Original Research Article

Heavy Metals Contamination of Rice and Soil samples in Nnatu St AzuuiyiUdene, Abakiliki, Ebonyi State, Nigeria

ABSTRACT

Aim: Assess the levels of heavy metals: arsenic (As), cadmium (Cd), copper (Cu), lead (Pb), and zinc (Zn) in three different sites of the major rice growing soils and determine its accumulation in the rice grown on the same site in Nnatu St Azuuiyi Udene, Abakiliki, Ebonyi State.
Study Design: Soil and rice samples were collected from three different farm locations into properly labeled plastic bags respectively using a 9mm soil Augerin Nnatu St AzuuiyiUdene, Abakiliki, Ebonyi State
Methodology: The collected samples were air-dried, ground, sieved and acid digested. The heavy metals in the samples were measured by atomic absorption spectrophotometer PG instrument AA500 FPC model.
Results: The Mean ± SD (mg/kg) of heavy metals in rice were; As: 0.0013, Cd: 0.001, Pb: 0.002, Zn: 0.3620. Cu: 0.001 in site 1 whereas in Site 2; As:0.0013, Cd:0.001, Pb:0.002, Zn:0.5040, Cu:0. 001. In site 3, the metals in rice were; As: 0.0013, Cd: 0.001, Pb: 0.002, Zn: 0.1950, and Cu: 0.040 respectively. The levels in the soil samples in site 1 were; As: 0.0013, Cd: 0.001, Pb: 0.002, Zn: 1.932. Cu: 0. 0267. In site 2, As: 0.0013, Cd: 0.001, Pb: 0.002, Zn: 1.597, Cu: 0.1550 and in site 3. As: 0.0013, Cd: 0.001, Pb: 0.002, Zn: 3.383, Cu: 0.0730 respectively. The mean values for arsenic, cadmium and lead in the soil and rice samples, respectively, were not significantly different ($P > 0.05$) in the three different sites whereas, for copper and zinc, the mean values were significantly different ($P < 0.05$) from each other at the different spots with an elevated concentration of copper and zinc in the soil samples than in the rice samples. However, these values were far lower than the values indicated by the World Health Organization as hazardous,
Conclusion: The rice samples grown in Nnatu St AzuuiyiUdene, Abakiliki is safe for consumption.

Key Words: Heavy metals, Soil. Rice, Abakiliki, Ebonyi State.

1. INTRODUCTION

Heavy metal is any metallic element that has a relatively high density and is toxic or poisonous even at low concentrations [1].Metals with relatively high densities, atomic weights, or atomic numbers are classified as heavy metals [2] when compared to water [3]. Heavy metal refers to metals and semimetals that may be hazardous to humans or the environment [4]. It is found in the earth's crust naturally, but found its way into soil and water resources due to human and geogenic activities [5].

Rice is considered an important agricultural crop in Ebonyi State, Nigeria. The rice can be contaminated by heavy metals when grown in contaminated paddy soil [6]. The consumption of heavy metal-contaminated rice has detrimental effects on human health [7].The risk of exposure to humans and the associated health effects depends on the extent of contamination in rice and the quantity of rice consumed by an individual [8].

Heavy metals from the contaminated paddy soil may be taken up by the rice plant and further bioaccumulate them in the grains [9, 10] although there are factors such as the high pH of the soil that may hinder its availability of in the soil to be absorbed by plant roots [11]. According to [10], the concentration of cadmium in rice was influenced by the level of cadmium in paddy soil. However, soil heavy metal contamination has become a severe problem in many different parts of the world [12].AcharaNuhu and Enyigba in Ebonyi North, Ndufu-Alike and Ohankwu in Ebonyi Central while Ishiagu and Afikpo in Ebonyi South, Nigeria are well known for their long history of mining activities. There is, therefore, an urgent need to review the occurrence of heavy metals in rice and soil within the study area.

The atmosphere can be loaded with heavy metals through the breakdown of applied waste materials, which gradually release the heavy metals in them. However, lead accumulation on Nigerian soil is a result of long-term cultivation [13]. While a significant increase in the concentration of zinc in pasture fields is due to the application of manure [14]. The soil is the pre-eminent source of most biologically active trace elements such as Lead, Zinc, Cadmium, Arsenic, Nickel and Copper that reach man through plants and animals. It is generally known that rivers and related urban environments have been severely contaminated by heavy metals such as Cd, As, Pb, Cu and Zn) as a result of Pb/Zn historic and modern mining operations and industrial activities [15].

Heavy metals in soils are, to some extent, essential for plant and crop growth; others are highly toxic to humans. Soils with toxic heavy metal contamination led to plant absorption and accumulation of higher concentrations of heavy metals, which ultimately pass into the human body via the food chain [16]. The main exposure pathway of heavy metal risk is through food consumption, exceeding those through air inhalation and skin absorption. During a population health risk assessment of the consumption of heavy-metal-contaminated food crops in Imo state it was reported that Levels of lead, cadmium, and nickel in food crops were highest in *Oryza sativa (Rice), Glycine max*, and *Pentabactamicrofila* respectively [17].

Heavy metal toxicity has proven to be a major source of concern as it poses several health risks to humans. However, heavy metals have a biological role to play in the human body, but on the contrary, their toxicity may lead to the malfunctioning of some physiological mechanisms in humans. [18 and 19] believed that the two major sources of heavy metals in the soil are usually natural and anthropogenic sources. The natural source of heavy metals which is the soil is associated with geochemical processes coupled with soil parental material, while the anthropogenic sources are attributed to the combustion of fossil fuels, agricultural activities such as pesticide and herbicide applications, contaminated irrigation water, municipal waste used for fertilization [20] mineral fertilizer containing traces of heavy metals [21]and mining activities. Others are direct waste disposal on farmland, use of lead as antiknock in petrol, traffic emissions, cigarette smoking, metallurgy and smelting, aerosol cans, sewage discharge, and building materials, such as paints [22]. It is observed that anthropogenic activities are reported to be the major sources of heavy metals in soil when compared to the geogenic process [23]. Elevated concentrations of cadmium, arsenic and lead in the environment are a particular issue in mining regions because of their documented deleterious human health effects [24 and 25].

Among the state's agricultural potential, the cultivation of the famous Abakaliki rice has helped it become a commercial beehive. Because of the salt of the Abakaliki rice mill's soil, Abakaliki rice is gifted with a variety of nutritious qualities. Those who are familiar with its nutritional values rate it much higher. Aside from its nutritional advantages, Abakaliki rice is naturally salty and has a pleasant flavour. The exquisite taste of Abakaliki rice has earned it a reputation [26].

2. MATERIALS AND METHODS

2.1: Study Area

This research was conducted in Nnatu St Azuuiyi Udene, Abakaliki in Ebonyi State, one of the states in the Southeast. The State lies approximately within latitudes 5˚40' and 6˚45' north of the Equator and longitudes 7˚30' and 8˚30' east of the Greenwich meridian. The state experiences a bimodal rainfall pattern with the first peak in July and the second in September, and annual rainfall is usually between 1613.8 mm to 2136.27 mm [27]. The dry season begins in November, when a dry continental north-eastern wind sweeps from the Mediterranean Sea, across the Sahara and Samarian deserts, and down to Nigeria's southern coast. Ebonyi is separated into two sections based on vegetation: the southern forested Ebonyi and the derived savanna of Ebonyi North. However, when one travels from the forested south to the northern part of Ebonyi State, the foliage becomes heavier. As a result, the state has been separated into three zones for soil sampling purposes: Ebonyi South, Ebonyi Central, and Ebonyi North. The state capital is Abakaliki, and the state is notable for its salt resources, as well as zinc, lead, limestone, granite, refractory clay, and gypsum, among other minerals [27].

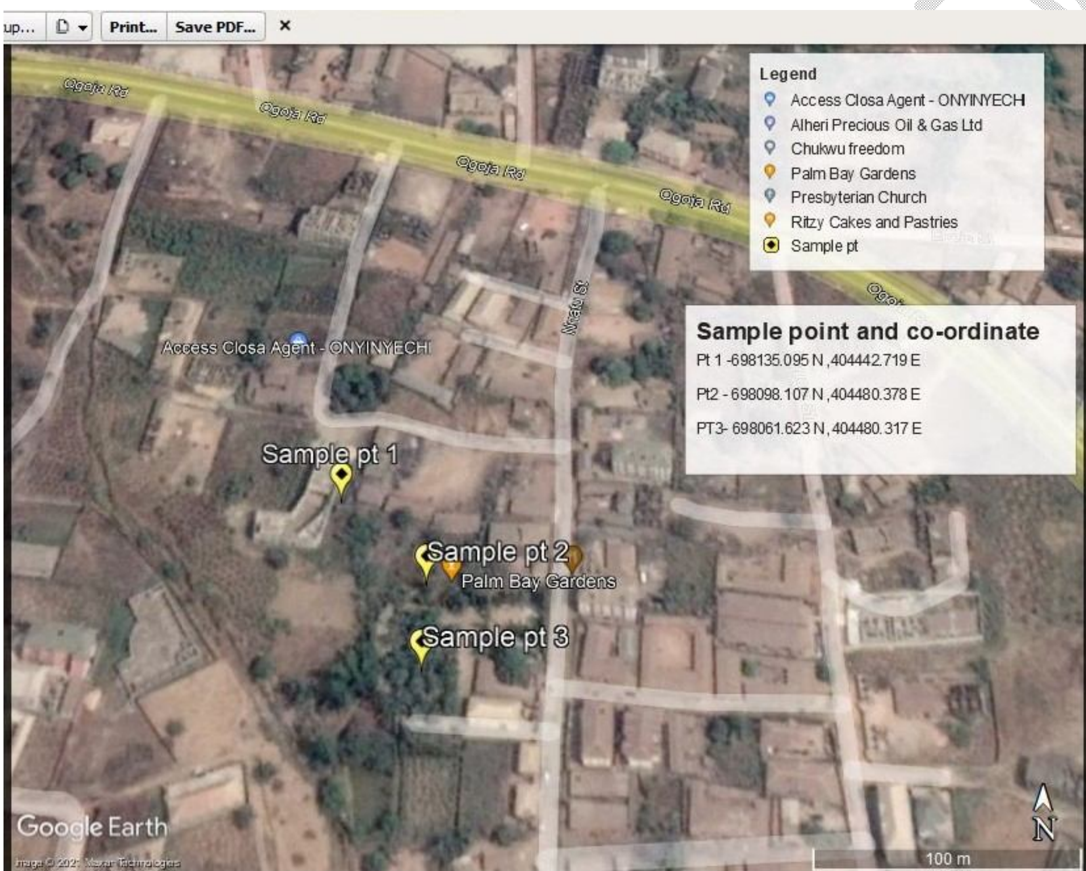

Figure 1: Map Location of Sample Collection Site (Google Map)

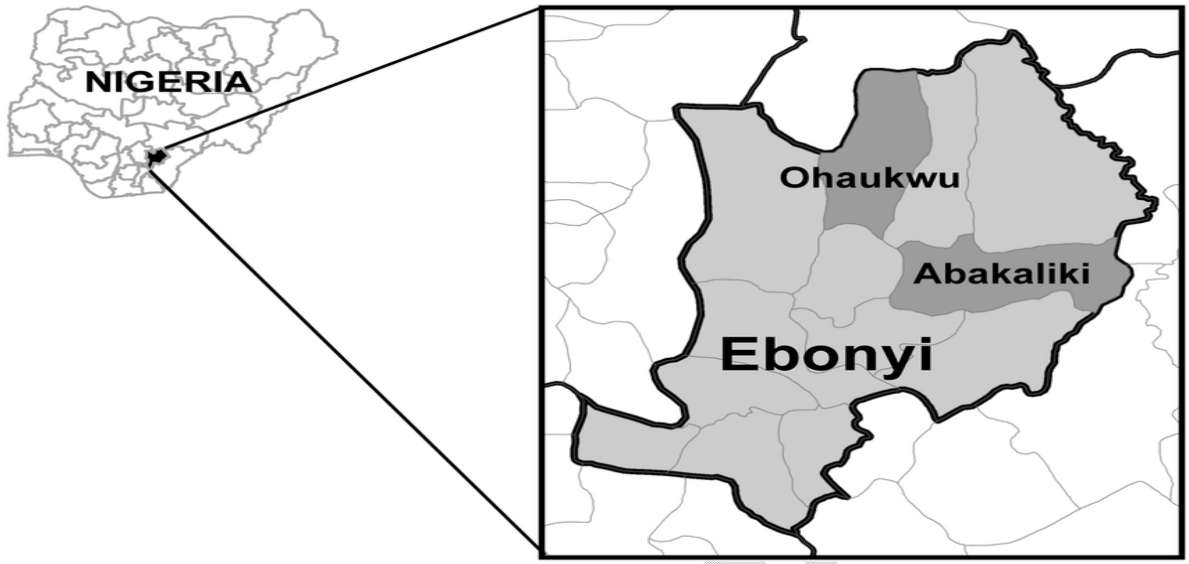

Figure 2: Geographical Location of Abakaliki in Ebonyi State (Google Map)

The Abakaliki soil is a Savannah variety that is ideal for rice cultivation [28]. Rice may be cultivated profitably in Abakaliki without artificial irrigation because the annual rainfall is over 1500 mm, the ground is pretty level, and the soil is clayed.

Ebonyi people are primarily agrarians and a leading producer of rice, yam, potatoes, maize, beans, and cassava, and have a notable basket market in Nigeria. In addition, Ebonyi has several solid mineral resources, including lead, crude oil, and natural gas, but few large-scale commercial mining mines, thus, making them also engage in mining activities.

2.2:Sample Collection

Soil and rice samples were collected at Nnatu St Azuuiyi Udene, Abakaliki in Ebonyi State. The samples were collected randomly at three different farming locations. In each spot where the rice sample was taken, four soil augur borings were buckled together to form a representative soil for the different locations into sterile sample plastic bags using a 9mm soil Auger and were labeled, spot 1, spot 2, and spot 3 respectively. This was done to consider the depth of the roots of the rice plant, where it absorbs its nutrients. These samples were taken to the laboratory for pretreatment and analysis.

2.3: Determination of Heavy Metals in Soil and Rice Grain using EPA 3050B Method

Accurately weighed One gram of dried soil sample was measured into porcelain, and 10 mL of a well-mixed solution of perchloric acid, Nitric acid, and sulphuric acid (1:2:2) was poured into the measured soil, the mixture was then heated using a heating mantle (Berghof Heater, Germany) for 20 minutes, and was then allowed to cool. After cooling, 20 mL of deionized water was added to the cooled mixture. The solution mixture was then filtered through Whatman Grade 1 filter paper into a 100 mL standard flask. The 100 mL volume of the standard flask was completed with deionized water. The Filtrate in the 100 mL standard flask was then transferred into a clean plastic container and aspirated into an Atomic Absorption spectrophotometer PG instrument AA500 FPC model where the amount of each metal was read out.A similar method was used for the rice grains after grinding them into powder form.

3. RESULTS AND DISCUSSION

Table 1 shows the heavy metal concentration in rice at the 3 different spots. The concentration of Copper and zinc when compared among themselves from the three different spots were significantly different ($p<0.05$) while the concentration of arsenic,cadmium and lead were statistically non significant when the means were compared.

Table 1: Heavy Metal Concentration in Rice Collected at the 3 different Spots (mg/kg) in Nnatu St Azuuiyi Udene, Abakiliki

Arsenic	Cadmium	Lead	Copper	Zinc
10.0013±0.0006	0.001±0.000	0.002±0.000	0.001±0.000^{a}	0.3620±0.001^{a}
20.0013±0.0006	0.001±0.000	0.002±0.000	0.001±0.000^{a}	0.5040±0.001^{b}
30.0013±0.0006	0.001±0.000	0.002±0.000	0.040±0.010^{bc}	0.1950±0.001^{c}
F = 1.000	-	-	F = 45.63	F = 71767
P > 0.422	-	-	P < 0.000	P < 0.000
NS	NS	NS	S	S

Means with different Superscripts are Significantly different (Turkey HSD, $p < 0.05$),n-3

Table 2: Heavy Metal Concentration in Soil Samples at 3 different spots in Nnatu St Azuuiyi Udene, Abakiliki

Arsenic (mg/kg)	Cadmium(mg/kg)	Lead (mg/kg)	Copper	Zinc
0.0013±0.0006	0.001±0.000	0.002±0.000	0.0267±0.0153^{a}	1.932±0.001^{a}
0.001±0.000	0.001±0.000	0.002±0.000	0.1550±0.001^{b}	1.59.7±0.001^{b}
0.0013±0.006	0.001±0.000	0.002±0.000	0.0730±0.001^{c}	3.383±0.001^{c}
F = 1.000	-	-	F = 161.5	F = 2703711

P = 0.422	-	-	P = <0.000	P = <0.000
Remark	NS	NS	S	S

Means with different Superscripts are Significantly different (Turkey HSD, $p < 0.05$),n-3

Table 3: Comparison between Heavy Metals Concentration of Rice to Soil Samples in the 3 different Spots in Nnatu St Azuuiyi Udene, Abakiliki

Arsenic	Rice	Soil	T value	P value	Remark
Spot 1	0.0013±0.0006	0.0013±0.0006	0.000	>0.999	NS
Spot 2	0.0013±0.0006	0.001±0.000	0.000	>0.999	NS
Spot 3	0.0013±0.0006	0.0013±0.0006	0.000	>0.999	NS

Legend: NS = Not Significant

Copper	**Rice**	**Soil**	**T value**	**P value**	**Remark**
Spot 1	0.001±0.000	0.0013±0.0153	2.910	0.044	S
Spot 2	0.001±0.000	0.155±0.001	266.7	<0.000	S
Spot 3	0.040±0.010	0.073±0.001	5.687	0.005	S

Legend: S = Significant

Zinc	**Rice**	**Soil**	**T value**	**P value**	**Remark**
Spot 1	0.3620±0.001	1.932±0.001	1923	<0.000	S
Spot 2	0.5040±0.001	1.597±0.001	1339	<0.000	S
Spot 3	0.01950±0.01	3.383±0.001	3904	<0.000	S

Legend: S = Significant

Heavy metal pollution of soil is a major global environmental issue [29] resulting from increased production and emissions from industrial development. Some metals, such as Cd, Cu, Zn, and As, are necessary or beneficial micronutrients for microbes, plants, and animals, but in high quantities, all of these metals are poisonous and constitute harm to the environment. Depending on their relative quantities, heavy metals present in various meals might pose substantial health risks.

The results gotten from this study showed that concentrations of copper and zinc significantly differ at ($P < 0.05$) in the three farming locations. While the concentrations of arsenic, cadmium, and lead in the rice and soil samples were low and do not differ significantly in the three farming spots. This does not agree with the work done by [30] where the concentration of cadmium and lead were increased above the permissible limit amidst other metals present in the rice types available in Shiraz market. Zinc has the highest concentration followed by copper as shown in Table 1 and Table 2 respectively. The concentration of zinc in the soil is highest in spot 3 followed by spot 1 and least in spot 2. While the concentration of copper in the soil was highest in Spot 2, followed by Spot 3 and least in Spot 1. Heavy metal variation in rice and soil samples was significantly different ($P < 0 .05$) in Cu and Zn, however, no such significance were not observed in Arsenic ($P > 0.05$) as shown in Table 3. Furthermore, the concentrations of zinc and copper were higher in these farming spots than lead, cadmium and arsenic which could be attributed to the higher fertilizer usage, welding activity and automobile servicing carried out around these farming locations. This idea was in total agreement with the views of Ihedioha[31].

3.1: Cadmium

The estimated concentrations of Cd in the soil (0.001 ± 0.000) mg/kg and rice (0.001 ± 0.000) mg/kg samples were below the WHO permissible limit. With this observation, there might be no fear of acute toxicity when rice is consumed since the concentration is below the WHO permissible limits of 3.0 mg/kg in food and soil.[32]. However, in green pea vegetables sold in markets around Abuja vicinity,cadmium levels were seen to be high in concentration [33].

3.2: Copper

Copper concentration estimation in soil (0.027 ± 0.015 to 0.155 ± 0.001) and rice (0.001 ± 0.000 to 0.040 ± 0.010) in this study is below the maximum permissible concentration of 73.0 mg/kg set by WHO [32] in food and 100mg/Kg in soil. No threat of acute toxicity is envisaged if this rice is consumed.

3.3: Lead

The permissible limit of Pb in the soil recommended by WHO [34] is 100 mg/kg. In the soil samples, the concentration of lead (0.002 ± 0.000) mg/kg was recorded below the permissible limit. Also, the concentration in rice is found to be lower than the maximum permissible concentration of 0.30 mg/kg set by WHO [34] posing no significant health risk.

3.4: Zinc

Zinc is one of the important trace elements that play a vital role in the physiological and metabolic processes of many organisms. Nevertheless, higher concentrations of zinc can be toxic to man. The concentration of Zn in the soil samples ranged between (1.932 ± 0.001 to 3.383 ± 0.001) mg/kg (Table 3). The permissible limit of zinc in soil according to WHO standard is 300 mg/kg. In all the collected soil samples, the concentration of Zn was recorded below the permissible limit. For the rice samples, the concentration of Zn ranged between (0.1950 ± 0.01 to 0.5040 ± 0.001) mg/kg (Table 3). This may not pose any health threat.

Other studies done by [31] reported Cadmium in soil (1.036 ± 1.86) and rice (0.024 ± 0.07) to be significantly high in Abakiliki. It was recorded that lead, cadmium, and nickel were high in *Oryza sativa* by [17] in Ohaji and Umuagwo and Owerri in South Eastern Nigeria. In 2016, Ihedioha *et al* [31]stated in their study 'An "ex-situ" microbial process for the removal of heavy metals from polluted soil: A case study of Ada rice field, Adani, Enugu State, Nigeria' that heavy metals were far above the WHO maximum permissible limits in rice samples. In a similar study conducted by Mundi *et al* [35], in Nasarawa state, the result of the study indicated that the rice samples were not polluted by Cd, Cu, Cr, Ni, Pb and Zn. This is to say that all soils differ in their compositions, and texture, making soils different for accumulation of heavy metals, thereby and affecting plants' absorption and accumulation of these heavy metals as reported in different locations. Different heavy metal pollution activities in different geographical locations may pollute the soils differently. Soil contamination by heavy metal depends on the type of heavy metal activities going on in those locations. If crude oil pollution is a continuous activity in a given area, the Lead concentrations of that soil will be elevated. Other human activities that may raise heavy metal concentrations are metal dumping, improper disposal of industrial waste, automobile services, and uncontrolled application of insecticides, pesticides and fertilizers.

4. CONCLUSION

The concentrations of zinc and copper were more in the soil samples of these farming area than lead, cadmium and arsenic. Despite the significant difference in the zinc and copper concentrations across the three farming spots, the heavy metals concentrations did not exceed the World Health Organization (WHO) permissible limit of these heavy metals in both the soil and rice. The rice is, therefore, fit for human consumption without any fear of generating issues of public health interest.

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