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CHARACTERIZATION AND SUITABILITY EVALUATION OF DREDGED ASA RIVER SEDIMENT FOR SUSTAINABLE REUSE

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ABSTRACT
Sediments typify one of the ultimate sinks for heavy metals discharged into the environment. Consequently, sustainable reuse of these environmental wastes which is on the increase owing to climate change requires a holistic approach. A characterization study was embarked upon on dredged Asa River sediments from four strategic locations. Physical properties- particle size, moisture and total solids- ; chemical parameters such as total nitrogen, organic matter, heavy metals (Fe, Mn, Zn, Pb, Cd, Ni, Co, Cu) as well as microbial characteristics were conducted using standard procedures. It was observed that the sediments were mainly sand with pH in the slightly acidic range (5.4 – 6.3). Total N and organic matter contents were high (4.1 – 5.2 g kg^{-1} and 10.9 – 15.9 g kg^{-1}, respectively), indicating low biological activity due to level of pollution and soil type. *Aspergillus species* were the most abundant isolated fungi with six different species while *Botryodiplodia theobromae* had the lowest percent occurrence of 2.8. It could thus be inferred from this study that Asa River sediment is a rich organic whose heavy metals mobility and toxicity could be modified by processes that could lead to their biotechnological potential in bioremediation using indigenous fungi.

KEYWORDS: Asa River, fungi, metals, sediment**.**

INTRODUCTION

Pollution of the natural environment by heavy metals is a worldwide problem of ecological significance because these metals are not removed from water as a result of self purification nor indestructible but rather accumulate in reserviour and most of them have toxic effects on living organisms, when they surpass certain concentration (Loska and Wiechula, 2003; Mac Farlane and Burchett, 2000). However, fungi have the inherent capacity to degrade or cause to deteriorate a wide variety of materials and compounds through mycodegradation and mycodeterioration and have been employed as bioindicators in air, soil and water pollution surveys (Maurice and Lagerkvist, 2000). Fungi are among the major decomposers of plant polymers such as cellulose, hemicellulose and lignin in any ecosystem. Also, they have the ability to mineralize, release and store various elements and ions, and accumulate toxic materials (Singh, 2006). Edible and /or medicinal fungi have been proven to modify soil permeability and soil ion exchange as well as detoxify contaminated soil (Pletsch *et al*., 1999) as well as do aquatic fungi (Hasija, 1994), through myco transformation. With rapid industrialization and economic development, heavy metals are continuously introduced to soils and sediments through several pathways, including fertilization, irrigation, rivers, runoff, refuse/ waste dump sites by inhabitants of the flood plain (Ige and Alao, 2003), industrial wastewater discharges, fossil fuel combustion, sewage wastewater and atmospheric deposition (Adekola and Eleta, 2007; Ibrahim *et al*., 2013; Ige and Alao, 2003). Consequently, the management of contaminated dredged sediments is a widespread problem and there is an urgent need to develop low cost and environmental friendly strategies able to reduce the concentrations of pollutants at levels which can allow the sediment re-use. Such a need is exacerbated for contaminated sediments (Adekola and Eleta, 2007) recently dredged along Asa River to forestall future flood occurrence in Ilorin.

Although, sediments are sources and sinks of heavy metals, they are poor matrix for the growth of fungi owing to low levels of substrate. This is because the sediment environment just like soil is antagonistic to mycelial growth, and fungi follow the distribution of organic matter in it (Dix and Webster, 1995). However, a variety of substrates which are also environmental wastes such as wood chips, wheat straw, peat, corncobs, sawdust, a nutrient-fortified mixture of grain and sawdust, bark, rice husk, annual plant stem/ remains and wood, compost could be employed in inoculum production for both in-situ and ex-situ or mixed with contaminated sediment/soil to enhance degradation (Bennett et al ., 2001). It is pertinent for successful use of mycotransformation to know the field conditions and factors that would induce fungal biodegradation of the heavy metals in Asa River sediment before development of the final design. Thus, this study aimed at characterization - physical, chemical and microbial - of Asa River sediment for suitability evaluation for its sustainable reuse.

METHODOLOGY

Description of the study area

Sediments were collected along Asa River with a surface area of 302 hectares and a maximum depth of 14m and located approximately 4km south of Ilorin (Adekeye, 2004). The river lies between latitude 8^0 C and 52' N and

longitude 4^0 35' East. Four sampling sites (Amilegbe, Coca - Cola, Post Office and Unity) were selected in relation to the industrial, agricultural and domestic effluents that enter the river. Site A, Amilegbe, (N08˚29'42.33'', E004˚33'39.6'') is about 1.5km from the effluent discharge, receives refuse and sewage from homes, cassava processing units and run offs from agricultural and poultry farms. Site B is Unity, (N08˚28'28'50.3.'', E004˚33'38.1'') where soap and detergent, flour mills and pharmaceutical effluents are discharged and runoff water is received from poultry farm lands, cassava processing units and refuse dumps from homes including laundering activities. Site C is Post office (N08˚29'16.6.'', E004˚33'39.6'') about 1km from the point of discharge (that is sampling Point B). Then site D, Coca-Cola, (N08˚28'26.7.'', E004˚33'40.6'') where effluents from some soft drinks plants (Coca Cola and 7up, cassava processing units, agricultural, poultry wastes, and runoffs from diffuse sources is received.

Sediments Sample Preparation

The samples were collected at the four different locations in labeled polythene bags and air dried in the laboratory to avoid loss of volatile substances. After air drying, the samples were sieved with a 2mm sieve to get finer particles in readiness for microbial, physical and chemical analysis.

Microbial Analysis of the sediments

Fungal Isolation

Fungal Isolation was by plate culture technique using Potato Dextrose Agar (PDA) medium. The medium was autoclaved at 121˚C for 15minutes. Ten fold serial dilution of soil were made in sterile water. Aliquots (1 ml) of the 10^{-3} soil dilution were then incubated at 28 ± 2˚C for 5days. The cultures were further purified on fresh PDA medium and stock cultures were prepared in McCartney bottles. Colony forming units per gram units of soil (cfu/gm) were estimated.

Identification of the organisms present in the sediment

Cultural Features

Each fungal isolate was observed on solid medium. Features such as pigmentation, growth pattern, sporulation colour of spores and colour of back of cultures were recorded.

Microscopic Features

Each fungal isolate was stained with cotton blue in lactophenol on a microscopic slide and observed using a ×40 Objective on a compound microscope. The features noted were: presence or absence of septa in hyphal filament, types and arrangement of asexual reproductive spore; type of sexual reproductive spores. Reference to standard mycology texts was employed for identification of isolates.

Physical Analysis of sediment

Physical characterization tests carried out were total solids, moisture content, and particle size distribution (Gee and Or, 2000) using standard procedures.

Chemical Analysis of sediment

The sediments were analyzed for pH in water and potassium chloride (1: 2.5 soil to water), Total Nitrogen (microkjeldahl method), Organic Carbon by Walkley-Black method, Organic matter calculated from organic carbon by multiplying with a factor (1.724), Exchangeable bases extracted with 1N *N* NH_4OAc pH 7.0, and sodium and potassium determined using flame photometry, and calcium and magnesium using atomic absorption spectrophotometry, Available P (Bray P-1), Exchangeable Acidity was extracted using 1N KCl and titrated with 0.1N NaOH, as detailed by Okalebo *et al*., 2002.

Statistical analysis

Descriptive statistic (% occurrence) was employed for isolated fungi in the sediment.

RESULTS & DISCUSSION

Sediment characteristics

Physical and chemical characteristics

The physical and chemical characterization of sediments is an initial step to furnish information on the particle size distribution, organic content and exchangeable bases (Ca, Mg, Na and K) of sediments. Typical results are presented in Table 1 for samples from four locations along the course of Asa River. The sediment samples were varied in composition, but consisted primarily of sand. The textural class of Asa river sediment at Coca cola was sand-silt (74.7: 18.1:7.2) but Unity, Post office and Amilegbe were sand with (88.8: 6.4: 4.8; 88.2: 9.4: 2.4 and 90.2: 7.4: 2.4) respectively. Cola cola samples contain higher percentage of silt content which maybe as a result of poor flowing channel. The dredged areas - Unity, Post office and Amilegbe allowed the running water to erode the silt content down. The pH values of Asa river sediment was in the slightly acidic range of 5.4 -6.3. Total N of the four points were observed to be high due to high wastes and industrial effluent discharged into the river, 4.1 g kg^{-1} at Post Office, 5.2 g kg^{-1} Coca Cola. Ogunwale and Azeez (2000) attributed the pH values of river sediments to the nature of the parent materials on which the sediment is developed. Organic matter of the sediment samples of Asa River ranged from 10.9 to 15.9 g kg^{-1} (Table 1) in four locations indicating that biological activity was low and availability and utilization of nutrients was not at its maximum. Dumping of refuse (Adekola and Eleta, 2007), surface runoff of plant and animal remains at various stages of decomposition, cells and tissues of soil organisms, and substances from aquatic organisms and soil microbes is considered as an additional source (Ghrefat, 1999). This result is similar to the one obtained by Shaffer and Ernst (1999) in wetlands of Oregon due to level of pollution and soil types.

Occurrence of Fungi in Asa River Sediments

Aspergillus species, Trichoderma species, Penicillium species, Fusarium species were dominant species present in the sediments. Figure 1 shows the percentage of occurrence of the fungi isolated from the sediments. Out of the 13 fungal isolates, the result showed that the genus *Aspergillus* had the largest occurrence of fungi with 6 different species. *Aspergillus niger* had the highest percentage occurrence of 24.4%, while *Botryodiplodia theobromae* had the lowest percentage occurrence of 2.8%. The biological removal of metals by fungi which include biosorption of metal ions on the surface of fungi that does not depend on requirements for growth, metabolic energy, and transport is achievable by the isolated organisms from the sediments studied aside intracellular uptake and chemical transformation of metal

ions. *Aspergillus niger* has been reported to remove Cr (Park et al., 2005) while *Cladosporium cladosporioides* sorb Cu and Cd (Pethkar *et al*., 2001). Zn uptake by fungi (Ross, 1994); *Fusarium solani* utilization of CN (Barclay and Kwowles, 2001) have been reported. Plate 1 – 5 show the colony and microscopic structures of predominant fungi isolated from the sediment. Abundance of fungi in the sediment could be attributed to the high organic matter contact and the slightly acidic pH that has been known to support proliferation of fungi. Fungi tend to dominate over bacteria and actinomycetes in acid soils as they can tolerate a wide range of pH (Rousk *et al*., 2009).

TABLE 1: Physico - Chemical properties of sediment samples

Parameters	Coca cola	Unity	Post Office	Amilegbe
Sand, silt &clay (%)	74.7: 18.1: 7.2	88.8: 6.4: 4.8	88.2, 9.4: 2.4	90.2: 7.4: 2.4
Textural class	sand – silt	sand	sand	sand
Moisture content (%)	25.71	22.57	22.02	20.50
Dry matter (%)	84.30	86.05	86.68	82.44
pH (KCl)	5.4	5.9	6.0	6.3
Total N (g kg^{-1})	4.7	5.2	4.1	4.8
Available P (mg/kg)	23.4	24.6	23.7	26.3
Organic Carbon (g kg^{-1})	6.3	7.6	8.8	9.2
Organic matter (g kg^{-1})	10.9	13.1	15.2	15.9
Exchangeable Acidity	0.56	0.67	0.52	0.72
Na (cmol/kg)	0.70	0.75	0.62	0.77
Ca (cmol/kg)	11.63	8.69	9.24	6.84
K (cmol/kg)	6.12	6.05	7.09	5.11
Mg (cmol/kg)	3.84	3.72	2.69	3.89

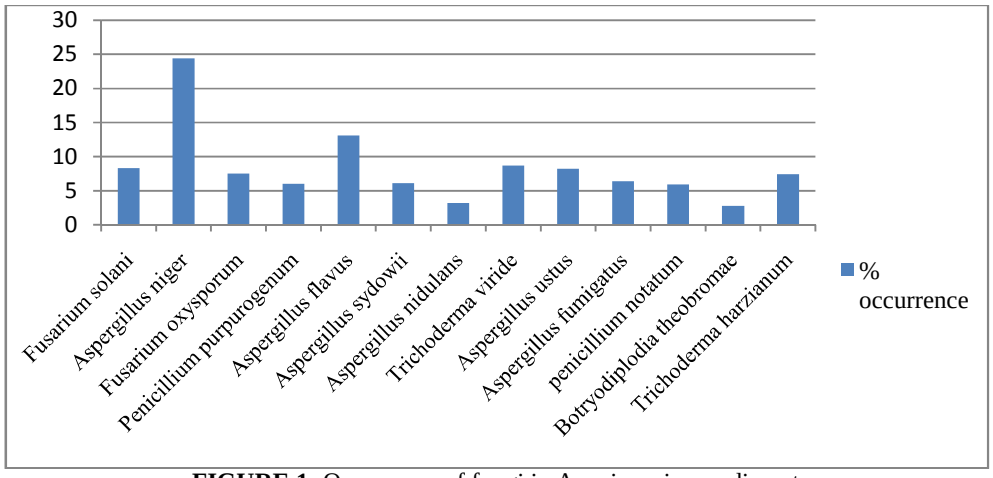

FIGURE 1: Occurrence of fungi in Asa river river sediment

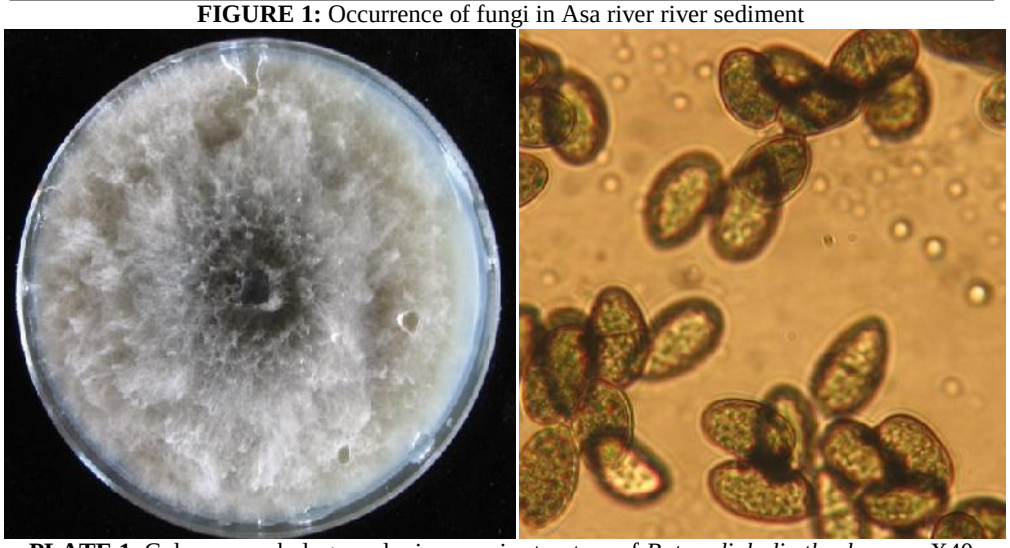

PLATE 1: Colony morphology and microscopic structure of *Botryodiplodia theobromae* X40

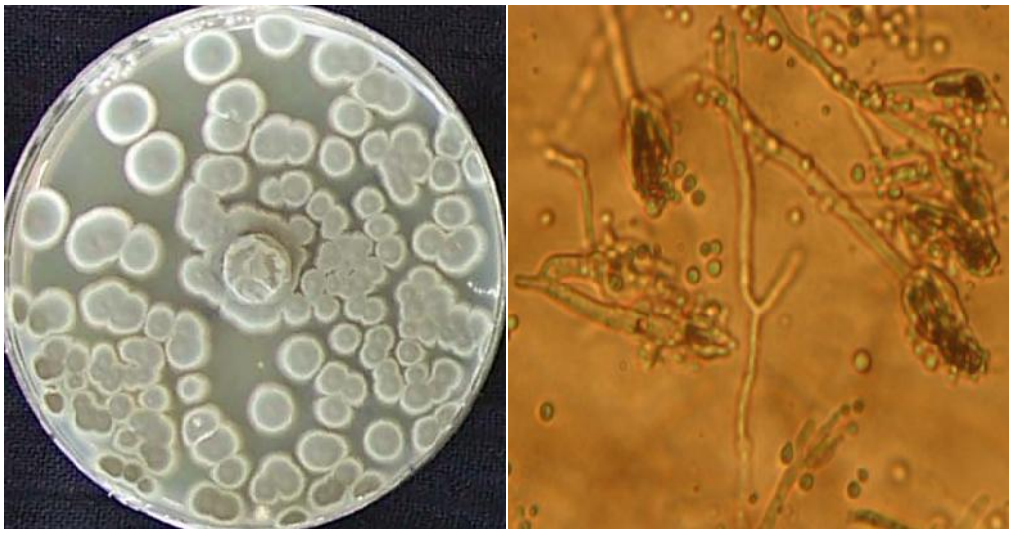

PLATE 2: Colony morphology and microscopic structure of *Trichoderma harzainum* X40

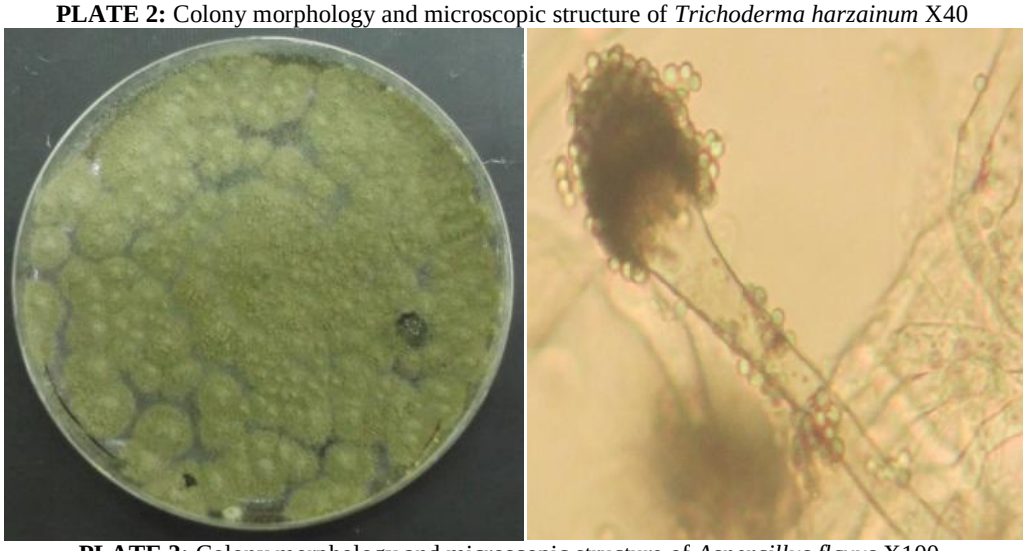

PLATE 3: Colony morphology and microscopic structure of *Aspergillus flavus* X100.

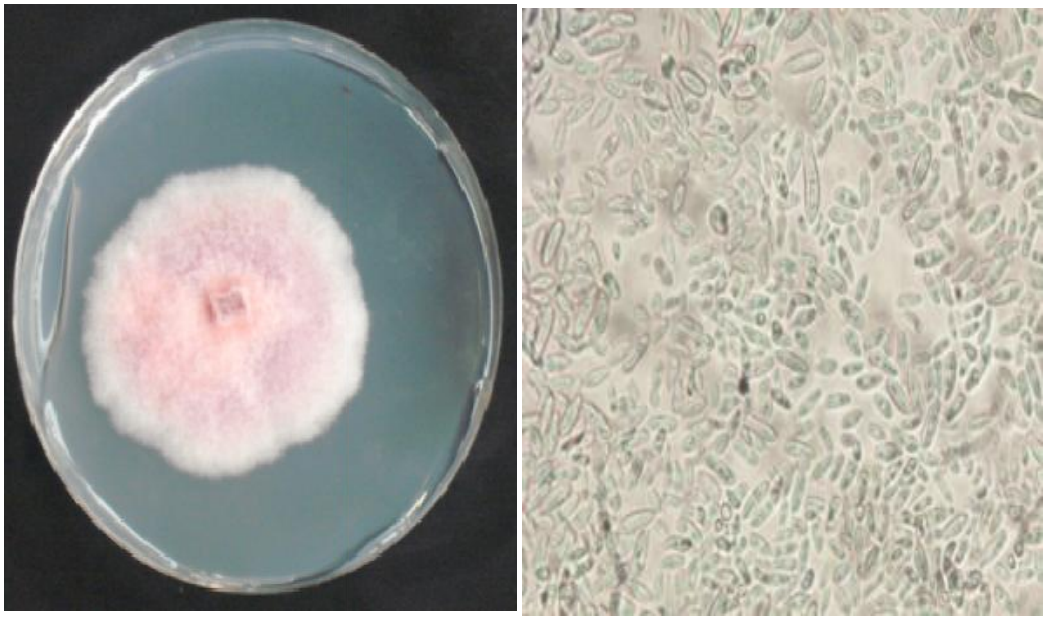

PLATE 4: Colony morphology and microscopic structure of *Fusarium oxysporum* X 40

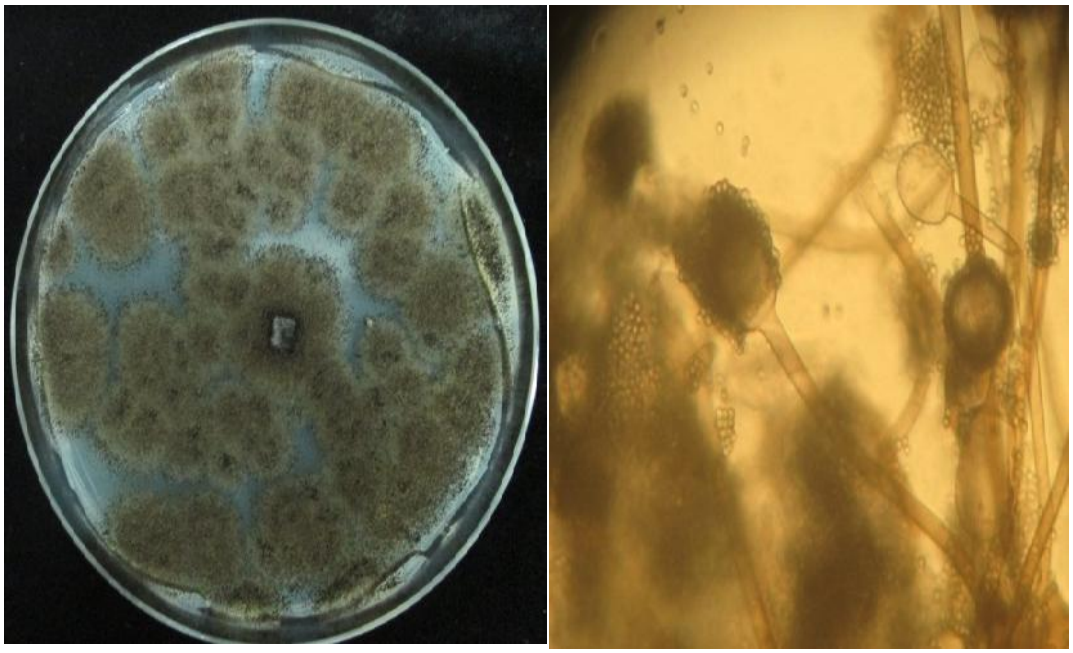

PLATE 5: Colony morphology and microscopic structure of *Aspergillus niger* X40.

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