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Full Length Research Paper

Assessment and biological treatment of effluent from textile industry

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The assessment of effluent generated from international textile industry (Nig) Ltd. Odongunyan Industrial Estate Ikorodu Lagos was carried out. The effluent was analyzed for biochemical oxygen demand (BOD), chemical oxygen demand (COD), total solid (TS), suspended solid (SS), dissolved solid (DS), odour and colour intensity prior to biological treatment with mixed culture of *Aspergillus niger* and *Aspergillus wentil*. The product of biological treatment was analyzed after 5 days of treatment. The result revealed that the effluent was initially of high BOD, COD, TS, DS, SS and colour intensity. The method used in this work has significantly reduced COD to well below 250 mg/l and BOD < 30 mg/l, TSS < 30 mg/l which are the upper limit for disposal into surface water. The result indicates remarkable overall COD reduction from 800 mg/l to 200 mg/l (75%), BOD (97.3%) from 750 mg/l to 20 mg/l and bioremediation of TSS < 30 mg/l (99.5%), DS (99.6%) and SS (99.3%).

Key words: Textile industrial effluent, *Aspergillus niger*, *Aspergillus wentil*.

INTRODUCTION

Effluents are waste water, unwanted fluids and chemical in liquid forms that are discharged as industrial waste. Large amounts of chemically different dyes are employed for various industrial applications including textile dyeing. Among the total dyestuff consumption, it has been reported that textile industry accounts for 67% of the total dyestuff market (Rajamohan and Karthikeyan, 2004). Azo dyes constitute the largest and most diverse group of dyes used in commercial applications. Azo dyes are a group of compounds characterized by the presence of one or more azo bonds (- N = N -) along with one or more aromatic systems. In spite of their low toxic effect on receiving bodies, these dyes create an aesthetic problem and its colour discourages the downstream use of wastewater.

Colour is the first contaminant to be recognized in the dyeing effluents and has to be removed before discharging into the water stream. Aesthetic merit, gas solubility and water transparencies are affected by the presence of dyes even in small amount. The removal of colour from wastewater has been rated to be relatively more important than the removal of soluble colourless organic substances, which usually contribute the major fraction of biochemical oxygen demand (Rajamohan and Karthikeyan, 2004).

Other sources of water pollution include industrial (chemical, organic and thermal wastes), pesticides and fertilizers (Melvin, 2006). Biochemical oxygen demand is defined as the amount of oxygen required by bacterial and fungi for breaking down to simpler substances, the decomposable organic matter present in any water, waste water or treated effluent. Effluent may also contain total solid (TS). Total solids are made up of dissolved solids (DS) and suspended solids (SS). Dissolved solids may be obtained by difference between total solids and suspended solids in the sample of the effluent (Ugoji and Aboaba, 2004).

Phanerochaete chrysosporium is capable of producing extracellular enzymes such as manganese peroxidase, effective in decolourization of textile effluent. This fungus

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Abbreviation: BOD, Biochemical oxygen demand; **COD**, chemical oxygen demand; **TS**, total solid; **SS**, suspended solid; **DS**, dissolved solid; **BT**, biological treatment.

appears to be the best candidate, so far studied, in treatment of the effluent from textile. The fungus is a good degrader that can utilize biostimulation of effluent from the textile industries. Manganese is known to catalyse several oxidation reactions important in lignin degradation, including decarboxylation and demethoxylation of aromatic substrate. It plays an important role in the degradation of phenol units and non-phenol units acting together with lipid. *P. chrysosporium* mineralize a variety of recalcitrant aromatic pollutants. Liginase has been shown to catalyse limited oxidation of benzopyrene, polycyclic aromatic and a number of phenolic pollutants. It degrades polyaromatic hydrocarbon, chlorinated aromatic rings connected by flexible and oxidative ring opening lignin, loss of phenolic and methoxyl groups and increase in carboxyl and carbonyl group contain carcinogens and endocrine disrupter.

The effluent do not affect the people alone, but also the environment in terms of ground water contamination which can affect the natural hydrologic cycle. Every production process goes with wastes generation. Traditional disposal method such as ocean dumping is now out of place following numerous incidents of severe negative impacts on the environment after years of disposal. Typical examples are the love canal episode of the Niagara fall in the united states of American and the mina Meta Bay experience in Japan where several tons of mercury was discharged through effluent into the bay and the inhabitants suffered the effect after over thirty years. The first type of waste water treatment equipment is the metal recovery ion-exchange system. This system was designed to remove metals within the waste water (McGraw Hill, 1982). Various treatment options are available for treatment of textile wastes before disposal. These may be physical and chemical techniques such as flocculation combined with flotation, electro-flotation, flocculation with Fe(II), $Ca(OH)_2$, membrane filtration, precipitation, ion-exchange, ozonation and katox treatment method involving the usage of activated carbon and air mixtures were also used. Even though some of the above mentioned methods are effective, most of them suffer from the short comings such as excess usage of chemicals, sludge disposal, expensive operating cost, ineffective colour reduction for sulfonated azo dyes and poor sensitivity towards shock load conditions (Marr and Cresser, 1983; Rajamohan and Karthikeyan, 2004; Ashokal et al., 2006; John, 2006).

Biotechnology is providing environmentally acceptable methods of modifying or destroying chemical wastes so that they are no longer toxic to the environment. Biological decolorisation has been employed under either aerobic or anaerobic environment. This usually involves finding bacteria or other microbes that can be genetically engineered to provide strains with better contaminant degrading potential than their natural counterparts (John and Dyer, 1971; Altken and Irvine, 1989; Hardman et al., 1993; Fernando et al., 1994; John, 2006; Melvin, 2006). However, a number of reports discourage the azo dye decolorisation by microorganism under anaerobic conditions as it leads to the formation of corresponding aromatic amines which cold be toxic (Coughlin et al., 2002). Also, reverse colorisation may take place when the degradation products are exposed to oxygen. Because of these above-mentioned problems, full-scale application of bacterial degradation is limited. Also, only a few research works have been reported on aerobic degradation of azodyes (Rajamohan and Karthikeyan, 2004).

The restrictive environmental legislation, the ecological problem and the high cost of conventional technologies for dye house effluent treatment have resulted in the search for economically viable and technologically suitable wastewater treatment plants. Many of the studies with aqueous or synthetic dye solution using bacterial and fungal strains have been reported to be of very little help in the development of biological process for treatment of textile dye effluent as they were carried out under conditions which does not resemble an industrial environment, for example using only a single non commercial synthetic dye (Rajamohan and Karthikeyan, 2004). Removal of a dye from an aqueous solution by the fungus *Aspergillus niger* has been reported to be more effective out millions of methods of waste water treatment (Yuzhu and Viraraghavan, 2000)

The present study aims at assessing the level of environmental pollution due to effluent from textile industries before and after the effluent has been treated biologically. The sample of effluent was treated with mixed culture of *Aspergillus* spp and the treated sample was analyzed for the level of BOD, COD, SS, DS, TS, colour and odour. The sample of effluent generated from international textile industries Nig. Ltd, Odongunyan industrial estate Ikorodu Lagos state, Nigeria, was used as case study. The study emphasizes the significance of minimizing the pollutants load in the effluent to be treated at the end of the production.

EXPERIMENTAL

Source of the sample

The dyehouse effluent was collected from International Textile Industries (Nig) Ltd., Odogunyan Industrial Estate Ikorodu, Lagos state, Nigeria. The characteristics of the dyehouse effluent were chemical oxygen demand (COD) 800 mgl^{-1}, biochemical oxygen demand (BOD) 750 mgl^{-1} and pH 5.29 ± 0.1 (APHA, 1989). The colour of the effluent was red due to the presence of dyes. The effluent was refrigerated at 4°C and used without any preliminary treatment.

Determination of colour intensity

The colour intensity of the sample was determined with the aid of Lovibond comparator by matching the colour of the sample with standards (APHA, 1989; Ademoroti, 1996).

Table 1. Overall percentage reduction of parameters.

Parameter	pH	Colour intensity (nm)	Odour	TS (mg/l)	SS (mg/l)	DS (mg/l)	COD (mg/l)	BOD (mg/L)
Initial	5.29	2.0	Pungent	5,000	2,000	3,000	800	750
Final	6.5	18	Odourless	27	15	12	200	20
Overall reduction (%)	-	-	-	99.5	99.5	99.6	75	97.3

Determination of odour

The sample of effluent was filled half way into the wide-mouth glass stopper bottle and vigorous shaking for 2 or 3 seconds. The stopper was removed and odour was quickly observed (APHA, 1989; Ademoroti, 1996).

Determination of total solids (TS)

A clean dish was dried of suitable size at 102 - 105^{0}C in an oven to a constant weight. 100 - 250 ml of thoroughly mixed effluent sample was accurately pipette into a dish, weighed and evaporated to dryness on a steam bath. The residue was dried in an oven for about 1 h at 103 - 105^{0}C and re-weighed after cooling to room temperature. The cooling was done until the weight of the dish plus residue was constant to within 0.05 mg. The weight of the dish was subtracted to obtain the weight of the total solids (APHA, 1989; Ademoroti, 1996).

Determination of suspended solids (SS)

100 ml of the sample of effluent was withdrawn into a conical flask with a pipette. It was filtered in Gooch funnel fitted with glass fibre filter paper which has been pre-dried at 103 - 105^{0}C. The glass fibre was carefully removed from the Gooch and dried to a constant weight at 103-105^{0}C and the weight subtracted from the weight of the filter paper to obtain the weight of the suspended solids (APHA, 1989; Ademoroti, 1996).

Determination of dissolved solid (DS)

Dissolved solid was obtained by difference between total solids and suspended solids (APHA, 1989; Ademoroti, 1996).

Determination of chemical oxygen demand (COD)

The untreated sample of the effluent was first analyzed for COD immediately after collection. The biologically treated sample was also analyzed for COD as earlier reported (APHA, 1989; Asamudo et.al., 2005).

Determination of biological oxygen demand BOD_5

The untreated sample of the effluent was first analyzed for BOD_5 immediately after collection. The biologically treated sample was also analyzed for BOD_5 as earlier reported (Marr and Cresser, 1983; APHA, 1989; Asamudo et.al., 2005).

Biological treatment

Mixed culture of *Aspergillus niger* and *Aspergillus wentii* which were mostly occurred during microbial isolation were grown in slant culture for 72 h at 30^{0}C. The spores of the 72 h old culture were harvested according to Akinyosoye and Akinyanju (1989). 10 mL of each of the medium containing fungal spores was added to 200 ml of the effluent in a 250 ml conical flask and inorganic nutrient amendment (biostimulation) was done using the mineral composition of czapecolox medium as a guide. The final pH was adjusted to 7 and incubated at 30^{0}C in an orbital shake (GALLEN-KAMP set at 100 rpm) (Fawole and Oso, 1988). COD, BOD, TSS, DS, SSS, colour intensity and pH levels of the effluent are measured after a fungi residence time of 24 h.

RESULTS AND DISCUSSION

The upsurge in the search for cost effective and environmentally sound alternatives to the conventional methods for dealing with wastes has been reported (Ugoji and Aboaba, 2004; Asamudo et al., 2005). The results obtained in this work provide a giant stride to compliment previous work in this area. The result obtained at the initial characterization of the sample of effluent from International Textile Industries (Nig) Ltd, Odogunyan Industrial Estate Ikorodu Lagos State, Nigeria is presented in Table 1. The results revealed initial level of pollutant in the effluent. It shows a high degree of COD, BOD, TSS, SS, DS, odour, colour intensity and acidity. The efficiency of the method used is seeing in the results of the analysis after the treatment with the organisms. The overall efficiencies of COD, BOD, TS, SS, DS, removal of the biological treatment are found to be 75, 97.3, 99.5 and 96.6%, respectively.

Table 1 shows the overall percentage reduction of different parameters after treatment with *A. niger* and *A. Wentii*. The ability of microorganisms to transform a variety of chemicals have led to their use in bioremediation processes Olutola et al. (2000). A number of micro organisms have been studied to unfold their degradative abilities in remediation of pollutant (Melvin, 2006). The results obtained after biological treatment showed a very good relationship with other method which had been reported to reduce the COD load of effluents below the upper limit of 250 mg/l (Rajamohan and Karthikeyan, 2004). Result revealed an overall COD reduction from 800 mg/l to 200 mg/l (75%), BOD (97.3%) from 750 mg/l to 20 mg/l and approximately 100% bioremediation of SS, TS, DS, colour and odour. The method had brought COD to well below 250 mg/l which is the upper limit for disposal of effluent into surface water and BOD whose upper limit for disposal into surface water is BOD < 30 mg/l, TSS < 30 mg/l respectively (John and Dyer, 1971).

After assessing the result of the present study and other technical aspects involved in removal of BOD, COD and TSS, there is a need to appreciate the efficacy of the degrader.

Conclusion

The result obtained from this research had revealed that effluent from industries like textile contain toxic and harmful components. The removal efficiency in the level of BOD, COD, TS, DS, SS colour, odour and pH have paved way for the adoption of the fungi which were used. It is evidently clear that *Aspergillus* spp. (*niger* and *wentii*) are capable of bioremediation. It is therefore recommended that these organisms be considered for biological treatment of effluents such as the one studied in this work. Efforts are in progress to extend the work to other industrial effluents and also determine the trace elements in the effluents that may be toxic or harmful to the environment.

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