Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

J P P Journal of Pharmacognosy and Phytochemistry

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(1): 2110-2113
Received: 21-11-2017
Accepted: 22-12-2017

Otitoju O
Dept. of Biochemistry, Federal University Wukari Taraba, Nigeria

Otitoju GTO
Home Science, Nutrition and Dietetics, university of Nigeria, Nsukka Enugu, Nigeria

Boyi R
Home Science, Nutrition and Dietetics, university of Nigeria, Nsukka Enugu, Nigeria

Correspondence
Otitoju O
Dept. of Biochemistry, Federal University Wukari Taraba, Nigeria

Risk assessment of agricultural farmland: A case study of Wukari, Taraba state Nigeria

Otitoju O, Otitoju GTO and Boyi R

Abstract

Evaluating the risk of exposure of farmers as well as consumers of agricultural products is an important step in maintaining sound environmental and human health. Rice, one of the staple foods in most Nigerian homes has been implicated to contain some quantities of heavy metals; hence the aim of this research was to assess the heavy metal concentrations in soil and *Oryza sativa* samples from a farmland in Wukari, Taraba State. Soil and *Oryza sativa* samples were collected from the Road side (RD) and the farm site (FS) and analysed for heavy metals, minerals and inorganic salt contents. The result showed that samples from RD locations show higher concentrations of Ca and Zn (1.55 and 2.56 ppm respectively) than the FS location which had 1.44 and 1.88 ppm for Ca and Zn respectively. Mg, K, P, Mn and Fe had lower concentrations in soil samples from RD than the FS locations. Heavy metal contents in soil shows that Cu, Pb and Cd concentrations were not significantly higher in the samples from RD. Some mineral elements present in the rice samples shows that Ca, K, Na and P concentrations were higher in rice harvested from road side farms than the farm site locations while Mg, Mn, Fe and Zn concentration was generally lower in roadside farm. The differences observed were not statistically significant ($p>0.05$). However, heavy metal results show that Cu, Pb, Co and Cd were present in rice harvested from RD at lower concentrations between 0.012-0.42 ppm than samples from the FS location with heavy metal concentrations ranging between 0.02-0.60 ppm. Husk samples harvested from Rd and FS shows that all the mineral elements were generally higher in the FS locations except for Fe concentration which was significantly higher ($p<0.05$) in the RD locations than FS locations. Generally, Pb and Cr concentrations were higher in rice samples from RD than the FS soil. The increase of about 50% in Pb and Cr concentrations may be due to bioaccumulation potential of *Oriza sativa* while cadmium concentration however decreased by about 50%. A similar trend was observed in the FS locations where Pb and Cr concentrations increased in the rice samples than the soil samples from the corresponding locations.

Keywords: Soil, *Oryza sativa,* Heavy metal, contaminants, hazardous, bioaccumulation

Introduction

The location of agricultural farmland is an important factor in evaluating the risk of exposure of farmers as well as consumers of agricultural products. Roadside farming and water harvesting to boost agricultural productivity may pose a lot of health risk to consumers of farm products. Observation shows that most rice farms in Nigeria including Wukari L.G.A. of Taraba State are usually situated along the road or close to water bridges which transport waste and flood water from most urban settlement exposing crops to fumes from automobile exhausts and erosion activities.

One of the most common contaminants of agricultural food crops today are heavy metals which pose serious health challenges to the general public. We had earlier estimated the quantities of some heavy metals in both locally produced rice samples and the foreign samples from China, India and Thailand (Nauman and Khalid, 2010; Otitoju *et al* 2014) [10, 11]. Our initial assumption was based on the fact that locally produced rice may contain lower quantities of heavy metals than the foreign ones but this assumption was defeated when we found out that locally produced rice contain in some instances higher level of cadmium, lead and mercury than the imported rice already implicated to contain high concentration of heavy metals.

Heavy metals are a dangerous group of soil pollutants. The contamination by heavy metals causes a serious problem because they cannot be naturally degraded like organic pollutants and they accumulate in different parts of the food chain (Fernandez-Luqueño *et al*., 2013; Šmejkalová *et al* 2003) [4, 14]. The high concentration of heavy metals in soils is reflected by higher concentrations of metals in plants, and consequently in animal and human bodies (Buszewski *et al* 2000) [1].

Rice is an increasingly important crop in Nigeria. It is relatively easy to produce and is grown for sale and for home consumption. In some areas like Wukari, Benue, Abakaliki and Adani, there is a long tradition of rice growing but for many, rice has been considered a luxury food for special occasions only. With the increased availability of rice, it has become part of the everyday diet of many in Nigeria. Hence possible contamination by heavy metals may pose serious health problems to vulnerable groups (children and pregnant mothers).

Heavy metals, (Co, Cd, Pb, Zn, Mn, Ni and Cu) in soil, fruit and vegetable samples have been implicated as possible causes of cancer (Türkdoğana *et al* 2003) [15]. The implication associated with heavy metal contamination is of great environmental and health concern, particularly in agricultural sector with increased farm inputs such as fertilizer and pesticides (Ray *et al*., 2010). These metals can pose a significant health risk to humans, particularly in elevated concentrations above the body tolerable dose (Gupta and Gupta, 1998) [6]. Dietary exposure to heavy metals, namely Cadmium (Cd), Lead (Pb), Zinc (Zn), Copper (Cu) has been identified as a risk to human health through the consumption of vegetable crops (Kachenko and Singh, 2006; Rubio-Arias *et al*., 2010) [9, 13]. Heavy metals have toxic and mutagenic effects even at very low concentration. Several cases of human disease, disorders, malfunction and malformation of organs due to metal toxicity have been reported (Ray, *et al*., 2010). Along with the human beings, animals and plants are also affected by toxic levels of heavy metals. Toxicological significance of heavy metals has been recognized several decades ago in developed countries. However, developing countries still lag behind in this area of research with scanty effort coming forth in recent years on heavy metal contamination in fruits and vegetables by different authors (Parveen *et al* 2003) [12].

Although rice belong to the grass family like the elephant grass, its capacity for metal uptake may be playing a dual role of good remediating agent while its fruits (grains) are good sources of food to the growing population. Bioremediation potential of *Oriza sativa* is a potential threat to food security globally especially in the developing nations where rice is a major staple food. This research aims at evaluating the risk of exposure to heavy metals in rice and soil samples obtained from both road side (RD) and farm site (FS).

Material and methods

Study site

The study was conducted in Wukari Taraba state Nigeria, from May to November 2013. Wukari is situated on longitude 9º 47'E and latitude 7º 51'N, Southern Taraba zone, Nigeria. The area is characterized by savannah vegetation zone interspersed with riparian forests along water course and rocky outgrowths constituting the major land form of the area. Rainy and dry seasons are the two major climatic seasons in the area. Agricultural practice is on the large scale in Wukari and environs, crops like rice, yam, maize etc are the major products available throughout the year. Five selected farm sites were examined in this study. Two along the roadside and three in water lodged area receiving flood water from urban drainage sources.

Sample Collection

Soil and rice samples were collected from different sites between the months of May-November 2013. Five selected farm sites were examined in this study. Two along the roadside and three in water lodged area receiving flood water from drainage sources. A total of 25 rice samples and 25 soil samples were collected for this study. Soil samples were collected using hand trolley at 0-20 cm depth.

Sample Preparation

The soil samples were dried at room temperature (27ºC) for 7 days and sieved (2 mm sieve). The samples were subjected to a cold extraction with 0.5 M HNO_3 for 30 minutes. Pb, Cd, Zn, Cu, Mg, Fe and Ca were determined using atomic absorption flame spectrophotometer. The pH of the soil layers were also measured instantly at the collection site. Rice samples were also dried for two weeks at room temperature, the samples were pulverised manually using hand grinder and were digested using HNO_3 before determining heavy metals concentrations atomic absorption flame spectrophotometer.

Results

In Table 1, soil samples from road side (RD) shows higher concentrations of Ca and Zn (1.55 and 2.56 ppm respectively) than the farm side (FS) location having 1.44 and 1.88 ppm for Ca and Zn respectively. Mg, K, P, Mn and Fe had lower concentrations in soil samples from RD than the FS locations. The result of heavy metal contents in soil is shown in Table ss. The result shows that Cu, Pb and Cd concentrations were not significantly higher in the samples from RD locations but Cr, Se, As and Hg concentrations (Table2) were generally low irrespective of locations (Rd or FS).

Table 3 shows the result of some mineral elements present in the rice samples analysed. The result shows that Ca, K, Na and P concentrations were higher in rice harvested from road side farms than the farm site locations while Mg, Mn, Fe and Zn concentration was generally lower in roadside farm than the interior ones. The differences observed were not statistically significant (p>0.05). However, heavy metal results (Table 4) show that Cu, Pb, Co and Cd were present in rice harvested from RD at lower concentrations between 0.012-0.48 ppm than samples from the FS location with heavy metal concentrations ranging between 0.02-0.60 ppm. The concentrations of Se, As and Hg were generally negligible and there was no significant difference (p>0.05) between the RD and FS locations.

Generally Table 4 shows that Pb and Cr concentrations were higher in rice samples from RD than the soil concentrations of the respective metals. This increase of about 50% in Pb and Cr concentrations may be due to bioaccumulation potential of *Oriza sativa* while cadmium concentration however decreased by about 50%. A similar trend was observed in the FS locations where Pb and Cr concentrations increased in the rice samples than the soil samples from the corresponding locations.

Table 1: Mineral speciation in Soil samples (Road side [RD] and farm side [FS]) harvested from some farmlands in Wukari urban Taraba State.

Samples	Ca cmol/kg	Mg cmol/kg	K cmol/kg	Na cmol/kg	P ppm	Mn ppm	Fe ppm	Zn ppm
RD	4.72±1.57	1.44±0.27	0.42±0.18	0.17±0.01	169.20±25.07	104.45±18.37	135.99±19.60	20.80±7.11
FS	4.34±1.89	1.24±0.47	0.31±0.27	0.16±0.01	152.98±55.05	97.92±19.27	113.44±27.50	16.15±8.01

Table 2: Heavy metal speciation in soil samples (Road side [RD] and farm side [FS]) harvested from some farmlands in Wukari urban Taraba State Nigeria.

Samples	Cu ppm	Pb ppm	Cd ppm	Se ppm	As ppm	Cr ppm	Hg ppm
RD	0.97±0.44	4.93±2.25	1.18±0.54	0.24±0.09	6.57±2.88	21.57±12.30	2.83±0.86
FS	1.16±0.39	3.41±1.43	1.14±0.37	0.42±0.14	5.16±1.84	14.12±6.69	3.06±0.64

Table 3: Mineral speciation in rice samples (Road side [RD] and farm side [FS]) harvested from some farmlands in Wukari urban Taraba State Nigeria.

samples	% Ca	% Mg	% K	Na ppm	PPM P	Mn ppm	Fe ppm	Zn ppm
FS1	2.03±1.34	0.35±0.17	0.72±0.28	0.07±0.01	59.64±7.80	1.93±0.53	70.92±24.63	2.66±0.92
RD1	1.74±0.94	0.76±0.413	0.26±0.12	.075±0.01	40.91±3.79	4.17±2.23	60.26±13.11	2.78±1.15

Table 4: Heavy metal speciation in rice samples (Road side [RD] and farm side [FS]) harvested from some farmlands in Wukari urban Taraba State Nigeria.

samples	Cu ppm	Pb ppm	Se ppm	As ppm	Hg ppm
FS1	0.68±0.16	0.004±0.002	0.03±0.009	0.002±0.0004	0.0002±0.00003
RD1	0.48±0.14	0.008±0.01	0.013±0.0037	0.002±0.0002	0.00014±0.00004

Discussion

Assessing the risk of exposure to heavy metal pollution continues to be one of the most serious environmental problems worldwide. They are the main group of inorganic contaminants found in the environment due to the use of sludge or municipal compost, pesticides, fertilizers, and emissions from municipal wastes. Excessive levels of heavy metals can result in soil quality degradation, crop yield reduction, and poor quality of agricultural products, thereby posing significant health hazards to humans, animals, and the ecosystem. Consequently, exposure to heavy metals via different routes remains a topic of global concern. Rice, one of the staple foods in most Nigerian homes has been implicated to contain some quantities of heavy metals; hence the aim of this research was to assess the heavy metal concentrations in soil and *Oryza sativa* samples from a farmland in Wukari, Taraba State.

Location of agricultural land may play significant role in evaluating the level of risks associated with the consumption of the finished products from the field to the tables of consumers. Although food contamination may take place at any given period or stages of production, establishing the relationship between environmental quantities of pollutants and sample quantities has become imperative to nutritionists, toxicologists, consumers and farmers. Citing of farmland for major agricultural purpose is determined by many factors, some of which include soil types, land availability, water etc. However, rice production is usually favoured by water availability which is a major risk to consumers of such products. The citing of rice farmland around water bodies with possible contaminants from industrial, domestic and urban effluents may pose a lot of risk to consumers of such rice samples. Road side citing of farm land may pose more hazard as rice samples from such lands had higher concentrations of Pb, Cd and As than samples harvested from farmlands cited at least 200 meters away from the roadside. This shows that Pb, Cd and As may be present in such samples due to vehicular emission as well as erosion activities and possible contamination of water bodies from urban run-off.

The difference in heavy metals concentrations in soil and *Oryza sativa* sample was generally observed. With high concentrations in the soil than *Oryza sativa* sample, this could possibly be caused by the slight acidity of the soil which favour heavy metal uptake. Slight difference was also observed in heavy metal concentrations of Soil and *Oryza sativa* samples from the RD and FS. Concentrations in the RD samples was possibly cause by human activities e.g from car exhaust while that of the FS may be due to fertilizer and pesticide application or contaminated wastewater.

Leaching of essential nutrients like Mg, K, P, Fe and Mn was observed in the RD than in FS. This may be due to erosion activity and increased wind action along the road side. Similarly, the removal of top soil rich in essential nutrients may also adduce for this observed low nutrient in soil samples from the RD. This result is in agreement with the report of xxx *et al* 2016). Pb and Cd were also higher in RD locations. This may be due to vehicular movement and the resultant release of TPH from the exhaust fume. A similar trend was observed in the rice samples with increased Na, Ca, K, and P levels. Also, increased heavy metal levels were observed in the rice samples from RD sites. A lot of work has been carried out on studying heavy metal bioavailability such as cadmium (Cd), copper (Cu), lead (Pb), chromium (Cr), zinc (Zn), and others in paddy soils (Halder and Mandal, 1981; Wang *et al* 2003; Cheng *et al* 2004; Li *et al*., 2005) [7, 16, 2]. Most previous studies on accumulation of heavy metals were focused on special field areas (e.g., industrial and mining regions). Little information is available on heavy metal accumulation in paddy fields at regional scales, and the spatial correlation between heavy metals in soil-rice system has seldom been investigated.

The risks of consumption of rice planted either in road side or flood prone environment may pose deleterious health effects to vulnerable population like children and pregnant women. Children are more at risk from consumption of rice and other susceptible crops like vegetables and spices, therefore renewed effort towards mitigating the exposure threshold should be adopted by the government and her regulatory bodies.

We had reported this earlier in our paper where we reported high heavy metal content in imported and locally produced rice (Otitoju *et al* 2014) [11]. Bioaccumulation of heavy metals has been reported by various researchers (Debopam *et al* 2010; Šmejkalová *et al* 2003; Nauman and Khalid, 2010) [3, 14, 10]. Although, our results showed increased heavy metal content in rice and soil samples, these quantities are less than FSAI (2009) [5] threshold. However, we recommend that adequate precaution should be adopted by farmers in order to reduce the risk of exposure of the populace from the consumption of this important food sources. Our interest should go beyond food availability to food safety in order to really define food safety.

References

1. Buszewski B, Jastrzębska A, Kowalkowski T, Górna-Binkul A. Monitoring of Selected Heavy Metals Uptake by Plants and Soils in the Area of Toruń, Poland. Polish Journal of Environmental Studies. 2000; 9(6):511-515.
2. Cheng WD, Zhang GP, Yao HG, Dominy P, Wu W, Wang RY. Possibility of predicting heavy-metal contents in rice grains based on DTPA-extracted levels in soil. *Commun.* Soil Sci. Plan. 2004; 35:2731-2745.
3. Debopam Banerjee, Himadri Bairagi, Sibabrata Mukhopadhyay, Anju Pal, Debabrata Bera, Lalitagauri Ra. Heavy metal contamination in fruits and vegetables in two districts of west Bengal, India. EJEAF Che, 2010; 9(9):1423-1432.
4. Fernandez-Luqueño F, López-Valdez F, Gamero-Melo P, Luna-Suárez S, Aguilera González EN, Martínez AI. *Et al*. Heavy metal pollution in drinking water – a global risk for human health: a review', Afr. J. Environ. Sci. Technol. 2013; 7(7):567-584.
5. Food safety authority of Ireland-FSAI. Mercury, lead, cadmium, tin and arsenic in food. Toxicology factsheet series, 2009; 1:1-13.
6. Gupta UC, Gupta SC. Trace elements toxicity relationships to crop production and ivestock and human health: Implication for management. Commun Soil Sci Plant Anal, 1998; 29:1491-1522.
7. Haldar M, Mandal LN. Effect of phosphorus and zinc on the growth and phosphorus zinc, copper, iron and manganese nutrition of rice. Plant Soil. 1981; 59:415-425.
8. Hansen H, Anderson A. Bly, Cadmium, Kobber og zinc I frugt og gron sagar () International publication of the National Food Institute, Soborg, Denmark, 1982, 1977-1980.
9. Kachenko AG, Singh B. Heavy metals contamination in vegetables grown in urban and metal smelter contaminated sites in Australia.Water, Air and Soil Pollution, 2006; 169:101-123.
10. Nauman Mushtaq, Khalid Saifullah Khan. Heavy Metals Contamination of Soils in Response to Wastewater Irrigation In Rawalpindi Region. Pak. J. Agri. Sci. 2010; 47(3):215-224.
11. Otitoju GTO, Otitoju O, Ogbonna VA. Quantification of heavy metal levels in some locally produced rice (oryza sativa) samples from South-East and South-South geopolitical zones Nigeria. Journal of Food Science and Quality Management. 2014; 23:20-24.
12. Parveen Z, Khuhro ML, Rafiq N. Market Basket Survey for Lead, Cadmium, Copper, Chromium, Nickel and Zinc in Fruits and Vegetables. Bull. Environ Contam. Toxicol. 2003; 71:1260-1264.
13. Rubio-Arias H, Quintana C, Jimenez-Castro J, Quintana R, Gutierrez M. Contamination of the Conchos river in Mexico: does it pose a health risk to local residents? Int. J. Environ. Res. Public Health. 2010; 7:2071-2084.
14. Šmejkalová M, Mikanová O, Borůvka L. Effects of heavy metal concentrations on biological activity of soil micro-organisms. Plant Soil Environ. 2003; 49(7):321-326.
15. Türkdoğana MK, Fevzi Kilicelb, Kazim Karac, Ilyas Tuncera, Ismail Uygana. Heavy metals in soil, vegetables and fruits in the endemic upper gastrointestinal cancer region of Turkey. Environmental Toxicology and Pharmacology. 2003; 13(3):175-179.
16. Wang QR, Cui YS, Liu XM, Dong YT, Christie P. Soil contamination and plant uptake of heavy metals at polluted sites in China. J. Environ. Sci. Health. A. 2003; 38:823-838.