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BIOREMEDIATION POTENTIALS OF SOME CHLOROPHYTA SPECIES ISOLATED FROM TEXTILE INDUSTRIAL EFFLUENT

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Abstract

Release of untreated textile effluents, especially into water bodies makes 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 the bioremediation potentials of some isolated species of chlorophyta (Green algae), namely *Spirogyra majuscula*, *Chlorella vulgaris* and *Volvox carteri* from African Textile Manufacturer (ATM) effluent in Kano, Nigeria. Bioremediations of textile effluent collected from Challawa industrial estates were carried out. The results obtained from the study revealed high rates of heavy metals which fluctuate based on the quantity and quality of the operation, using morphological, phycological and biochemical characteristics. Their ability to adsorb heavy metals was carried out for 21 days and the results shows that, they are all potential to adsorb heavy metals. Adsorption efficiencies of different algal species were expressed in mg/l. Results indicated effectiveness of the investigated species for removal of the target contaminants. Removal of heavy metal from the ATM ranged from 20.32mg/l to 67.48mg/l was established, with *Spirogyra majuscula* (67.48mg/l), *Chlorella vulgaris* (59.43mg/l) and *Volvox carteri* (47.13mg/l,). Analysis of variance of the results revealed that, there were statistically significant differences ($p \leq 0.05$) in adsorption of heavy metals (Cd, Cr and Zn) between individual organisms. The isolated algal 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: Adsorption, Algal Species, Effluent, and Heavy metals

Introduction

The continuing industrial development has led to a corresponding increase in the amount of waste water generation leading to a consequential decline in levels and quality of the natural water in the ecosystem. Textile industries consume over 7 x 10^5 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). Research on biological treatment has offered simple and cost-effective ways of bioremediation of textile effluent. Algal 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 acceptable limits cause direct toxicity to all living beings. Metallic effluents can have ecological impacts on water bodies leading to increased nutrient load especially if they are essential metals. Heavy metals such as zinc, lead, nickel, cadmium and chromium can bio-accumulate through the food chain to toxic level in man. These metals in effluent may increase fertility of the sediment and water column and consequently lead to eutrophication, which in open water can progressively lead to oxygen deficiency, algal bloom and death of aquatic life (Ashoka *et al.,* 2000). 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 (both plants and microorganisms) to break down and detoxify dangerous chemicals in the environment. Presences of dyes in the effluent pose 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 affect photosynthesis. Both aerobic and anaerobic processes have been successfully used for bioremediation the textile effluent, but the best appears to be a combination of both. Most studies on metabolism of organic contaminants have been performed with algae especially in context of bioremediation (Glazer, 1997). Algae generally are easier to culture and they grow more rapidly than bacteria and fungi as a result of their photosynthetic activities. They are more amenable to molecular genetic manipulation. Algae such as *ulva* and *Dunaliella* 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)

Materials and Methods

Experimental Design

This research involved sampling of ATM effluent in Kano Metropolis. Isolation, characterization of selected algal isolates and biodegradation/Decolourisation of potential algal isolates was carried out in the Central Laboratory of Bayero University, Kano, Nigeria.

Study Area

Kano lies on (Latitude 11°30I N 8.30 I, Longitude11.5°N 8.5°IE), in Northern Nigeria. The State has a total of area of 20,131 km2 (7.14 sq mi) of land. Most industries in the city are textiles, tannery, chemical and allied. Kano City is located on the main watershed which separates the two main river basins in Challawa and Tamburawa (Dan’ azumi and Bichi, 2010). The climate is characterized by well-defined wet and dry seasons. The wet season spreads from May to October, August usually being the wettest and dry season which lasts from November to April. Water pollution comes from domestic and industrial activities in which thousands of tonnes of waste waters flow into the water ways.

Sampling Point

The samples were collected from the discharge and drainage pipes of the site and the effluents paths of flow.

Sample collection

Samples were collected during the finishing steps of chemical and mechanical phases of he operations. Samples were collected in one Litre (1L) plastic containers with screw caps from each point and transported in ice packs to the Central Laboratory, Bayero University, Kano, for analyses within 24 hours of collection.

Sample Preservation and Laboratory Analysis

The samples were preserved by adding 1.5ml of HNO_3 to one liter of sample and the pH adjusted to 2.0 by adding 2 drops of HCl and recorded using pH meter. The sample was stored in a refrigerator at about 4^{o}C for subsequent analysis. As samples may contain particulate or organic materials, pre-treatment in the form of digestion was required before analysis. Nitric acid digestion was employed in accordance with APHA (1995). The digested samples were taken for Atomic Adsorption Spectrophotometer (AAS) for analysis. The analysis began with selection and adjustments of various units of the machine (lamp selection, wavelength selection, slit adjustment and flame adjustment) and the machine was standardized by aspirating distilled water to get zero absorbance. A standard solution of 1000 mg/l for all the metals was prepared, and from them working solutions (with concentrations within the range of 0-5 mg/l) was prepared by serial dilution APHA (1995). The standard solution was taken through the same digestion technique as mentioned. After digestion, the solutions was taken to AAS and the absorbance value read and recorded. A graph of absorbance vs. concentration (the calibration curves) was plotted. The sample was then aspirated into the machine and the absorbance value read and recorded. The concentration (in mg/l) was obtained by interpolating/extrapolating the values of absorbance from the calibration curve. The procedure was repeated for all the samples.

Bioremediation bioassay of textile effluents using selected algal species

Two separate flasks of 250 ml set up were mounted for each isolate. One was to examine the action of individual algal isolate; the second flask set up contained no algal inoculums and served as control. Isolates were selected based on three criteria; ability to grow on minimum basal medium, ability to degrade textile effluents and also ability to adsorb heavy metals. Trace of yeast extract (0.6 %), sucrose (3.5 %), $MgSO_4$ (0.02 %), and Na_2 CO_3 (1.0 %) were added to the effluents as co-substrates to help maintain the culture as stated by Senan *et al.,* (2004). The pH was adjusted to 7 ± 0.2 using NaOH. Then, the flasks were sterilized at 121 ^{0}C for 15 minutes. The sterilized flasks were inoculated under aseptic condition with 3 ml suspension of selected algal species into 250 ml Erlenmeyer flasks containing 200 ml of sterile effluents. The flasks were incubated on an orbital shaker at 200 rmp for 10 days at room temperature. Samples were drawn at 48 hour intervals for observation. Three milliliter of the each sample solution was filtered and centrifuged at 5000 rpm for 20 minutes. Biodegradation 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) and Decolourisation. Adsorption capacity of algal species was estimated using the following formula $\frac{wc-c}{c}$ X 100 (Kadiri and Opute, 2013). Where (WC) is the final concentration of heavy metal in the algal species after inoculation for time (t) and (C) is the initial concentration of heavy metal in algal species before inoculation.

Results and Discussion

Three algal isolates exhibited high growth potential when inoculated on minimum basal medium at different concentrations with rapid degradation of textile effluents in 48 hours (Table 1). These rapid growing isolates were selected for bioremediation studies. Adsorption capacity of various isolates from ATM revealed that *Spirogyra majuscula* demonstrated highest efficacy in adsorption of chromium with a value of 67.48 mg/l with minimum adsorption of zinc value of 43.88 mg/l (Fig. 2). Similarly, *Chlorella vulgaris* adsorbed 59.43 mg/l from 81.6 (Fig 1). However, fig. 3 below reveals the adsorption capacity by *Volvox carteri* which sequestered 20.32mg/l, 47.13mg/l and 32.21mg/l of cadmium, chromium and zinc respectively. However, the adsorption rates of Cr by all isolates ranged from 47.13mg/l to 67.48mg/l after bioremediation. Chromium and zinc had the highest concentration of 81.6 mg/l and 72.7 mg/l respectively before bioremediation. While the least adsorption capacity was recorded by *Volvox carteri*

Table 1: Heavy metals Adsorption potentials of algal isolates in textile effluents

Identified Isolates	1% ATMeft MBM	1.5% ATMeft MBM	2% ATMeft MBM
Chlorella vulgaris	+	+	+
Spirogyra majuscula	+	+	+
Volvox carteri	+	+	+

Key: ATMeft = African Textile Manufacturer effluent, MBM= Minimum Basal Medium, + = Adsorption

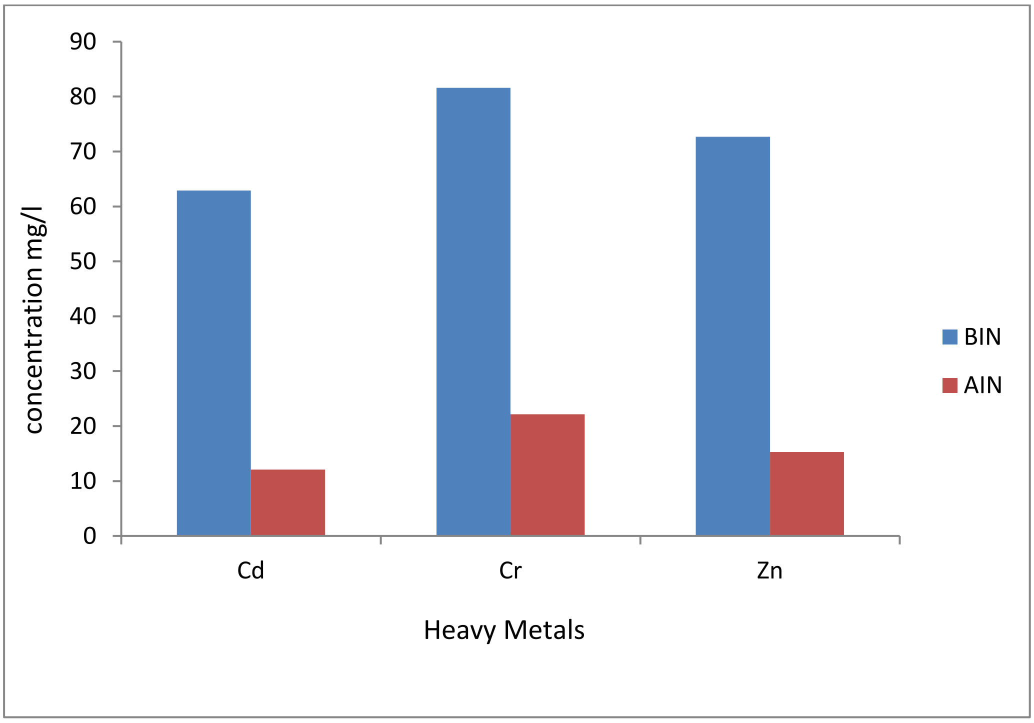

Figure 1: Heavy metals adsorption before and after inoculation by *Chlorella vulgaris*
Key: BIN = Before Inoculations, AIN = After Inoculations

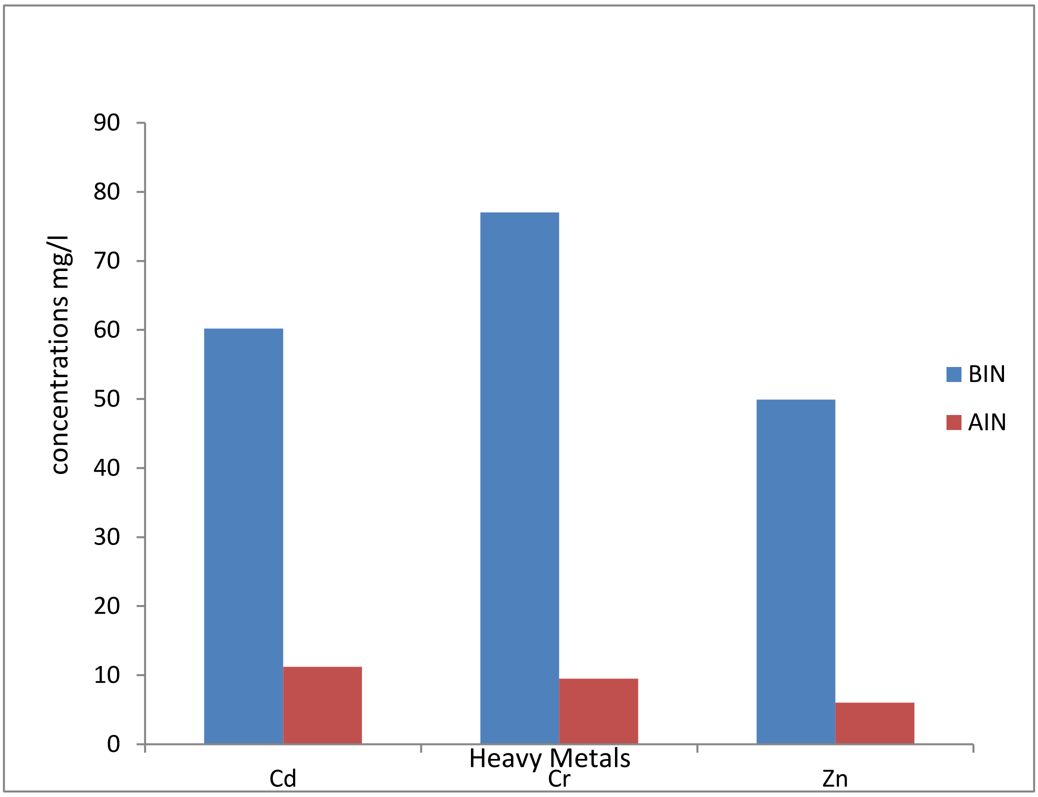

Figure 2 : Heavy metals adsorption before and after inoculation by *Spirogyra majuscula*
Key: BIN = Before Inoculations, AIN = After Inoculations

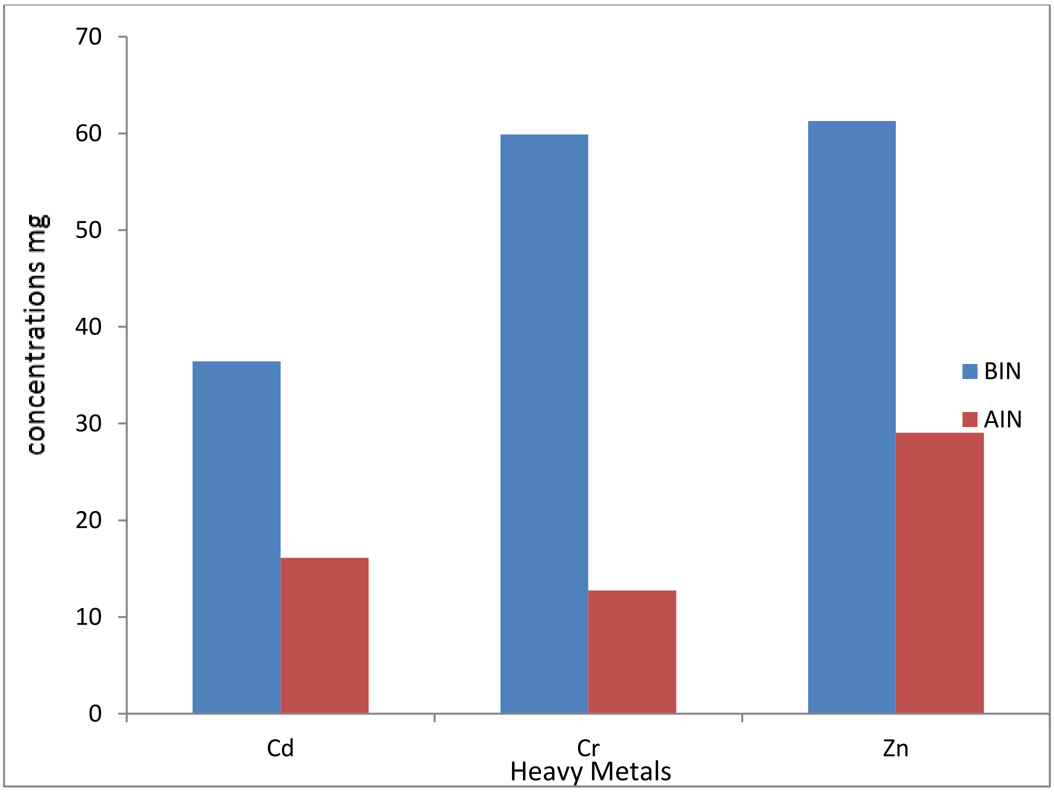

Figure 3: Heavy metals adsorption before and after inoculation by *Volvox carteri*
Key: BIN = Before Inoculations, AIN = After Inoculations

Conclusion

Although Bioremediation is a challenging process to both the textile industry and the wastewater treatment analyst. The result of this study and literature suggest a great potential for algal species to be used to remove pollutants from textile effluents. Interestingly, the evidence for algal bioremediation of effluent from textile wastewaters was established and adsorption of metal ions is appreciable. The removal efficiency in the level of pollutants and heavy metals adsorption paved way for the adoption of the algal species which were used in this study. These findings established that the algae were adaptive in nature and can degrade contaminants. The ability of the algae 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 *Chlorella vulgaris*, *Spirogyra majuscula* and *Volvox carteri* were capable of bioremediation of textile effluents and represent a promising tool for application in biodegradation of textile industries effluents at large scale.

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