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HEAVY METAL CONTAMINATION AND FUNGAL DIVERSITY IN DUMPSITES: CASE STUDY OF OBIO/AKPOR LOCAL GOVERNMENT AREA, RIVERS STATE, NIGERIA.

[1]*Wofu, N. B., [1]Fayam, E. S. and [1]Nneji, C. A.
[1]Department of Plant Science and Biotechnology, Rivers State University, Port Harcourt, P. M. B. 5080, Rivers State, Nigeria.

Abstract: This study assessed heavy metal contamination and fungal communities in soils from two dumpsites in Nigeria: Ogbogoro and Rivers State University. Heavy metal compositions were determined using standard methods, while fungal isolates were characterized macroscopically and microscopically to determine probable organisms and percentage incidence. Results showed that Rivers State University dumpsite exhibited higher levels of most heavy metals, particularly Cd (0.9276 ppm vs. 0.3260 ppm), Cu (0.6735 ppm vs. 0.3059 ppm), Zn (9.1770 ppm vs. 3.2819 ppm), Cr (0.061 ppm vs. 0.0094 ppm), Ni (0.9656 ppm vs. 0.6566 ppm), As (0.023 ppm vs. 0.010 ppm), and Fe (5.8458 ppm vs. 5.1892 ppm). In contrast, Pb (0.085 ppm vs. 0.043 ppm) and Hg (0.043 ppm vs. 0.014 ppm) were higher at Ogbogoro, with Se identical at 0.267 ppm across both sites. Fungal characterization revealed *Rhizopus sp*. as the dominant isolate at Rivers State University (90% incidence), with minor *Candida sp*. (10%). At Ogbogoro, *Rhizopus sp*. occurred at 60%, alongside *Aspergillus niger* (40%).These findings highlighted differential heavy metal accumulation and fungal adaptation between the dumpsites, with Rivers State University showing elevated contamination and strong *Rhizopus* dominance, underscoring the potential influence of site-specific waste profiles on soil pollution and microbial ecology.

Keywords: Heavy Metal, Fungi, Ogbogoro, Rivers State University, Dumpsites

Background of Study

The rapid pace of urbanization and population growth in developing nations has created significant challenges for municipal solid waste management, with open dumping remaining a prevalent disposal method in many regions (Al-Khatib *et al*., 2015). In areas like Sub-Saharan Africa and South Asia, inadequate waste collection infrastructure leads to over 90% of generated waste accumulating in informal dumpsites, often lacking proper liners or leachate controls, resulting in widespread soil and groundwater contamination (UNEP, 2018). These dumpsites serve as reservoirs for environmental pollutants, including heavy metals and microbial communities, posing serious ecological and public health risks (Amuno, 2011). Heavy metals such as lead (Pb), cadmium (Cd), chromium (Cr), mercury (Hg), and arsenic (As) are particularly concerning due to their persistence, bioaccumulation, and toxicity at low concentrations, causing issues like neurological disorders and carcinogenic effects (Bakshi *et al*., 2021).

Research consistently shows that heavy metal concentrations in dumpsite soils often exceed regulatory limits. For instance, studies in Nigeria reported mercury levels of 0.100-0.367 mg/kg and chromium levels of 0.117-0.926 mg/kg, significantly surpassing World Health Organization (WHO) standards (Ogundiran and Afolabi, 2008). Similarly, in China, cadmium and arsenic concentrations in landfill soils were found to be 1-2 times higher than background values, largely due to industrial waste inputs (Tengrui *et al*., 2007). In Laos, assessments revealed elevated metal accumulations in surrounding water, soil, and vegetation, threatening agricultural productivity and water safety (Vongdala *et al*., 2019).

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These metals originate from diverse sources, including electronic waste containing lead and cadmium, batteries with mercury, industrial byproducts with chromium, and household refuse with arsenic from pesticides or treated wood, all leaching into the environment through natural degradation processes (Islam *et al*., 2012).

Concurrently, refuse dumpsites foster diverse microbial communities, particularly fungi (mycoflora), which are critical for decomposition and biogeochemical cycling but may include pathogenic species capable of causing respiratory or allergic reactions (Kalwasinska and Burkowska, 2013). The interaction between heavy metals and mycoflora is complex: some fungal species exhibit metal tolerance and bioremediation potential by sequestering metals, while others enhance metal mobility through organic acid production and enzymatic activity, potentially exacerbating contamination (Chen *et al*., 2005). For example, fungi like *Aspergillus* and *Penicillium* can produce chelating agents that mobilize metals, influencing their bioavailability in soil (Gadd, 2010).

Despite increasing recognition of dumpsite contamination, integrated studies examining both heavy metal pollution and associated mycoflora remain scarce, especially in developing regions with inadequate waste management systems (Longe and Enekwechi, 2007). Most research focuses on either chemical contaminants or microbial populations in isolation, overlooking their synergistic interactions (Rejsek *et al*., 2012). Moreover, seasonal variations, such as fluctuations in contamination levels and microbial activity between wet and dry seasons, are often ignored despite evidence of significant differences driven by moisture and temperature changes (Grisey *et al*., 2010). This gap underscores the need for comprehensive assessments to inform effective remediation strategies and mitigate the environmental and health risks posed by dumpsites.

Materials and Methods

Sample Collection

Soil samples were collected from the Ogbogoro Community Dumpsite and Rivers State University dumpsite all in Obio/Akpor Local Government Area, Rivers State, Nigeria. Two composite soil samples were obtained from the surface layer (0–15 cm depth) using a sterile soil auger to ensure representative sampling across the dumpsites. The samples were placed in clean, labeled polyethylene bags to prevent contamination and transported under controlled conditions to the laboratory. Each sample was subdivided, with one portion sent to Spring Research & Analytical Laboratory Nig. Ltd. for heavy metal analysis, while the other portion was delivered to the Department of Plant Science and Biotechnology, Rivers State University, for fungal isolation, identification, and characterization.

Heavy Metal Analysis

Heavy metal analysis was carried out using a Varian AA240 Atomic Absorption Spectrophotometer following the standard methods of the American Public Health Association (APHA, 1995). The analysis was based on the principle of atomic absorption spectrophotometry, in which samples aspirated into an oxidizing air–acetylene flame was atomized and exposed to element-specific radiation. The amount of radiation absorbed at the characteristic wavelength was directly proportional to the concentration of the metal in the sample. For sample digestion, five grams of dried soil sample were weighed into a digestion flask and treated with 20 mL of an acid mixture comprising concentrated nitric acid, perchloric acid, and sulfuric acid. The mixture was heated until a clear digest was obtained and subsequently diluted with distilled water to a final volume of 50 mL. The digested samples were aspirated into the atomic absorption spectrophotometer for metal determination.

Isolation of Fungal Organisms

Isolation of fungal organisms was carried out using a three-fold serial dilution technique (Wofu & Tariah, 2024). One gram of sample was transferred into a test tube containing 9 mL of sterile normal saline and serially diluted. Aliquots (0.1 mL) from the second and third dilutions were plated in triplicate onto Sabouraud Dextrose Agar supplemented with ampicillin to inhibit bacterial growth. The inoculated plates were incubated at ambient temperature (25 ± 3 °C) for five days and observed for up to seven days to ensure

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optimal fungal growth (Chuku, 2009). Pure cultures were obtained through repeated sub-culturing.

Identification of Fungal Organisms

Fungal isolates were identified using microscopic examination with the needle mount method (Cheesebrough, 2000). Spores were teased apart, stained with lactophenol cotton blue, and examined under low and high power objectives. Identification was based on colonial morphology, spore characteristics, mycelial structure, and other diagnostic features using standard taxonomic keys (Barnett & Hunter, 1998).

Determination of Percentage Incidence of Fungal Organisms

The percentage incidence of fungal organisms was determined following the method described by Chuku *et al*. (2019). The percentage incidence was calculated as the ratio of the total number of each fungal species (X) to the total number of all identified fungal organisms (Y) in a sample, multiplied by 100.

Results

A total of ten (10) heavy metals where analyzed from soil samples taken from Ogbogoro and Rivers State University dumpsites (Table 1). The soil at Rivers State University dumpsite showed higher concentrations of most-heavy metals compared to the Ogbogoro dumpsite. Cadmium, copper, zinc, chromium, nickel, arsenic, and iron are notably elevated at Rivers State University, with zinc showing the largest difference (about 2.8 times higher). In contrast, lead and mercury levels are higher at Ogbogoro, while selenium remains the same at both sites.

Among the fungal isolates, *Rhizopus sp*. dominated at Rivers State University with 90% incidence, accompanied by a low 10% presence of *Candida sp*. At Ogbogoro, *Rhizopus sp*. is still common (60%) but shares the community more evenly with *Aspergillus niger* (40%). The NDDC Hostel site therefore displayed stronger dominance by *Rhizopus sp*. and lower overall fungal diversity.

Table 1: Heavy Metal Composition (ppm) of Soil Samples

Parameters	Composition in Dumpsites	
	Ogbogoro	Rivers State University
Cadmium (Cd)	0.3260	0.9276
Copper (Cu)	0.3059	0.6735
Zinc (Zn)	3.2819	9.1770
Lead (Pb)	0.085	0.043
Chromium (Cr)	0.0094	0.061
Iron (Fe)	5.1892	5.8458
Nickel (Ni)	0.6566	0.9656
Arsenic (As)	0.010	0.023
Mercury (Hg)	0.043	0.014
Selenium (Se)	0.267	0.267

Table 2: Characterization of Fungal Isolates of Soil Samples

Isolate Code	Macroscopic Characterization	Microscopic Characterization	Probable Organism	Percentage Incidence (%)
O1	Rapid growth; carbon black to dark brown surface with a white to pale yellow reverse.	Septate hyphae; large, globose conidial heads; dark brown to black conidia.	*Aspergillus niger*	40

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O2	Rapid, "lid-lifter" growth; cottony white texture turning brownish-grey with age.	Non-septate; brown sporangiophores; globose sporangia with flattened bases.	*Rhizopus stolonifera*	60
R1	Small, circular, creamy to white colonies; smooth, convex, and opaque with a yeast-like odor.	Budding yeast cells (blastoconidia); spherical to oval; presence of pseudomycelium.	*Candida sp.*	10
R2	Rapid, "lid-lifter" growth; cottony white texture turning brownish-grey with age.	Non-septate (coenocytic) broad hyphae; brown sporangiophores; globose sporangia; grayish-black powdery spores.	*Rhizopus stolonifera*	90

KEY:
O= Ogbogoro Dumpsite
R = Rivers State University Dumpsite

Discussion

The study indicated that Rivers State University dumpsite was more heavily contaminated with the majority of the analyzed metals compared to Ogbogoro. Specifically, cadmium (0.92 ppm), copper (0.67 ppm), zinc (9.17 ppm), chromium (0.06 ppm), nickel (0.96 ppm), and arsenic (0.02 ppm) were all significantly higher at the university dumpsite. The most striking difference was observed in zinc levels, which were nearly three times higher at the University dumpsite. These findings aligned with research by Olayinka *et al*. (2017), who observed that urban dumpsites near residential and academic areas often accumulate higher levels of zinc and copper due to the disposal of electronic waste and household metallic scraps. Conversely, Ogbogoro dumpsite showed higher concentrations of lead (0.08 ppm) and mercury (0.04 ppm). The presence of these specific metals often suggested different waste streams, such as lead-acid batteries or industrial paints, which are common in more commercialized dumpsite areas (Adesina *et al*., 2015).

The microbial landscape was dominated by three key genera: *Rhizopus sp*., *Aspergillus niger*, and *Candida sp*. The University dumpsite exhibited lower overall diversity but a much stronger dominance of *Rhizopus sp*. (90%), whereas the Ogbogoro dumpsite showed a more balanced distribution between *Rhizopus* stolonifer (60%) and *Aspergillus niger* (40%). The prevalence of these fungi in heavy-metal-rich soils is not accidental. Many species of *Rhizopus* and *Aspergillus* are known for their bioremediation potential and resistance to toxic environments. According to Iram *et al*. (2009), *Aspergillus niger* and *Rhizopus* species possess a high capacity for biosorption, allowing them to survive in soils where metal concentrations might inhibit other microbes. This explains why *Rhizopus sp*. remained the dominant organism at the University dumpsite despite its elevated cadmium and zinc levels.

The coexistence of these fungi and heavy metals presents a dual health risk. In terms of human health, *Rhizopus sp*. and *Aspergillus niger* are primary agents of human disease. Rhizopus is the leading cause of mucormycosis, an aggressive infection in immunocompromised patients (Ribes *et al*., 2000), while *A. niger* is frequently implicated in pulmonary aspergillosis and otomycosis (Schuster *et al*., 2002). Furthermore, Candida sp. (found at the University dumpsite) is a well-known opportunistic human pathogen responsible for candidiasis (Pfaller & Diekema, 2007). In terms of agricultural impact, *Rhizopus sp*. is a documented cause of soft rot in fruits and vegetables (Bautista-Baños *et al*., 2014), and *Aspergillus niger* causes black mold in crops such as onions and grapes, often leading to post-harvest decay (Pawar *et al*., 2008).

Conclusion

The study demonstrated that informal dumpsites in Rivers State serve as hazardous reservoirs for heavy metals and pathogenic fungi. The Rivers State University site exhibited higher contamination levels for most metals, including zinc (9.17 ppm) and cadmium (0.92 ppm), likely

due to electronic and household waste. In contrast, the Ogbogoro site showed higher concentrations of lead and mercury, indicating commercial waste streams.

The microbial landscape was dominated by *Rhizopus sp.*, *Aspergillus niger*, and *Candida sp.*, with *Rhizopus sp.* showing a 90% dominance at the university site. This prevalence highlights the high metal tolerance and bioremediation potential of these fungi in toxic environments. However, their presence poses a dual risk: they are agents of human diseases like mucormycosis and aspergillosis, and they cause agricultural damage such as soft rot and black mold. These findings underscore the urgent need for improved waste management and soil remediation to protect public health.

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