mg/l)*	*EC (µs/cm)*	*DO {mg/l)*
7.20 ± 0.00	37.00 ± 0.00	2743 ± 0.00	1622 ± 0.00	2577 ± 0.00	6.33 ± 0.00

Table 1: Initial values of Physicochemical Parameters of Textile Industry in Challawa Industrial Area.

Biodegradation/decolourisation of textile effluents samples

The biodegradation/decolourisation obtained in this study were expressed in percentages with *Pseudomonasaeruginosa* (99.20%), *Pseudomonasfluorescens* (96.00%) and Bacillus megaterium (89.00%). The role of some bacterial spp for the decolourisation and degradation of textile dyes have also been reported by (Jumarkar et al., 2006; Olukanni et al., 2006; Togo et al., 2008), Chen et al. (2003); Senan et al., (2004) reported the isolation and screening of bacteria capable of decolourising various azo dyes from industrial effluent samples collected from wastewater treatment sites contaminated by dyes. Iyang (2006); Prasad et al. (2010) and Samuel et al. (2011) isolated bacterial spp that are potential degraders of hydrocarbon and textile effluent belonging to Bacillus spp and Pseudomonas spp. Our findings is line with the findings of Saranraj et al. (2010) who reported *Pseudomonasaeruginosa* (97.33%) as a potential degrader of dye effluent. Others include. In contrast to this study, Ajibola et al. (2005); Chimezie and Thomas, (2011) checked the ability of *Staphylococcusaureus*, *Bacterioidesfragilis*, *Bacillussubtilis*, *Bacilluscereus*, *Alcaligenes faecalis*, *Aeromonas hydrophila*, *Escherichia coli* and *Peptostreptococcusspp* in degradation of dye effluent with percentage ranges 75% of 90.00% with temperature of 31°C to 35°C and pH range of 7-8. The effectiveness of microbial decolourisation depends on the adaptability and activity of selected microorganisms (Abdulrahman, 2009). A number of microorganisms have been studied to unfold their degradative abilities in bioremediation of pollutants (Ajibola et al. 2005)). Biodegradation of textile effluent using B. licheniformis and B. megaterium has been documented by (Omalay et al., 2008; Praveen et al., 2009). *Bacillusbrevis* have the ability to decolourize textile effluent sample in twelve days Muller et al. (1992). All the samples exhibited effluents degrading capabilities. Control shows no decolourisation which probably confirms that biodegradation is as a result of metabolic activities of the introduced microbes. This can be attributed to the physiological difference and the decolourisation enzymes ability of bacterial spp used. This supports the findings of Omar et al. (2009), who reported that, when each pure culture was tested individually, they showed less decolourisation.

Bacterial Sp.	*pH*	*Temp (°C)*	*COD (mg/l)*	*BOD (mg/l)*	*EC (µs/cm)*	*DO {mg/l)*
P.earuginosa	BFB 7.20±0.00 ATB 6.65±0.13	BFB 37.00± 0.00 ATB 30.10± 0.40	BFB 2743 ± 0.00 ATB 804.40 ± 88	BFB 1622±0.00 ATB 665.30±86	BFB 2577±0.00 ATB 1051.7±209	BFB 6.33±0.00 ATB 9.02±0.54
B.megaterium	BFB 7.20±0.00 ATB 6.53±0.20	BFB 37.00±0.00 ATB 30.60±0.37	BFB 2743 ± 0.00 ATB 847.10 ± 96	BFB 1622±0.00 ATB 744.30±110	BFB 2577±0.00 ATB 838.50±12	BFB 6.33±0.00 ATB 8.03±0.45
P.fluorescence	BFB 7.15 ± 0.05 ATB 6.75 ± 0.90	BFB 35.50 ± 0.05 ATB 30.70 ± 0.33	BFB 2831.50±0.50 ATB 1268.50±269	BFB1902 ± 0.50 ATB805.60 ± 189	BFB 3050.51±0.05 ATB 1328.1±325	BFB 5.55±0.05 ATB 7.92±0.33

Table 2: Mean of the physicochemical parameters of the effluent before and after bioremediation by bacterial species.

Conclusion

Although Bioremediation/degradation is a challenging process to both the textile industry and the wastewater treatment analysts, the result of this study and literature suggest a great potential for bacteria to be used to remove pollutants from textile effluents. Interestingly, the evidence for bacterial bioremediation of effluent from textile wastewaters was established. The reduction in BOD, COD, EC and DO are appreciable. The removal efficiency in the level of pollutants adsorption paved way for the adoption of the bacteria spp which were used in this study. These findings established that the bacteria were adaptive in nature and can degrade contaminants. The ability of the bacteria to adapt and degrade effluents from textile at high concentration gives it an advantage for treatment of effluents from textile industry. It was evidently clear that *P. earuginosa*, *Pseudomonas flourescens* and *B. megaterium* were capable of bioremediation of textile effluents and represent a promising tool for application in biodegradation of textile industries effluents at large scale.

Recommendations

i. The bacterial spp should be screened in the laboratory for pathogenicity and toxicity before use on the field in order to avoid cross infection to plants, humans and other animals.
ii. Simple and rapid microbiological tools are required to monitor bioremediation efficacy. This will provide important information on the effective ways of harnessing environmental pollution and will give microbial ecologists further insight in response of microbial communities to pollutants.
iii. More avenues of research have arisen from bioremediation study. It is recommended to characterize the predominant bacteria using both molecular method and conventional techniques to enable control, consistency and predictability of the degradation processes. In consequence, this will lead to standardization of the effluent treatment process.
iv. Application of the study to more dyes and identification of end products of the dyes using mass spectrometry is required to confirm the fate of aromatic amines.
v. A more complete study should be conducted on the operative parameters for the reduction of all pollutant indicators by the use of microbial organism to support efficient wastewater treatment.
vi. From the findings it is recommended that, all the tested pure culture of bacteria used in the study should be further used in large scale as an alternative treatment system for industrial textile effluent before discharging to appropriate channels.

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Volume 3 Issue 6 December 2022