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Heavy Metal Content of *Pteridium aquilinum* from Njere River Bank in Umuakam Okaiuga Nkwoegwu, Umuahia North L.G.A of Abia State

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Authors' contributions

This work was carried out in collaboration between all authors. Authors IAO and DA designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors IAO and UM managed the analyses of the study. Author DA managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To assess the heavy metal content of *P. aquilinum* from Njere river bank in Umuakam Okaiuga Nkwoegwu, Umuahia North L.G.A of Abia state.
Study Design: Plant samples were collected from upstream, midstream and downstream locations of the river bank.
Place and Duration of Study: Department of Chemistry, Michael Okpara University of Agriculture, Umudike between June 2009 and December 2009.
Methodology: Composite samples were made from the samples from the various locations. They were air-dried, milled, sieved and used for Atomic absorption Spectroscopy.
Results: Total concentrations of Ni, Cd, Fe, Zn and Pb, soluble metal concentrations of Ni, Cd and Zn and exchangeable metal concentrations of Ni, Cd, Fe, Zn, and Pb were below the W.H.O standard for all the plant samples.
Conclusion: The plant from Njere river bank is relatively safe for animal and human consumption.

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Keywords: Heavy metals; plants; food chain; toxicity; bioavailability; accumulation.

1. INTRODUCTION

Plants are a basic source of food needed for various biological processes in living organisms [1,2,3]. Plants growing in heavy metal environments undergo changes in their physiological and biochemical processes that affect their growth [4] and ultimately lead to food insecurity. Heavy metals have been found in different kinds of plants and food crops including: fruits such as apples, pineapples, oranges, and banana) [5]; vegetables such as fluted pumpkin [6] and even teas [7].

Heavy metals are elements that possess high relative atomic weight with atomic number that is greater than 20 and possess attributes of metals [8,3]. They are highly recalcitrant [9], toxic and occurs naturally in the earth. Plants are able to take up heavy metals that are easily solubilized in soil solution and root exudates [10]. Heavy metals cause oxidative stress that alters cell function and enzyme activities [11]. Kibra, [12] reported that rice plants cultivated on Hg polluted soils showed decline in height. Ahmad et al. [13] reported that under Cd toxicity, the root and shoots of wheat plants declined in their growth. Another study by Ghani [14] showed a decline in the growth and protein content of maize plant grown under a combined heavy metal toxicity of Cd, Cr, Co, Mn, Hg and Pb. In a review article, Peralta-Videa et al. [15] documented the processes of plant uptake and bioaccumulation of heavy metals, including their negative effects on man. Plants source is one of the known ways by which heavy metals are introduced into the food chain. This pose a serious challenge as humans and other lower animals may be potentially at risk as they consume plants contaminated by heavy metals.

The Njere river has remained the main source of water for the people of Umuakam Okaiuga, Nkwoegwu L.G.A, Abia state for decades now. It is located on Longitude (N $05^0$34'24.3'') and latitude E $007^0$27'52.0''. Aside its use for domestic activities, its bank is used for all season agricultural activities including vegetable farming. This research was conducted to assess the heavy metal content of *P. aquilinum* growing around the Njere river. The result of this experiment will help offer useful advice to the rural dwellers on possible mechanisms to employ to ensure production of healthy foods and crop yield in the area.

2. MATERIALS AND METHODS

2.1 Sample Collection and Preparation

The plant sample were collected by forming composites of plants collected from the bank of the Njere river based on the upstream, midstream and downstream locations. The samples were labeled accordingly in clean polythene bags. The samples were dried at room temperature, milled and sieved using 0.01µm sieve. The ground plant sample was stored in clean polythene bags and well labeled. The samples were collected in June, 2009.

2.2 Determination of Total Metal Concentration

From the ground plant sample, 1 g was weighed out into a conical flask. It was digested by adding 15 ml of HNO_3, 10 ml of HCl and heated at 100^oC in a fume cupboard for 30 minutes. Thereafter, 25 ml of deionized water was added and the heating continued for 90 minutes. It was allowed to cool, filtered with whatmann no 1 filter paper into a 50 ml volumetric flask and made up to mark with deionized water. Ten ml of the filtered solution was measured into clean sample bottles for determination of Pb, Zn, Fe, Cd and Ni using Atomic Absorption Spectrophotometer (AAS 240 FS Agilent Technologies).

2.3 Determination of Water Soluble Metal Concentration

One gram of plant sample was weighed into a flask to which was added 20 ml of deionized water and allowed to stand for 30 minutes. It was filtered into 50 ml volumetric flask using whatmann no 1 filter paper and made up to mark with deionized water. A quantity of 10 ml of the filtrate was measured out into clean sample bottle for analysis with AAS.

2.4 Determination of Exchangeable Metal Fraction

One gram of plant sample and twenty ml of 1M $MgCl_2$ were poured into a clean conical flask. The pH of the solution was adjusted using potassium phosphate buffer, boiled for 60 minutes at ambient temperature. It was allowed to cool, filtered into a volumetric flask and made up to mark with deionized water. Ten ml of the filtrate was measured out into clean sample bottles for exchangeable metal fraction determination using AAS.

2.5 Statistical Analysis

Excel software 2007 was used to compute the means of the data obtained. The results were presented as means of duplicate determinations.

3. RESULTS AND DISCUSSION

The result of the total metal ions in *P. aquilinum* from around Njere river is depicted on Table 1. The plant from the upstream location had a maximum Ni concentration of 0.242 ppm while the midstream samples had the lowest value of 0.108 ppm. The maximum concentration of Cd (0.137 ppm) was observed in the plants from the upstream location while the minimum value (0.025 ppm) was in the midstream sample. Fe concentration was highest in the downstream sample (1.881 ppm) and lowest in the midstream sample (1.338 ppm). Zn concentration was highest in the upstream sample (1.265 ppm) and lowest in the midstream (0.502 ppm). The plant samples from the upstream location had the highest concentration of 0.164 ppm while the midstream had the lowest value of 0.021 ppm. The Ni, Cd, Fe, Zn and Pb concentration in the plant from the upstream, midstream and downstream were all below the W.H.O standard for each metal.

Table 2 shows the result of water soluble metal ions in *P. aquilinum* from around Njere river. The soluble Ni concentration was highest in the midstream (0.187 ppm) sample while the lowest was the upstream (0.021 ppm) samples. Soluble Cd ion was highest in the midstream (0.045 ppm) and lowest in the downstream (0.002 ppm) sample. Ni, Cd and Zn, concentrations were below the W.H.O standard. Fe and Pb were only detected in the plant samples from upstream and downstream locations and at concentrations below the W.H.O standard. The low level of metal ions correlates the low level of soluble metal ions in the plants.

Table 3 shows the result of the Exchangeable metal ions in *P. aquilinum* from around Njere river. Exchangeable Ni ion was highest in the midstream (0.213 ppm) and lowest in the downstream (0.137 ppm) samples. Exchangeable Cd ion was highest in the upstream (0.118 ppm) and lowest in the downstream (0.075 ppm) samples. Exchangeable Fe ion concentration was highest in the upstream (0.135 ppm) and lowest in the downstream (0.109 ppm) sample. Plants from the upstream (0.203 ppm) location had the highest exchangeable Zn concentration while plants from the downstream (0.1 ppm) location had the lowest.. In all the plant samples from the different locations, the concentrations of Ni, Cd, Fe, Zn, and Pb were all below the W.H.O standards of 1-10 ppm, < 0.1 ppm, 250 ppm, 5-100 ppm and 6-9 ppm respectively.

The total heavy metal ion concentration is an indication of all the chemical forms present in a given sample. The result shows very low accumulation of total heavy metal in the plant from the study area (Table 1). This could be

Table 1. Total metal ions in *P. aquilinum* from around Njere river

Total of metal ion	Location	Mean conc of metal ion (ppm)	W.H.O standard (ppm)
Ni	Upstream	0.242	1-10
Ni	Midstream	0.108	1-10
Ni	Downstream	0.145	1-10
Cd	Upstream	0.137	<0.5
Cd	Midstream	0.025	<0.5
Cd	Downstream	0.1	<0.5
Fe	Upstream	1.881	250
Fe	Midstream	1.338	250
Fe	Downstream	3.349	250
Zn	Upstream	1.265	5-100
Zn	Midstream	0.502	5-100
Zn	Downstream	0.718	5-100
Pb	Upstream	0.164	6-9
Pb	Midstream	0.021	6-9
Pb	Downstream	0.162	6-9

Values are means of duplicate determinations

Table 2. Water soluble metal ions in *P. aquilinum* from around Njere river

Type of metal ion	Location	Mean conc of metal ion (ppm)	W.H.O standard (ppm)
Ni	Upstream	0.021	1-10
Ni	Midstream	0.187	1-10
Ni	Downstream	0.05	1-10
Cd	Upstream	0.008	<0.5
Cd	Midstream	0.045	<0.5
Cd	Downstream	0.002	<0.5
Fe	Upstream	0.056	250
Fe	Midstream	ND	250
Fe	Downstream	0.019	250
Zn	Upstream	0.262	5-100
Zn	Midstream	0.271	5-100
Zn	Downstream	0.258	5-100
Pb	Upstream	0.001	6-9
Pb	Midstream	ND	6-9
Pb	Downstream	0.003	6-9

Values are means of duplicate determinations

Table 3. Exchangeable metal ions in *P. aquilinum* from Njere river

Total of metal ion	Location	Mean conc of metal ion (ppm)	W.H.O standard (ppm)
Ni	Upstream	0.213	1-10
Ni	Midstream	0.227	1-10
Ni	Downstream	0.137	1-10
Cd	Upstream	0.118	<0.5
Cd	Midstream	0.1	<0.5
Cd	Downstream	0.075	<0.5
Fe	Upstream	0.135	250
Fe	Midstream	0.116	250
Fe	Downstream	0.109	250
Zn	Upstream	0.203	5-100
Zn	Midstream	0.18	5-100
Zn	Downstream	0.1	5-100
Pb	Upstream	0.049	6-9
Pb	Midstream	0.043	6-9
Pb	Downstream	0.025	6-9

Values are means of duplicate determinations

possibly due to the fact that the study area is still a suburb with very minimal industrial activities. Most of the heavy metals assessed could be basically from natural sources such as weathering and volcanic eruptions. Dossa et al. [16] and Ives and Kendal [17] reported that combinations of agricultural, industrial and anthropogenic activities are key sources of increased heavy metals in the environment. However, Pueyo et al. [18] reported that total heavy metal ion concentration alone cannot be used to evaluate the mobility, bioavailability and any possible toxicity of metals.

The low concentration of soluble heavy metals accumulated by the plants could also correlate the concentration of total metal ions (Table 2). Increases in soil pH have been implicated in mobilization of heavy metals in plants [19], as well as soil properties [20].

The results obtained in this study have lent credence to the fact that the study area Umuakam Okaiuga Nkwoegwu community is still under-developed with little or no industrial activities. Also, ingestion of the plants by animals and humans may be relatively safe.

4. CONCLUSION

Since man continues to depend on food for survival, there is need to ensure production of quality food products for health and sustainability of human and animal health. The urban cities still depend greatly on the rural communities for these food products. The Njere river bank can therefore serve as a good site for dry season crop production. The water can also support irrigation agriculture.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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