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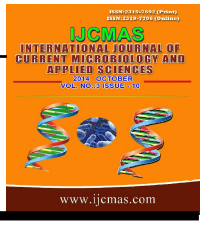

Original Research Article

Bioaccumulation of Heavy metals and pollutants by edible mushroom collected from Iselu market Benin-city

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A B S T R A C T

The bioaccumulation of heavy metals and pollutants by edible mushroom were investigated. The results from this study showed the concentrations of seven heavy metals which include Mercury(Hg), Iron (Fe), Zinc (Zn), Lead (Pb), Copper (Cu), Nickel (Ni) and Cadmium (Cd) in four edible mushrooms which include *Pleurotus squarrosullus, Volvariella volvacea, Schizophyllum commune and Auricularia auricular* sold in Benin City. There was a variation in the composition and concentration of the heavy metals in the different edible mushroom samples analysed. The heavy metal concentration ranged from 2.50 to 5.75 mg/kg for Ni, 2.25-4.88 mg/kg for Cd, 1.55-1.86 mg/kg for Cu, 1.25-1.88 mg/kg for Pb, 6.46-27.33 mg/kg for Zinc and 8.25-58.25 mg/kg for Fe. The results from this investigation showed that edible mushroom can serve as a bioremediation agent because of its ability to bio accumulates substances such as heavy metals, thereby removing them or reducing their concentration which may be harmful or hazardous from the polluted soil. This investigation also revealed the need for public awareness on edible mushrooms and their bioaccumulation ability especially in areas with frequent pollution like crude oil pollution in the Niger Delta area of Nigeria.

Keywords

Bio-accumulation, edible mushrrom, heavy metals

Introduction

In many countries of the world including Nigeria, edible mushrooms have been priced as delicacies for several years. Apart from their medicinal values, they constitute an important food source in the world. Mushrooms have been reported to be rich in protein, glycogen, vitamins, crude fibres and essential mineral compounds (Stamets, 1993; Jonathan, 2002). In fact, Bano (1976) reported the rich nutrient contents of mushrooms compared to those of meat and vegetables. Mushrooms such as *Flammulina velutipes Lentinus edodes, Agaricus bisporus, Pleurotus oestratus, Volvariella volvacea and Agaricus campestris* among others, have been cultivated for food in

several countries of the world especially in America, Europe and Asia. Extensive information is available on the metal content in many mushroom species. Literature data for 25 species, commonly consumed from unpolluted areas in Central Europe, were tabulated in our previous review (Kala and Svoboda, 2000).

However, a plausible assessment of the health risk from mushroom consumption has been difficult, due to very limited knowledge on the chemical form of the metals and their bioavailability in man. Some countries have established statutory limits for the metals in edible mushrooms. Mushroom grows, breaks down and absorbs or mineralizes environmental pollutants into non-toxic form (Hamman, 2004). The presence of heavy metals and other harmful contaminants, which mushroom attacks and digests led to increase in mushroom as opposed to inhibition of mushroom and subsequent removal of toxic metal in the environment by Shiitake mushroom (Hitivani and Mecs, 2003). The scavenging of metals from polluted sites by mushrooms are due to remediation and purifying abilities of mushrooms. Emuh (2009) reported that mushroom grows in the presence of heavy metals, secretes enzymes and detoxify such contaminants.

Stamets (2005) reported that mushroom channels heavy metals from land to fruity bodies for removal from the soil/ environment. This is first by denaturing the toxins and finally absorbing such heavy metals. Mushroom are hyper accumulators of heavy metals and radioactive metals that are toxic to consume and are thus eliminated from the environment. These are bio concentrated in solid forms in the mushroom (Wasser et al., 2003; Sasek, 2003). Similarly, Arica et al., (2003) reported, the use of Turkey tail mushroom and Phoenix oyster mushroom mycelia to eliminate 97% mercury ion from water. Mushroom is a fungus, which feeds by secreting enzymes and digests food externally and absorb the nutrients in net like chain called hypha. The net like chain (hypha) is exposed to stimuli in their ecological niche and act as a conscious intellect and respond to stimuli. Dense and regular branching of hypha endows fungi with potentials to pervade any substrate thoroughly (Hudson, 1986). The higher the mycelium thickness, the higher the rate of mechanical penetration and breaking down of substrate. This culminates at the higher the rate of digestion of substrate through the secretion of extra- cellular enzymes. This shows the potentials of bioremediation capabilities of mushroom (Bouchez et al., 1996; Juhaz and Naidu, 2002). This hypha/mycelium penetrates contaminated soils, thus placing a mat on them; it is the process of breaking down and adsorption of toxic products or pollutants. Generally the bonds in hydrocarbon and petroleum products such as PMS and AGO are similar to bonds that hold the plant materials together.

The enzymes produced by mushroom which are lignin peroxidase, manganese peroxidase and laccase penetrate, break and digest or mineralizes these hydrocarbon, petroleum products and pesticides to primary non-solid products and are liberated in the forms of water and carbon (iv) oxide (Schliphake et al., 2003). These enzymes act singly or collectively in aiding mycelium to break down natural or human made resistant materials (Stamets, 2005). Similarly, Hitivani and Mecs (2003), reported that the mycelium of Shiitake mushroom exposed to heavy metals of cadmium, copper, lead, mercury and zinc increased the production of enzymes laccase, decolorized them and subsequently absorbed the heavy metals.

Materials and Methods

The sporocarps of four healthy edible mushroom species namely *A. auricula, P. squarrusolus, S. commune and V. volvacea* were purchased from retail markets (Ekiuwa, New benin, Oliha, Santana and Oba market) in Benin City. Samples were purchased during the rainy season between the months of August to December. The mushroom samples were kept in clean labelled collection bags and taken to the laboratory for analysis. The mushroom samples were thoroughly cleaned, dried on blotting paper, cut into pieces and oven dried at 105°C for 24hrs. Dried samples were homogenized using a blender into fine powder and stored in pre-cleaned polyethylene bottles, prior to analyses. The samples were thereafter analysed for heavy metals. 1g of each mushroom sample was placed in a porcelain crucible and ashed at 480°C in a muffle furnace for 18-24 hours; then the ash was dissolved in 2ml concentrated nitric acid (HNO3), heated again at 480°C for 4hrs and dissolved in 1mL concentrated sulphuric acid (H2SO4), 1ml HNO3 and 1ml hydrogen peroxide (H2O2) and then diluted with distilled water up to a volume of 25 ml. A blank digest was carried out in the same way. This solution was used for heavy metal determination using an atomic absorption spectrophotometer. The concentrations in mg/L of metals were determined in all the samples with the Atomic Absorption Spectrophotometer. The flame used for the analysis was air-acetylene mixture. Standard solutions ranging from 0.2 to 5.0mg/l were prepared for calibration curves of the various metals. A blank analysis was performed with distilled water treated to the sample treatment. The following concentrations of metal solutions were prepared to determine the baseline absorbance value at 4.0 Pb: 9.4mg/L, Zn: 1.2mg/L, Cu: 3.7mg, Cd: 3.0mg/L, Fe: 5.5 mg/l. The metal concentrations were determined one after the other using their respective hollow cathode lamps (HCL) and calibration curves. Air-acetylene wave flame was used for all the analysis. The respective wavelengths employed for the metal determinations were Fe at 248.7nm, Pb at 217.0nm, Zn at 213.9nm, Cu at 324.8 and Cd at 228.8nm

Results and Discussion

The results from this study showed the concentrations of seven heavy metals which include Hg, Fe, Zn, Pb, Cu, Ni and Cd in three edible mushrooms (*P.squarrosollus, V.volvacea, S.commune and A.auricular*) sold in Benin City. There were variation in the composition and concentration of the heavy metals in the different edible mushroom samples analysed. The heavy metal concentration ranged from 2.50 to 5.75 mg/kg for Ni, 2.25-4.88 mg/kg for Cd, 1.55-1.86 mg/kg for Cu, 1.25-1.88 mg/kg for Pb, 6.46-27.33 mg/kg for zinc, 8.25-58.25 mg/kg for Fe (Table 2). The heavy metal concentrations in the fruiting bodies of the edible mushroom analysed varied generally between species. This may be ascribed to differences in substrate composition, as determined by the ecosystem and great differences in uptake of individual metals by the mushroom species (Tyler, 1982; Michelot et al., 1998). Kalac and Svoboda (2000) reported that the age of the fungal fruiting body or its size is of less importance in the accumulation of heavy metals by mushrooms. However, there were variations in heavy metal accumulation and it could be ascribed to individual species potential and their ecosystem (Seeger,1982). Zinc was accumulated in high concentrations (27.33 mg/kg) by *V.volvacea*, while the least concentration of 6.46 mg/kg was found in S. commune.

Table.1 Edible mushrooms sold in selected Benin Markets

Scientific name	**Local name**	**Uses**	**Usual prices and season**	**Source**
Schizophyllum commune	Kpekperu	Soup thickener,dietarysuppliments	₦200 per kg.Rainy season	Grows from dead logs of rubber
Plerotussquarrosulus	Itun	Substitute for meat	₦50 per kg.Rainy season	Grows in felled mango log
Volvariellavolvacea	Itun	Substitute for meat	₦250 per kg..Rainy season	Grows from oilpalm
Auricularia auricular	Itun	Used as substute for meat,to prevent strokes and heart attack	₦150 per kg..Rainy season	Dead wood

Table.2 Heavy metal content of the edible mushroom samples

Parameter	Unit	A	B	C	D	WHO, 1995
Hg	Mg/kg	ND	ND	ND	ND	0.001
Fe	Mg/kg	58.25	8.25	11.00	8.25	10
Zn	Mg/kg	25.09	27.33	6.46	7.74	50
Pb	Mg/kg	1.25	1.25	1.56	1.88	0.2
Cu	Mg/kg	1.68	1.55	1.76	1.86	10
Cd	Mg/kg	3.37	4.88	2.25	3.38	0.05
Ni	Mg/kg	2.50	5.75	4.24	5.75	1.0

Key:
ND-No detection

A- *Pleurotussquarrosollus*
B- *Volvariellavolvacea*
C- *Schizophyllumcommun*
D- *Auriculariaauricula*

However, the zinc content is below permissible level of 50 mg/kg (WHO, 1995). Zinc is wide spread in living organisms due to its biological significance. The levels reported here are in agreement with values reported by Turkekul et al., (2004), Tuzen et al., (1998). The cadmium content ranged from 2.25 mg/kg in Schizophyllum commune to 4.88 mg/kg in V.volvacea. The levels of cadmium in edible mushrooms were higher than the WHO permissible limit (WHO, 1995). Cadmium contents of mushroom samples in the literature have been reported to be in the ranges: 0.81 7.50 mg/kg (Svoboda et al. 2000).The lead level ranged from 1.25 to 1.88 mg/kg for Pleurotus squarrosollus and Aricularia auricula. Lead contents of mushroom samples in the literature have been reported to be in the ranges: 0.75-7.77 mg/kg (Tüzen et al., 1998), 0.40 - 2.80 mg/kg (Svoboda et al., 2000), 1.43 - 4.17 mg/kg (Tüzen, 2003), 0.800 - 2.700 mg/kg (Türkekul et al., 2004), 0.82 -1.99 mg/kg (Soylak et al., 2005), and 0.9 - 2.6 mg/kg (Sesli et al., 2008), respectively. The lead results of all mushroom species were in agreement with those found in the literature.

Lead is similar to Cadmium that has no beneficial role in human metabolism, producing progressive toxicity. Lead can reach humans through air, water, and food. Lead accumulates in bones, and it can take in place of calcium. Lead creates health disorders such as sleeplessness, tiredness, hearing, and weight loss. The highest Fe concentration was found in pleurotus squarrosollus (58.25 mg/kg) and the least concentration (8.25mg/kg) in Aricularia auricula and V.volvacea. Latiff et al., (1996) reported Fe concentration range of 100 1216 g/g in mushroom. Similarly, Turkekul et al., (2004) reported Fe content of 568 3562 mg/kg in mushroom samples from Tokat, Turkey. Variations in Fe content may be attributed to the different mushroom species, uptake levels and the levels accumulated by the substrate from which the mushrooms were harvested. Minimum and maximum concentration of Cu accumulated by the mushrooms was 1.55 and 1.86 mg/kg respectively, with Aricularia auricular accumulating the highest Cu concentration of 1.86 mg/ kg. Isildak et al. (2004) reported a Cu concentration of 107 ± 8.5 g/g in wild growing Agaricus biosporus from the middle black sea region of Turkey. However, the Cu range obtained in this study is in agreement with reported range of 10 70 g/g (Agrahar-Murugkar and Subbulakshmi, 2005).

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