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Bioreduction of Heavy Metals Concentration from Tannery Polluted Soil by *Aspergillus niger* and *Aspergillus aculeatus*

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Authors' contributions

This work was carried out in collaboration among all authors. Author YBA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors AHR and AHZ managed the analyses of the study. Author SSDM managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Reduction of Heavy metals content from the polluted soil by tanneries in sokoto metropolitan using slurry of fungi *A. aculeatus*, *A. niger* and co-slurry of both was evaluated. Heavy metal Cu, Fe, Zn, Cd, Pb, Ni, and Cr content was determined in duplicate using atomic absorption spectrophotometer (AAS) up to 12 weeks. The reduction mean ranged was 6.51-9.09 mg/kg, 3.57-9.33 mg/kg and 2.12-10.12 mg/kg Cu for fungi carrying *A. aculeatus*, *A. niger* and co-slurry respectively while Cd, Ni and Pb were removed in all the setup. Chromium was decreased most especially in the co-slurry of both fungi 22.10-113.25 mg/kg. Meanwhile, Heavy metal contents in all the setups were different from the control. The study reveals local tanneries utilized many synthetic chemicals for use in their production which becomes detrimental to our soil environment.

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Keywords: Heavy metals; fungi; soil; tanneries; reduction.

1. INTRODUCTION

A relative industrial and population increase has lead to a global concern of particular environmental threat posed by elements with greater atomic density and mass [1] specifically, heavy metals. Heavy metals in soil may significantly be natural or present in trace amount causing no harm and a times pollutants as a result of their continue accumulation often becoming highly concentrated leading the environment unsafe or unsuitable for use [2]. Ordinarily, heavy metals are incapable of decomposing [3] and their presence in soil may be link to food chain, the point for the release of their toxicity causing harm to ecosystem [4]. Accumulation of excess volume of heavy metals can affects soil composition, plants and microbial diversity [5,6]. Exposure to heavy metals was reported as agents that induced cancer and mutation [7]. It enters the living system through contact or consumption of metal-enriched crops [8]. Upon the function of living system, heavy metals like Ni, Mn, Fe, Cu, Zn and Cr can be essential at certain limited amounts but injurious at excess level and Pb, Hg and Cd are toxic even at low quantity [6].

In a place where skins of animals are processed called tannery, the major polluting ladders in hierarchical production processes include liming and tanning [9,10]. Chemicals, natural matter (trees bark or grasses) or co-utilization of both may be use for such processes and as a result, effluents as a waste are released to the nearby surrounding environment [11]. The effluents and other solid waste in the tannery may composed of several number of heavy metals deposited to the environments leading to pollution [12]. >250 synthetic chemicals and >3000 g of chemicals for every ton of skin treated are reported to be use in the tannery [13,12].

Generally, half of the tanning processed materials in a job are released to the soil either via effluents, fallout or remains of the substances used [14,12].

Tanneries in sokoto are still using local procedures (vegetable tanning) but enhanced with advanced materials like synthetic chemicals for time and energy save. Some tanneries releases effluents in an open bordered vicinity stored and remains untreated and others discharges effluents through flowing drainages which may find their way to receiving water. The study aim at determining, the ability by fungi strains *A. niger* and *A. aculeatus* to remove or reduce heavy metals from soil accommodating tannery effluents.

2. MATERIALS AND METHODS

2.1 Study Area

Rijiyar Dorowa, Unguwar Rogo and Tudun Wada are major tannery areas situated in metropolits of sokoto state, Nigeria. High volume of effluents has been free out to the soil, enclosed the surrounding areas and this may as well lead to pollution.

2.2 Sample Collection

Clean polyethylene bags were used for collection of sample, tannery waste polluted soil from the study areas mentioned. The sampled soils from kernels up to 150 mm depth at different spots were immediately transported to the laboratory and combined together to attain compound sample.

2.3 Preparation and Inoculation of Fungal Slurry

Slurry of fungi was prepared adopting procedure used by [15]. Colony culture (a week old) was inoculated in 500 ml Erlenmeyer flask containing saboraud dextrose broth, incubated in rotary shaker 160 rpm at 30°C for one week. Cells were counted using haemocytometer (superior marienfeld, Germany) as described by [16].

The sampled soil was dispensed in 200 g of four (4) sets of 4 containers. Biological reduction was evaluated for 3 months. Fungal slurry 80 ml was inoculated per set, for a spore concentration of 10^5 cells $gram^{-1}$ of soil [17]. The setups were consisted of three, containing slurry of fungi isolated from unpolluted, polluted site and their co-culture. While the other setup considered as control was with no organism. Each setup was in pairs. These were kept in the laboratory aerobically at room temperature (25±2°C).

2.4 Heavy Metal Analysis

Completely randomized design (CRD) was adopted for the experiment. The amended

polluted soil was sampled subsequently for heavy metal concentrations and monitored for 4 week intervals up to 12 weeks. Two gram (2 g) of soil sample was placed in digestion flask (250 ml) with 10 ml nitric acid (HNO_3) and 2 ml perchloric ($HCLO_4$) in the ratio of 5:1. The mixture was heated for at least 10-15 minutes, allowed to cool and distilled water (38 ml) was poured, leveled the volume to 50 ml [18]. The mixture was filtered by the use of filter paper (whatman). In the filtered liquid, concentrations of heavy metals were determined using atomic absorption spectrophotometer, AAS (SHIMADZU, AA 7000, Japan).

2.5 Statistical Analysis of Data

GenStat statistical software was used for the analysis. Analysis of variance (ANOVA) was adopted and mean differences were determined. Level of significance was at P≤0.05. Results were presented in charts with bars.

3. RESULTS AND DISCUSSION

Concentration of heavy metals in amended tannery polluted soil was presented in Figs. 1 to 3 and control (Fig. 4). The results revealed that heavy metals decreased with increase in time in polluted soil. In the setup carrying fungi (*A. aculeatus*) slurry from unpolluted soil (Fig. 1), the level of copper (Cu) decreased in the range of 6.51-9.09 mg/kg as against 8.09-9.51 mg/kg control; same reduction pattern of copper (Cu) from week 4 to 12 was observed. In the amended soil with fungi (*A. niger*) from polluted soil (Fig. 2), Copper (Cu) were reduced substantially and ranged from 3.57-9.33 mg/kg; reduction differ at week 8 to 12 while in polluted soil amended with co-slurry of both fungi, Cu were 2.12-10.12 mg/kg which reduced successively at week 4 to 12 (Fig. 3). Copper at this level do not render soil toxic and that may be suitable for plant growth [19]. Meanwhile Cu in all the setups exceeded NASREA (0.5 mg/kg) permissible limit.

Iron (Fe) 73.12- 76.15 mg/kg maintained its content in the setup carrying fungi (*A. aculeatus*) slurry from unpolluted soil (Fig. 1) throughout the period and substantial reduction of Iron was seen in Fig. 2 while Iron contents reduced in the Co-slurry of both fungi ranging from 21.72-74.37mg/kg (Fig. 3). The contents of Fe reduced, depend by fungi in each setup. There was little reduction at week 8 to 12 in the amended tannery polluted soil carrying fungi (*A. aculeatus*) slurry from unpolluted soil while in the other setup (*A. niger* slurry), Fe were reduced successively from week 0 to 12. Total reduction in the mixed slurry was higher than in the other setups and it takes the form S3>S2>S1>S4. Study [9,12] confirmed the presence of Fe in the tannery. The contents of iron in the tannery exceeded the level reported [12].

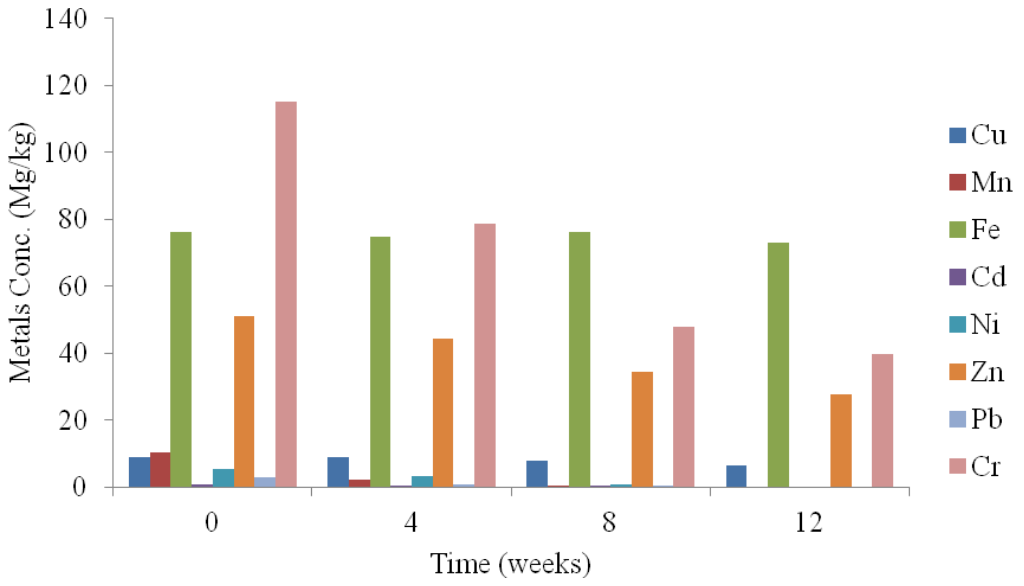

Fig. 1. Heavy metals in soil amended with slurry of *A. aculeatus* from unpolluted soil

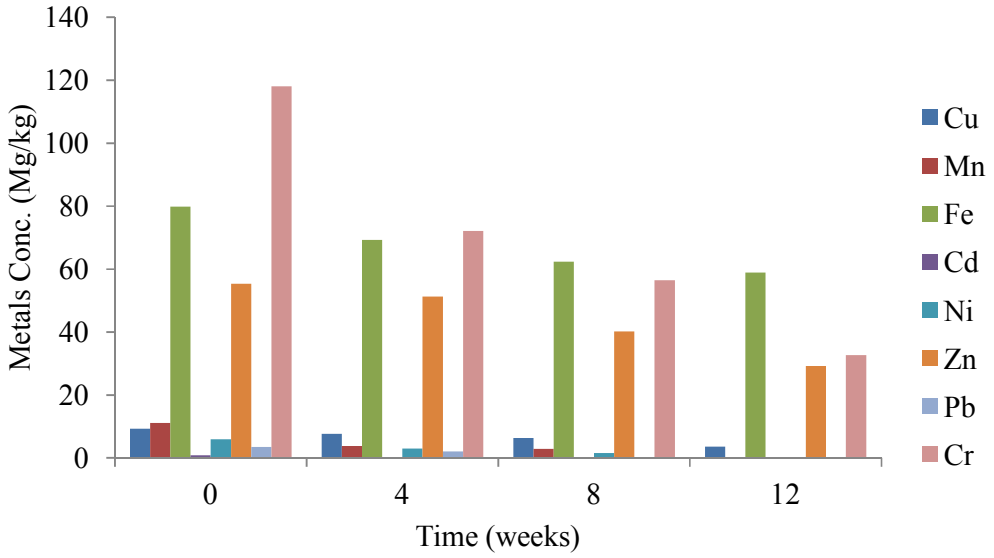

Fig. 2. Heavy metals in tannery waste polluted soil amended with slurry of *A. niger* from tannery polluted soil

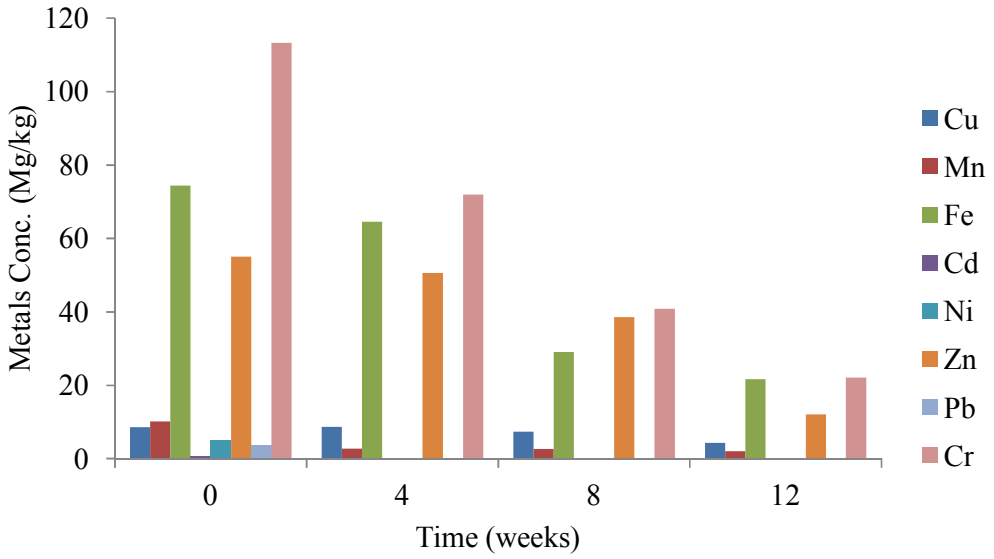

Fig. 3. Heavy metals in tannery waste polluted soil amended with co-slurry of both fungi from unpolluted and polluted soil

In the setup carrying fungi (*A. aculeatus*) slurry from unpolluted soil (Fig. 1), Cadmium (Cd), Nickel (Ni) and Lead (Pb) were removed and ranged from 0-0.80, 0-5.56 and 0-2.85 mg/kg as against control 0.68-0.85, 5.80-6.90 and 2.89-3.76 mg/kg respectively. In the amended soil with fungi (*A. niger*) slurry from polluted soil (Fig. 2), Cadmium (Cd) and Lead (Pb) were removed completely at week 8 while amended soil with co-slurry of both fungi (Fig. 3), Cadmium (Cd), Nickel (Ni) and Lead (Pb) were all removed completely at week 4. Cd, Ni and Pb were found present in the tannery [20,21,22]. The concentration of Cd, Ni and Pb were higher, compare to the reported contents by Ali et al. (2013). Meanwhile, the level obtained in the tannery exceeded the NASREA permissible limit.

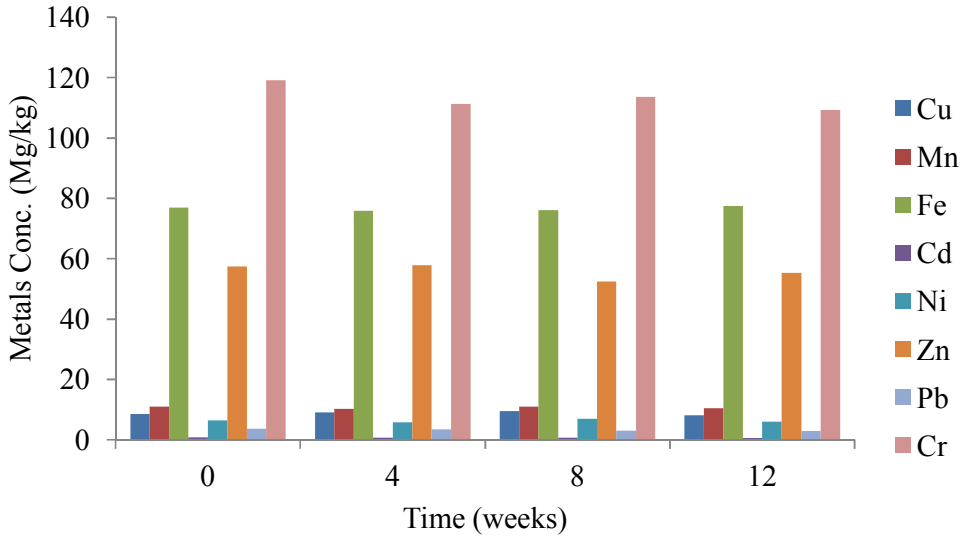

Fig. 4. Heavy metals in tannery waste polluted soil with no added inoculum (control)

Chromium (Cr) 39.82-115.27 mg/kg (Fig. 1) gradually decreased and Cr 22.10-113.25 mg/kg was decreased substantially (Fig. 3). The setup carrying fungi (*A. aculeatus*) slurry reduced chromium from week 0 to 8 greater than week 8 to 12. Likewise, fungi (*A. niger*) slurry decreased chromium contents from week 8 to 12 higher than week 0 to 8. Mixed slurry of both fungi showed better activity by reducing chromium in a hierarchical period from week 0 to 12. Heavy metal contents in all the setups were different from the control (Fig. 4). Chromium is one recalcitrant heavy metals reported to be present in almost all the present tanneries in the globe [23,20,21,22]. Heavy metal Cr content from the study was below the level reported [12] but higher the contents reported [21]. Also, the level obtained was above the NASREA permissible limit.

4. CONCLUSION

In the remediated soil, inherent fungi *A. niger* perform greater than foreign fungi *A. aculeatus* individually but their co-slurry have been shown to be active in the reduction of concentration of Zn, Fe, Cu, Cd, Ni and Pb from the tannery polluted soil down to NASREA threshold acceptable limit.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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