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Lead tolerance and bioadsorption potentials of indigenous soil fungi in Ado Ekiti, Nigeria

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ABSTRACT

Mycological investigation was carried out on soil samples from different parts of Ado Ekiti, including lands with heavy spillage of used engine oil. The isolated fungi from soil samples were tested for lead tolerance and biosorption. Fungal lead tolerance was determined at 500 – 2000ppm, while lead biosorption was determined at a concentration of 1000ppm with varied pH of 5, 7 and 9. Fungi isolated from engine oil contaminated environments include Aspergillus flavus, Penicillium chrysogenum, Penicilium oxalicum, Aspergillus tamari, Fusarium oxysporum and Penicilium citrinium, while from soil not contaminated with engine oil, Aspergillus tamari, Aspergillus terreus, Penicillium chrysogenum, Trichoderma hazarnium, Fusarium compacticum, Fusarium oxysporum, and Penicillium oxalicum were isolated. All the fungal isolates were resistant to lead up to a concentration of 2g/litre. The result of biosorption varied from species to species and was pH dependent. While extreme pH favoured some of the fungal isolates, Aspergillus tamari and Penicillium oxalicum showed better adsorption at neutral pH i.e. pH 7, while lead bioadsorption increased with pH in the case of P. chrysogenum. At pH 5 and 7 Aspergillus tamari recorded the highest adsorption of 97.2 and 97.1% respectively, while at pH 9 P. chrysogenum showed the highest adsorption of 98%.

Key words: Lead tolerance, Biosorption, Indigenous soil fungi.

INTRODUCTION

Heavy metals are the major inorganic contaminants present in effluents from industries such as mining, electroplating, battery, refineries, etc. Under certain environmental conditions, metals may accumulate to toxic levels and cause ecological damage [1].

Heavy metals released into the environment by industrial activities are non-biodegradable, and so tend to persist indefinitely, circulating and eventually accumulating throughout the food chain, becoming a serious threat to the environment. Waste water from industries such as electroplating, plastic and paint manufacturing, and battery contain heavy metals such as lead and cadmium, which when discharged into water bodies poses a serious threat to aquatic life. It has thus been discovered that river dumping is not a proper disposal technique as it posed a serious health risk to both aquatic organisms and organisms which depend on the aquatic organisms, especially man [1].
Of the important metals, mercury, lead, cadmium, arsenic and chromium (VI) are regarded as toxic; whereas, others, such as copper, nickel, cobalt and zinc are not as toxic, but their extensive usage and increasing levels in the

environment are of serious concerns [2,3,4]. Some metals cause physical discomfort while others may cause life-threatening illnesses, damage to vital body system, or other damage.

Microorganisms are generally the first to be affected by the discharges of heavy metals into the environment. Microbial ecosystem can drastically alter the fate of the metal entering into aquatic or soil environments. Bacteria such as cyanobacteria and fungi alter the form of occurrence of metal through methylation, chelation, complexation catalysis or adsorption affecting their bio-availability and movement in the food chain. Many types of yeast, fungi, algae, bacteria and some aquatic plants have been reported to have the capacity to concentrate metals from dilute aqueous solutions and to accumulate them inside the cell structure. [5,6,7]. Biosorption process in microorganisms can be affected by some environmental factors such as pH and temperature of the environment, the nature of the contaminants and the biomas concentration [8,9].

The study was aimed at unraveling the potentials of indigenous fungi in adsorption of heavy metals, using lead as case study, thereby contributing to bioremediation of the environment.

MATERIALS AND METHODS

Collection of soil samples

The soil samples were collected using auger from different locations within mechanic workshops that had heavy spillage of used engine oil, as well as uncontaminated fallow lands using auger.

Isolation of fungi

Serial dilutions were carried out on soil samples and 1ml of each was cultured on potato dextrose agar using pour plate techniques. The plates were incubated at room temperature for 3 to 5 days until fungi growths were observed. Subculturing was done several times until pure fungi isolates were obtained.

Determination of heavy metal resistant fungi isolates

The fungal isolates were inoculated potato dextrose agar plates impregnated with lead concentrations of 500, 1000, 1500 and 2000mg/L; incubated at room temperature for 3-5 days.

Biosorption at 1g/l concentrationand at different pH

Growth conditions were optimized at three different pH (5 which is acidic, 7 neutral, and 9 alkaline). One gramme of lead metal salt was added to 1000ml of potato dextrose broth contained in a three volumetric flasks and the pH were adjusted to pH of 5, 7 and 9 respectively. A volume of 100ml of each pH was dispensed into a 250ml conical flask. One gramme of the mycelium of each fungal isolates was inoculated into each conical flasks containing heavy metal salt (lead) at the varied pH under sterile conditions for 3-4 days in an orbital shaker (100rpm) at 28^0c.

The supernatant with free residual metal was obtained by centrifugation at 3000rpm for 15minutes and it was also filtered to remove the remaining particle that was not removed by centrifugation. The concentration of metal in the supernatant was determined using an Atomic absorption spectrophotometer, Perkin Elmer analyst 300.

Data evaluation

The biosorption capacity was calculated as follows:

$$\%R = \frac{(Ci - Cf)}{Ci} \text{ X } 100\%$$

%R is percentage of the metal adsorbed, *Ci* is the initial concentration of the metal in the solution (ppm), *Cf* is the final concentration of the metal in the solution (ppm) [10,11].

Statistical analysis

Paired *t* test was used to test for significant difference in the distribution of organisms along gender, using SPSS 16.0 window.

RESULTS AND DISCUSSION

Fungi isolated from engine oil contaminated environments include *Aspergillus flavus*, *Penicillium chrysogenum*, *Penicilium oxalicum*, *Aspergillus tamari*, *Fusarium oxysporum* and *Penicilium citrinium*, while from soil not contaminated engine oil, *Aspergillus tamari*, *Aspergillus terreus*, *Penicillium chrysogenum*, *Trichoderma hazarnium*, *Fusarium compacticum*, *Fusarium oxysporum*, and *Penicillium oxalicum* were isolated (Figure 1). All the fungal isolates were tolerant to lead up to a concentration of 2g/litre.

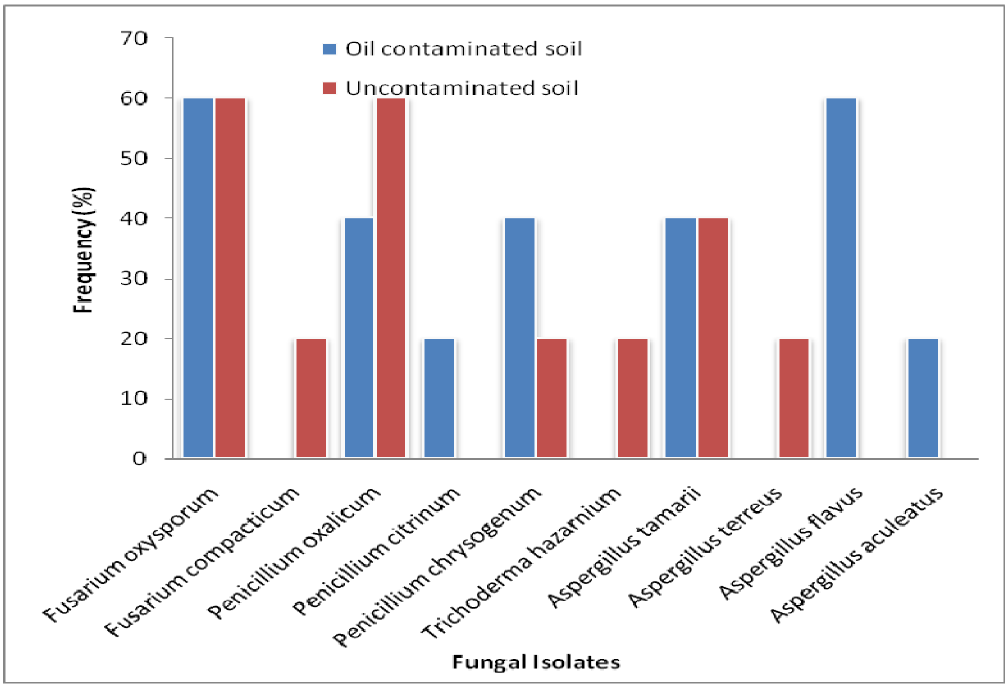

Figure 1: Fungal isolates from engine oil contaminated and uncontaminated soil

The seven fungal species used for biosorption of lead at concentration of 1000ppm with varied pH of 5, 7 & 9, showed variations in adsorption of lead (Figure 2). The result of biosorption varies from species to species and its pH dependent. While the extreme pH of 5 and 9 favour some fungal isolates such as *A. flavus*, *T. hazarnium* and *F. oxysporum*; *Aspergillus tamari* and *Penicillium oxalicum* showed better adsorption at neutral pH, and lead bioadsorption increases with pH in case of *P. chryseogenum.* At pH 5 and 7 *Aspergillus tamari* recorded the highest adsorption of 97.2 and 97.1% respectively, while at pH 9 *P. chryseogenum* the highest adsorption of 98%. There was no significant difference in variation of fungal adsorption of lead with pH, $p=0.187$ and $p=0.608$ for fungal isolates from engine-oil contaminated and uncontaminated soil respectively.

Fungi constitute a high proportion of the microbial biomass in soil and contribute significantly to heavy metal dynamics in soil. Fungal biosorption of heavy metals varies from species to species and also dependent on factors such as biosorbent size, metal solution concentration, solution pH, shaking time and ionic concentration [12]. All the fungal isolates used for the study, were effective in biosorption of lead.

Earlier studies have found non –living biomass of *Aspergillus flavus* to absorb more than 80% zinc from aqueous solution [13,14]. Goomes and coworkers [15] reported that the biomass of *Aspergillus terreus* and *Penicillum chrysogenum* were very effective in accumulating heavy metals, most especially zinc and lead.

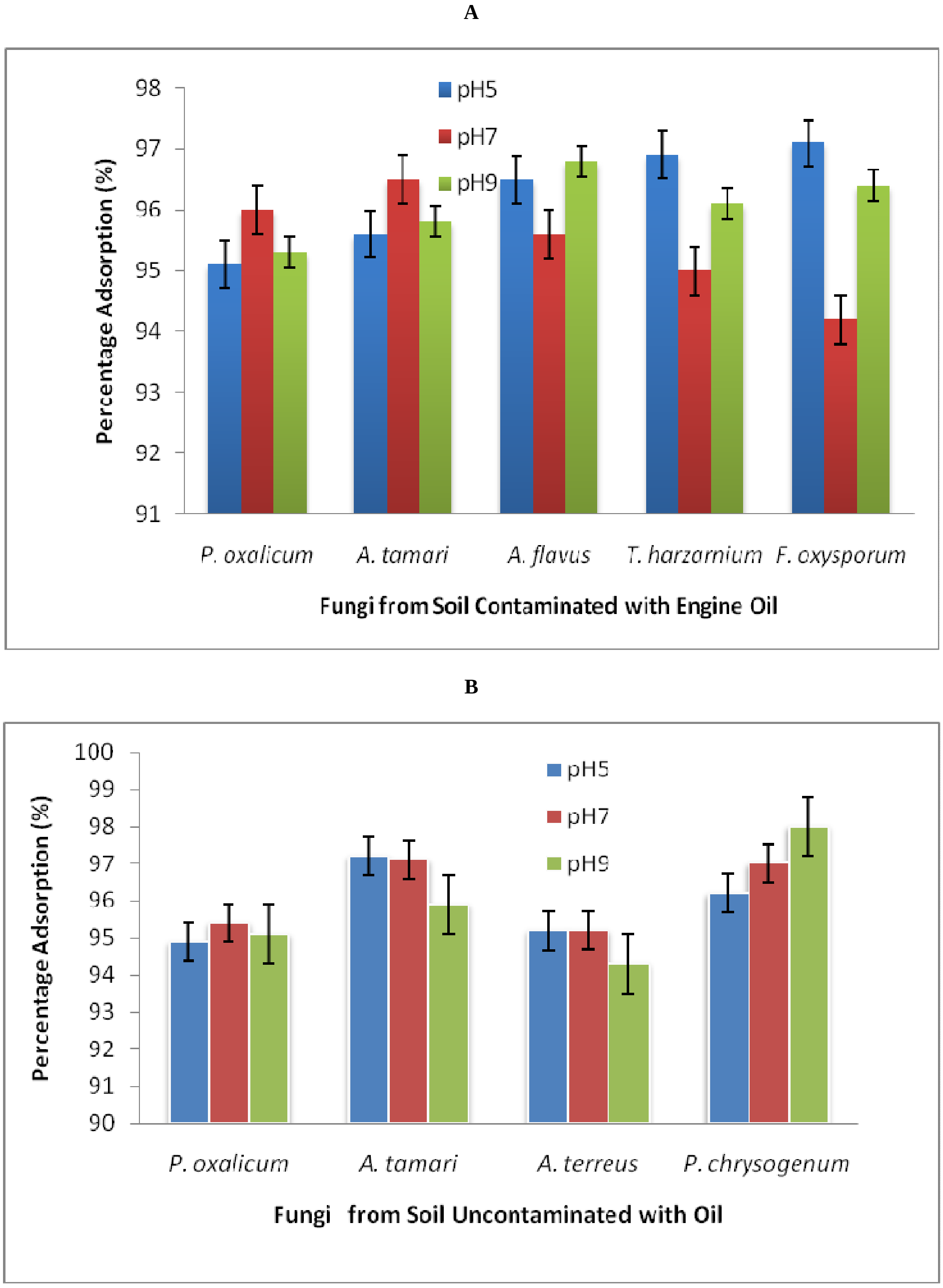

Figure 2: Lead adsorption of fungal isolates from (A) soil contaminated with engine oil and (B) uncontaminated soil

CONCLUSION

Based on the observation made in the present study, living biomass of fungi, having the capability of multiplication within an ecosystem, could be effectively used in land reclamation of soil contaminated with heavy metal.

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