

Effects of Chemical Fertilizers and Herbicides on Accumulation of Some Heavy Metals in Wetlands Under Different Land Use Types in Odeda, Southwest Nigeria

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Abstract

This study investigated the effects of chemical fertilizers and herbicides application on the wetland soils at the Federal University of Agriculture, Abeokuta and Odeda Farm Settlement, Eweje. The land use types studied were maize, plantain, rice, vegetable, and fallow land. Data on land history, land use and management practices, and concentrations of heavy metal were collected through field surveys, interviews, and nutrient analysis. Concentration of copper, cadmium, iron, manganese, lead, and zinc were assessed. The surface water quality was assessed using WHO maximum permissible limits. Heavy metal in the soil samples ranged between 0.06 mg/kg and 262.35 mg/kg across the land use types. The concentration of metals like Fe, Mn, Cd, and Pb in the surface water of agrochemical applied fields were above the WHO permissible levels for agricultural and domestic purposes. The soil cultivated years, the types and quantity of applied fertilizers, timing of application, and land use patterns were the main reasons for differences in the heavy metal content of the soils. The study concluded that application of agrochemicals polluted the wetlands, thereby making the water toxic. Soil testing programme should be conducted on agricultural land before any use, and proper agronomic practices of production should be adopted to minimize uncontrolled agrochemical usage.

Keywords: Wetlands; Agrochemicals; Heavy metals; Land use types

Introduction

The quest to address food insecurity especially in developing countries has led to the cultivation of wetland soils. This is so, since the productivity of upland soils have been frequently threatened with improper land use and management practices, soil erosion and degradation thereby leading to decline in crop yield (Ogban *et al.*, 2011). The increase in wetlands cultivation is driven partly by population increase, upland soil deterioration, economic and financial motivation (Schuyt, 2005), as well as increasing issue of food insecurity in developing countries (Taiwo, 2013).

In an attempt to enhance agricultural production, farmers have been relying on the use of agrochemicals because they are generally considered as a panacea for the increase in crop production. Abah *et al.* (2009) stated that wrong usage of agrochemicals in crop cultivation as practiced by the majority of the rural farmers portends great dangers to the qualities and yield potentials of crops. It has been reported that heavy applications of chemical fertilizers, pesticides, and herbicides in crop cultivation resulted in the buildup of residual chemicals in soils, plants and crops, and consequently extend beyond agricultural system (Abah *et*

al.,2012).

Land use types have significant implications for heavymetal concentration in the soil. Change in land use always leads to a change in cultivation management, which may deeply influence the soil properties (Fu, 2000). The accumulation and retention of metals in soil are strongly dependent on soil properties (Hou *et al.*, 2015). The content of heavy metals in soil is becoming one of the most important evaluation indices for soil quality. However, heavy metal accumulation in agricultural soils cannot only lead to the disorder of soil function which in turn affects crop growth, but heavy metals can be transferred to crops thus posing a risk to human health (Lee *et al.*, 2006).

The farming practices and agrochemicals usage including possible environmental pollution from agriculture in wetland soils of Odeda, Nigeria has not been investigated. Thus, it is envisaged that the baseline information presented in this study will contribute to the understanding of land use situation in the study area, and the possible effects of the use of agrochemicals in cultivations. It was on this premise that the study was conducted to evaluate the effects of chemical fertilizers and herbicides on the accumulation of some heavy metals in wetlands of Odeda Local Government Area under different land uses.

Materials and Methods

Description of the Study Locations

The study was conducted on wetlands under different land uses of maize, plantain, rice, vegetable and fallow at Crop Production Farm of Directorate of University Farms, Federal University of Agriculture, Abeokuta and Odeda Farm

Settlement, Eweje, Abeokuta (Figure 1). The sites were located in the north eastern part of Abeokuta within latitude $07^{\circ}23'N$ and longitude $03^{\circ}43'E$, and latitude $07^{\circ}23'N$ and longitude $03^{\circ}51'E$ respectively. Geologically, the study areas fall within the Pre-Cambrian rocks of southwest, Nigeria basically from Basement Complex rock origin. The major rock types are schist, quartz, granite, gneiss, and migmatite (Aiboni, 2001). The climate falls within the sub-humid forest and derived savannah region with two separate seasons; the wet season (April-November) and the dry season (December-March). The area has an annual rainfall of between 1,000-1,500 mm, mean temperature of $27^{\circ}C$, and high relative humidity which ranges from 75-95%. Equally, there is Harmattan season from late December to February (Oyegoke, 2011).

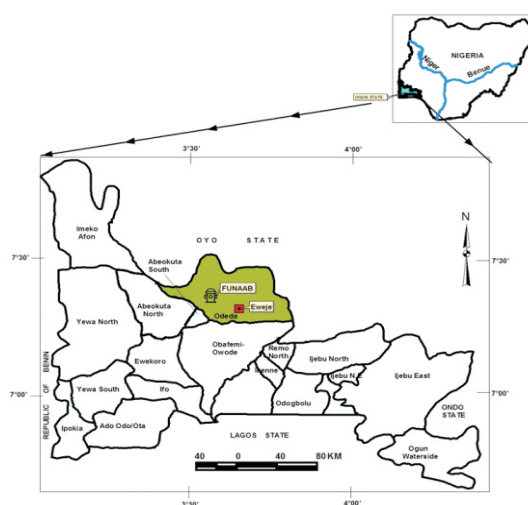


Figure 1: Map of Ogun State, Nigeria showing the Study Area

History of the Study Area

FUNAAB Site

The farms were established in late 2005 basically as a demonstration plot for Agricultural Media Resources and Extension Centre (AMREC). It was handed

over to Teaching and Research Farms Directorate (TREFAD) in 2008 upon the decision of University Management to go into commercial farming and movement of personnel's in charge to this directorate. In December 2011 TREFAD was given a new name and it is now being called Directorates of University Farms (DUFARMS). The soil series found in the area are Matako, Jago, and Ikire (Aiboni, 2001). Various hectarages have been planted to arable and plantation crops, and different management practices have been adopted, among these are ploughing and harrowing through tractorization, uses of agrochemical to control weeds, pest, and boost yield. The size of land use types used for the study are, maize (4 hectares), plantain (3 hectares), rice (4 hectares), vegetables (1.2 hectares), and fallow (10 hectares).

Eweje Site

The Odeda Farm Settlement, Eweje, Abeokuta was established in 1960 with the mandate to train farmers. It was founded during the regime of Late Chief Obafemi Awolowo as Premier Western region for Agricultural Development Program of the region. Due to the large expanse of the area, the lands have been allotted to the trained farmers, researchers and villagers to manage. The common soil series recognized are Matako, Jago, Ikire, and Oshun (Smyth and Montgomery, 1962). Crops planted in the areas are maize (5 hectares), cassava (7 hectares), leafy vegetables (1 hectare), rice (3 hectares), plantain (1.5 hectares), and oil palm (about 28 hectares). The land has been ploughed at different intervals over times and has been subjected to diverse agrochemicals (fertilizers and pesticides).

Field Study

Soil Sampling

Surface and subsurface soil samples were randomly collected at 0-15 cm and 15-30 cm respectively with the use of soil auger. Samples were collected from fields where chemical fertilizers (NPK 15:15:15, Urea) applied at 150-200 kg/ha, and herbicides (roundup, weedoff, primextra and forceup) were applied at the rate of 4-5 L/ha to the crops. The fallow field (uncultivated) without the usage of fertilizers and herbicides in each of the locations serves as a control. Samples were later bulked together and composite samples taken were air-dried in preparation for laboratory analysis.

Water Sampling

There is a need to determine the quality of the water in the study area due to the end effects of these agrochemicals applied to the soil. Water samples were collected from the streams from the selected land use types using 2 litres white plastic kegs.

Laboratory Analysis

The air-dried soil samples were grounded and sieved by 2 mm sieve. Samples were further sieved through 0.5 mm for organic carbon, nitrogen, and heavy metals determination before subjected to laboratory analysis. They were processed for physical and chemical analysis of the fine earth (<2 mm) fraction with the standard analysis method of IITA (1982). Heavy metal concentrations were determined by taking subsamples of air-dried 0.5mm soil samples. 100 mg of the samples were digested with a mixture of 6 ml HF, 4 ml HNO₃ and 1 ml HClO₄ following a method described by Bruce and Whiteside (1984). The water samples were

analyzed for heavy metals using the air-acetylene flame (APHA, 1998). The metals were read using Atomic Absorption Spectrophotometer.

Statistical Analysis

The data obtained were subjected to Analysis of Variance (ANOVA) using GenStat 12th edition to assess the spatial variation as affected by land use types and agrochemicals.

Assessment of Surface Water Quality

The heavy metal concentrations results of the surface water were compared with

World Health Organization (2011) Standards to determine the quality and level pollution of the water.

Results and Discussion

Tables 2 and 3 showed the physical and chemical properties of the soils. The sand content dominates the particle size distribution. The clay content increased with increased depth, while silt content fluctuates within the soil. The lowest bulk density (1.39 g/cm³) was recorded on the fallow soil of Eweje while FUNAAB maize field has the highest bulk density (1.56 g/cm³). The higher bulk density in

Table 1: History of the Land Use for the Study Area (2005-2015)

Land Use Types	FUNAAB		Eweje	
	Period of cultivation (Years)	Application of agrochemicals (Years)	Period of cultivation (Years)	Application of agrochemicals (Years)
Maize	>10	10	8	5
Plantain	8	6	7	3
Rice	5	5	7	6
Vegetable	7	5	8	4
Fallow	6	Nil	5	Nil

Source: Field Survey, 2015

Table 2: Physical and Chemical Properties of Soil Samples under FUNAAB Site

Sampling Location	Land Use Types	Depth (cm)	Sandg/kg.....	Silt	Clay	BD g/cm ³	pH (H ₂ O)	OM %	TN %	Avail-P mg/kg	Ex. Bases cmol/kg				CEC cmol/kg	BS %
											Na	K	Ca	Mg		
	Maize	0-15	822	64	114	1.56	6.17	1.11	0.12	11.04	0.47	0.29	1.74	0.96	3.46	96.6
		15-30	820	74	124	1.54	5.95	0.73	0.08	8.23	0.47	0.24	1.68	0.84	3.23	96.9
	Plantain	0-15	812	54	134	1.53	6.31	1.09	0.13	6.82	0.48	0.30	2.05	1.14	3.97	98.5
		15-30	802	64	134	1.53	6.19	0.58	0.06	3.23	0.46	0.24	1.86	0.99	3.55	98.3
FUNAAB	Rice	0-15	732	74	194	1.45	6.33	0.93	0.10	13.80	0.48	0.32	1.96	1.34	4.10	97.4
		15-30	722	74	214	1.44	6.28	0.69	0.07	7.11	0.45	0.26	1.67	1.09	3.47	97.2
	Vegetable	0-15	792	74	134	1.49	6.35	0.83	0.09	8.92	0.47	0.30	1.99	1.01	3.77	96.9
		15-30	782	64	154	1.47	6.28	0.75	0.08	4.84	0.48	0.23	1.40	0.80	2.91	98.3
	Fallow	0-15	802	84	124	1.51	7.21	1.17	0.14	4.25	0.52	0.26	2.19	1.20	4.17	98.0
		15-30	792	84	144	1.49	7.05	0.91	0.10	4.04	0.53	0.25	1.93	0.93	3.64	97.7

Table 3: Physical and Chemical Properties of Soil Samples under Eweje Site

Sampling Location	Land Use Types	Depth (cm)	Sandg/kg.....	Silt	Clay	BD g/cm ³	pH (H ₂ O)	OM %	TN %	Avail-P mg/kg	Ex. Bases cmol/kg				CEC cmol/kg	BS %
										Na	K	Ca	Mg			
	Maize	0-15	782	74	144	1.45	6.07	1.04	0.11	6.76	0.51	0.29	2.56	0.96	4.32	97.5
		15-30	772	74	154	1.44	5.91	0.97	0.10	4.39	0.47	0.23	1.85	0.79	3.34	96.4
	Plantain	0-15	752	84	164	1.42	5.98	1.20	0.15	7.64	0.72	0.28	2.48	1.28	4.76	98.6
		15-30	752	74	174	1.40	5.79	0.74	0.08	5.80	0.48	0.34	1.96	0.94	3.74	97.9
Eweje	Rice	0-15	772	74	154	1.43	6.14	0.82	0.09	5.35	0.49	0.23	1.87	0.94	3.53	97.4
		15-30	762	64	174	1.41	6.02	0.66	0.07	4.84	0.46	0.41	1.69	0.80	3.36	97.1
	Vegetable	0-15	782	64	154	1.44	6.40	0.86	0.09	7.36	0.51	0.31	1.93	1.53	4.28	96.7
		15-30	772	74	154	1.43	6.23	0.62	0.07	7.10	0.51	0.23	1.24	0.85	2.83	97.8
	Fallow	0-15	762	74	164	1.41	7.26	1.29	0.15	4.42	0.48	0.32	2.71	1.16	4.67	98.4
		15-30	752	74	174	1.39	7.15	1.24	0.13	3.77	0.45	0.20	2.49	1.04	4.27	98.2

Table 4: Heavy Metal Concentration of Soils at FUNAAB

Land Use Types	Depth (cm) mg/kg					
		Cu	Cd	Fe	Mn	Pb	Zn
Maize	0-15	2.25	0.27	32.54	262.35	0.58	38.54
	15-30	0.93	0.16	30.52	152.05	0.32	24.25
Plantain	0-15	2.82	0.33	30.99	182.08	0.64	39.02
	15-30	1.55	0.21	28.37	128.93	0.34	23.65
Rice	0-15	1.25	0.29	27.63	85.90	0.37	29.67
	15-30	1.07	0.16	25.43	74.36	0.25	26.31
Vegetable	0-15	1.42	0.22	25.24	107.30	0.30	30.54
	15-30	0.99	0.15	23.25	91.88	0.23	28.27
Fallow	0-15	1.19	0.18	16.68	73.28	0.23	27.01
	15-30	0.76	0.07	15.26	61.55	0.17	21.74

agrochemical applied fields could be attributed to the effect of mechanization and trampling of cattle respectively. The pH ranged from 5.68 to 7.26 and differs significantly ($p < 0.05$) between agrochemical applied fields and the fallow fields. Ogbodo and Onwa (2013) reported that acidification or lowering of soil pH has negative impacts on most crop growth and occurs as a direct result of the application of specific types of fertilizers. Available

phosphorus was higher under agrochemical applied fields. The higher availability of phosphorus in the cultivated plot could be attributed to the application of inorganic fertilizers (NPK and Single Superphosphate).

The highest content of organic carbon and total nitrogen were recorded in both fallow fields. There was a significant relationship ($p < 0.05$) between organic carbon and total N content. This is an

obvious reason why to expect an increase in the level of nitrogen content in increased organic matter (OM) content of a soil as OM is essentially the main source of nitrogen. Mulatu *et al.* (2014) indicated that the low OM was due to the rapid decomposition of OM that was facilitated by excessive drainage of wetlands, ploughing of soil for cultivation, low coverage and clearing of vegetation. The CEC of the soils were low to moderate, an indication that the soils at their natural pH levels remain low in CEC, indicating a low capacity of the soils to retain nutrients. There was a general relationship between clay and colloidal OM with CEC value (Brady and Weil, 2007). The depletion of OM as a result of continuous cultivation could result for reduced CEC under cultivated sites.

Heavy metals like Copper (Cu), Iron (Fe), Manganese (Mn), Zinc (Zn), Cadmium (Cd), and Lead (Pb) were found in soil samples (Tables 4 and 5). These results differed significantly ($p < 0.05$) between the agrochemical applied fields and the fallow fields. The agrochemical applied field's recorded higher values of these metals. These conditions may not be unconnected with the usage of chemical fertilizers and herbicides in these fields.

The results showed that heavy metal concentrations in top soil were higher than the subsoil. The increase in the heavy metal content of the soil can lead to increased plant uptake of metals that may be injurious to human health (Rattan *et al.*, 2005; Kumar *et al.*, 2007). Copper concentration of the soils ranged from moderate (0.54 mg/kg) to high (2.55 mg/kg). Use of copper oxychloride pesticide has been reported to increase Cu concentration in soil and consequently in edible crops (Modaihsh *et al.*, 2004). The Cd result showed that plantain soil at FUNAAB had the highest concentration (0.33 mg/kg), while Eweje fallow soil had the lowest concentration (0.06 mg/kg). European Food Safety Authority (EFSA, 2009) stated that atmospheric pollution, phosphate fertilizers and sewage sludge appear to be the major contributors to cadmium deposition in agricultural soils. Plants grown on soil containing high levels of Cd show visible symptoms of injury reflected in terms of chlorosis, growth inhibition, browning of root tips and death (Mohanpuria *et al.*, 2007; Guo *et al.*, 2008).

The Fe content of the soils was very high (13.65 mg/kg – 32.54 mg/kg), being greater than 4.5 mg/kg in all the land use types examined, while the Zn content was

Table 5: Heavy Metal Concentration of Soils at Eweje

Land Use Types	Depth (cm)	mg/kg					
		Cu	Cd	Fe	Mn	Pb	Zn
Maize	0-15	1.67	0.18	19.70	55.13	0.29	33.61
	15-30	0.71	0.11	19.42	54.80	0.17	24.52
Plantain	0-15	1.56	0.23	23.49	122.98	0.36	31.86
	15-30	1.07	0.15	19.80	91.25	0.25	23.82
Rice	0-15	1.15	0.31	25.45	97.09	0.32	25.87
	15-30	0.76	0.21	18.43	77.62	0.24	24.42
Vegetable	0-15	1.54	0.22	23.25	99.30	0.27	27.68
	15-30	1.11	0.15	19.34	76.89	0.16	23.77
Fallow	0-15	0.92	0.11	15.91	29.31	0.20	23.28
	15-30	0.54	0.06	13.65	26.17	0.10	19.66

19.66 mg/kg to 38.54 mg/kg. The value obtained for Fe and Zn were very high when compared with Amacher *et al.* (2007) ratings for these metals. The Mn in the soil ranged from 26.17 mg/kg and 262.35 mg/kg. The Eweje fallow soil has the lowest concentration while the FUNAAB maize soil has the highest concentration of this metal. The Pb content ranged between 0.10 mg/kg and 0.64 mg/kg. Steel industry wastes recycled into fertilizers had been reported to contain high levels of Zn, Mn, and Pb (EFSA, 2010). Lead was also reported to exert an adverse effect on morphology, growth and photosynthetic processes of plants (Nagajyoti *et al.*, 2010). The result of the hypothesis (test of significant difference in physical and chemical properties, and heavy metals concentration across the study locations) showed that there was no significant difference in physical and chemical properties of the soils across the study locations as tested using one-way Analysis of Variance (ANOVA) and presented in Tables 6 and 7, but, there was significant difference in the heavy metals concentration between FUNAAB and Eweje (Tables 8 and 9). The results in Table 9 revealed that there is a significant difference in the heavy metals across the land use types in Eweje ($F = 6.711$, $P < 0.05$). These results therefore, indicate that the heavy metals concentrations varied across the land use types. Furthermore, a post-hoc multiple comparisons was carried out to indicate the significant differences among the land use types in Eweje with respect to the agrochemicals application (using the Least Significant Difference (LSD) method). The results showed that there was a significant difference in concentrations of heavy metals at plantain

field when compared with other land use types (Table 10) been having the highest mean value (Mean = 158.4100). The vegetable field also showed a significant difference when compared with the rice, maize and control fields respectively. Also, there were also significant differences among the remaining three land use types (Table 10).

Climate is of great significance in every phase of agricultural activity. This has remained an uncontrolled factor in crop production under different land uses except in cases of environmental modification or where there is wide variation in climate between seasons, which can cause seasonal variations in nutrient uptake (Lavanya *et al.*, 2010). The levels of heavy metals in soils of the agrochemical applied farms were higher than the control (fallow) farm soils. Variations in metal content of soils could be due to seasonal changes which modify bioavailability with pattern varying with each metal (Wong *et al.*, 2002; Kakulu and Jacob, 2006). Other possible reasons for metal level variation across the land use types could be due to the differences in soil cultivated years, uneven distribution of metals in soil, and continuous atmospheric deposition of these metals.

The results of heavy metals concentration in the water samples were presented in Table 11. The results revealed that Cu (0.05 mg/L – 0.40 mg/L) and Zn (0.06 mg/L – 0.23 mg/L) values are moderate. This is an indication that these metals cannot constitute any hazard to human at these levels but care must be taken not to increase their concentration through agrochemical application. The value obtained for Fe (2.01 mg/L – 15.60 mg/L) and Mn (2.96 mg/L – 6.34 mg/L) were above the permissible limit (3.0 mg/L) and

Table 6: Test of difference of chemical and physical properties across the land use types in FUNAAB

Sources of Variation	Sum of Square	Df	Mean Square	F-Valve	P-Value	Decision
Between Group	374.922	4	93.730	2.992	0.130	NS
Within Group	156.618	5	31.324			
Total	531.539	9				

Source: Computed from laboratory analysis 2015, NS = Not significant

Table 7: Test of difference of chemical and physical properties across the land use types in EWEJE

Sources of Variation	Sum of Square	Df	Mean Square	F-Valve	P-Value	Decision
Between Group	23.162	4	6.291	0.867	0.542	NS
Within Group	36.263	5	7.253			
Total	61.426	9				

Source: Computed from laboratory analysis 2015, NS = Not significant

Table 8: Test of difference of heavy metals across the land use types in FUNAAB

Sources of Variation	Sum of Square	Df	Mean Square	F-Valve	P-Value	Decision
Between Group	35295.428	4	8823.857	3.863	0.085	NS
Within Group	11422.111	5	2284.422			
Total	46717.539	9				

Source: Computed from laboratory analysis 2015, NS = Not significant

Table 9: Test of difference of heavy metals across the land use types in EWEJE

Sources of Variation	Sum of Square	Df	Mean Square	F-Valve	P-Value	Decision
Between Group	10525.657	4	2631.414	6.711	0.030	S
Within Group	1960.595	5	392.119			
Total	12486.252	9				

Source: Computed from laboratory analysis 2015, S = Significant

Table 10: Post-Hoc (LSD) showing the Mean Values

Land Use Types	N	Mean	Standard Deviation	Standard Error
Maize	2	105.15	7.672	5.425
Plantain	2	158.41	31.21	22.07
Rice	2	135.93	20.15	14.25
Vegetable	2	136.84	21.80	15.42
Control	2	64.95	6.752	4.775

Source: Computed from laboratory analysis 2015.

Table 11: Heavy Metal Concentration of Surface Water from FUNAAB and Eweje Sites

Sampling Location	Land Use Types	Cu	Cd	Fe	Mn	Pb	Zn
..... mg/L							
FUNAAB	Maize	0.40	BDL	9.12	6.34	0.62	0.23
	Plantain	0.18	0.01	2.97	BDL	0.14	0.11
	Rice	0.74	0.01	15.30	5.31	0.10	0.12
	Vegetable	0.23	0.01	3.24	BDL	0.11	0.19
	Fallow	BDL	BDL	2.01	BDL	BDL	0.08
Eweje	Maize	0.11	0.01	3.24	2.96	BDL	0.08
	Plantain	0.08	0.04	2.55	3.92	BDL	0.09
	Rice	0.15	BDL	15.60	BDL	BDL	0.16
	Vegetable	0.05	BDL	3.66	BDL	BDL	0.11
	Fallow	BDL	BDL	2.45	BDL	BDL	0.06

BDL: Below Detection Level

(0.4 mg/L) respectively. These elements can lead to coloration of the water thus initiating sedimentation in the system, which can result in corrosion (Egereonu, 2004). Also, they affect the organoleptic quality of water as do others metals such as Cu, Al, and Zn. The values for Cd (0.01 mg/L – 0.04 mg/L) and Pb (0.11 mg/L – 0.62 mg/L) were equally above the permissible limits (0.003 mg/L) and (0.01 mg/L) respectively. The values constitute health hazard as they are not within the permissible level and this must be totally removed from water because they are carcinogenic (Edet and Okereke, 2001; Otukune and Biukwu, 2005). Lead was not detected at Eweje site indicating a very low concentration of this metal in the soils of the area.

Table 12 presents the comparison of water parameters against the WHO maximum permissible standards. Copper and Zn values among the heavy metals found in the water samples were below the maximum permissible level of WHO (2011). The standard for Cu and Zn were 2.0 mg/L and 3.0 mg/L respectively. The fallow fields generally tend to have had lower values when compared with

agrochemical applied fields. On the other hand, the Fe and Mn values were above the maximum permissible limits (3.0 mg/L) and (0.4 mg/L) respectively recommended by the WHO (2011). Also, the values for Cd and Pb were higher when compared with the WHO standard ratings of 0.003 mg/L and 0.01 mg/L. Iron and Pb values in plantain fields were less than the permissible level, and also the fallow fields.

Conclusions and Recommendation

The results of this study revealed that application of chemical fertilizers and herbicides had significant effects on the metallic level of the wetlands in the study area thereby making the water and soil polluted. The varying concentrations of these metals in soil and water revealed the level of pollution and differ from one land use type to another. The concentration of metals like Fe, Mn, Cd, and Pb in the surface water of agrochemical applied fields were above the WHO permissible levels for agricultural and domestic purposes. The soil cultivated years, the types and quantity of applied fertilizer, timing of application, and land use patterns were some of the main reasons that

Table 12: Comparison of Water Parameter Results with WHO Standards

S/N	Heavy Metals (mg/L)	FUNAAB					Eweje					WHO Max. Permissible Standards
		Maize	Plantain	Rice	Vegetable	Fallow	Maize	Plantain	Rice	Vegetable	Fallow	
1.	Copper	0.40	0.18	0.74	0.23	BDL	0.11	0.08	0.15	0.05	BDL	2.0
2.	Iron	9.12	2.97	15.30	3.24	2.01	3.24	2.55	15.60	3.66	2.45	3.0
3.	Manganese	6.34	BDL	5.31	BDL	BDL	2.96	3.92	BDL	BDL	BDL	0.4
4.	Zinc	0.23	0.11	0.12	0.19	0.08	0.08	0.09	0.16	0.11	0.06	3.0
5.	Cadmium	BDL	0.01	0.01	0.01	BDL	0.01	0.04	BDL	BDL	BDL	0.003
6.	Lead	0.62	0.14	0.10	0.11	BDL	BDL	BDL	BDL	BDL	BDL	0.01

BDL: Below Detection Level

accounted for differences in accumulation of heavy metals in the soils. Although, the present levels of some heavy metals like Cu and Zn are still within the regulatory limits; their continuous accumulation is a concern to produce safety and quality. The agrochemical applied fields have higher contents of these metals compared with the fallow (control) fields showing the impact of the agrochemicals. Therefore, it is recommended that soil testing programme should be conducted before any further use of the wetlands, proper agronomic practices of crop production should be adopted to minimize the uncontrolled usage of agrochemicals during crop production and regular monitoring of metals in soils is essential for prevention of excessive buildup of these metals in the soil.

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