Soil Chemical Properties Response to Regular Application of Agrochemicals in Ifite-Ogwari, Anambra State, Nigeria

Okafor M J[1], Madueke, C. O[1], Nnabuihe, E. C.[1], Ibeh, C. U.[1], Ibigwe, M. N.[1], Onunwa, A. O.[1], Nwosu, T.V.[1]*

[1]*Department of Soil Science and Land Resources Management, Nnamdi Azikiwe University, Awka, Nigeria*

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*CORRESPONDING AUTHOR

mj.okafor@unizik.edu.ng

ABSTRACT

The study on the soil chemical properties response to regular application of agrochemicals was carried out in rice farms at Ifite-Ogwari. Soil samples were taken from rice field that receives various forms of agrochemical and that of adjacent field as control using random sampling techniques at depths of 0-15cm and 15-30cm in three replicates. Sampled soils were air dried, sieved and analyzed in the laboratory using standard routine procedures. Heavy metals As and Pb were analyzed in the laboratory using double acid method. The rest showed that pH was strongly acidic both at soils with applied agrochemicals (rice field) and control, 5.41 and 5.12 respectively. The control also recorded high organic carbon (1.90%), while soil with applied agrochemicals (rice field) had the lowest organic carbon (1.01%); so also, was total nitrogen. Calcium content was low ranging from 2.27 to 4.80Cmolkg^{-1}; magnesium content was moderate ranging from 1.20 to 2.27Cmolkg^{-1}; potassium was very low ranging from 0.14 to 0.19Cmolkg^{-1}; sodium was also very low ranging 0.09 to 0.15Cmolkg^{-1}. Available phosphorus showed low to medium, 3.63mg/kg and 10.4mg/kg respectively. Heavy metals studied also showed that arsenic (As) content which was between 0.01 to 0.16mgkg^{-1} and lead (Pb) 0.13 to 0.22mgkg^{-1} didn't reach the permissible limit given by FAO. The study showed that calcium, available phosphorus, soil pH and arsenic concentration responded significantly to the regular use of agrochemicals in the rice farm.

INTRODUCTION

Agrochemicals are chemicals used in agricultural activities to eradicate weeds, reduce pests and boost soil nutrients (Whitson *et al*., 1999). Herbicides for weed control, pesticides for pest control and, inorganic fertilizers for boosting soil nutrients. Soil which is a recipient to all these agrochemicals acts as filter; buffer, and naturally degrade potential pollutants with the help of soil organic carbon (Burauel and Bassman, 2005), it is also a known fact that the soil is a potential pathway of pesticide transport to contaminate water, air, plants, food and ultimately to human through runoff and sub-surface drainage, interflow and leaching; and the transfer of mineral nutrients and pesticides from soils into the plants and animals that constitute the human food chain (Abrahams, 2002). Inappropriate use of chemical fertilizers and pesticides by farmers can contribute significantly to the soil degradation process. There is evidence that prolonged use of heavy doses ammonium based fertilizers can result in soils becoming more acidic that has serious implications in terms of long-term productivity of soils. One of the environmental risks in using agrochemicals especially, when it is excessively used is the accumulation of various heavy metals in the soil leading to serious consequences (Okafor and Chidozie, 2016). Thus, pollution of heavy metals poses a threat to a country's food production. Some fertilizers and pesticides are known to contain various levels of heavy metals, including Cr and Cu (Kabata-Pendias and Pandias, 1992). Once in the soil, heavy metals are adsorbed - by initial fast reactions (minutes, hours), followed by slow adsorption reactions (days, years) and are redistributed into different chemical forms with varying bioavailability, mobility, and toxicity (Shiowatana *et al.,* 2001; Buekers, 2007). These metals are extremely persistent in the environment, non-biodegradable, non-thermo-degradable and thus readily accumulate to toxic levels. Since they do not break down, they might affect the biosphere for a long time, which is why they are the most dangerous substances in the environment due to their high level of durability and toxicity to the biota (Alkorta *et al.,* 2004). Most rural farmers have long depended on herbicides, pesticides and inorganic fertilizers in growing their crops especially rice, these chemicals often time are judiciously applied, thus tend to constitute environmental hazard. The objective of this study therefore was to ascertain the response of regular use of agrochemicals on soil chemical properties and on selected heavy metals.

Materials and method

The study area

The study was carried out at Ifite-Ogwari, Anambra state which lies between latitude 6^{o} 14' 28" N longitude 7^{o} 6' 46" E and latitude 6^{o} 14' 51" N longitude 7^{o} 6' 47" E. the area falls within tropical savanna, dominated by grasses and sparsely distributed trees. The area experiences two major seasons – rainy or wet (usually starting in March and ends in October) and harmattan or dry season which usually begins in November and last till February (Ejikeme *et al*., 2017). The temperature pattern of the area has mean daily and annual temperatures as 28^{o}C and 27^{o}C respectively. "The mean daily temperature can rise to about 32^{o}C during hot periods of the year usually in the month of February (Ejikeme *et al*.,2017). Humidity is relatively high between 65-80% throughout the year, with average rainfall between 1520–2020 mm per annum (Madueke *et al*., 2021). The textures of soils of the studied sites are mainly clay loam (Umeakuchukwu and Okafor, 2021). The common crops grown by the farmers in the areas are rice, yam, cassava, okra, melon and maize.

Soil sampling

The study focused on rice field with minimum of four (4) years of regular use of agrochemicals like 2,4-D Amine, butachlor and glyphosate (herbicides); Imidacloprid 17.8% SL (brand name-courage) and Kombat (all pesticides). Random sampling techniques were employed in sampling of the soil. Soils were collected randomly at two depths, 0-15 and 15-30 and replicated thrice in an active rice field; same method was used to sample soils at same depth and replication at a nearby two years fallow farm used for yam production which served as control. The sampled soils were air dried and readied for laboratory analysis.

Soil Analysis

The chemical properties that were analyzed are soil pH, total nitrogen, organic carbon, exchangeable bases, exchangeable acidity, effective cation exchange capacity, percentage base saturation, available phosphorus, arsenic and lead.

Soil pH was estimated using pH meter in ratio of 1:2.5 ratio of soil to water (Tan, 1998). Soil organic carbon was determined by titration method (Walkley and Black, 1934).Total Nitrogen was determined using Kjeidahl digestion method. Exchangeable basic cations (Ca2+, Mg2+, K+ and Na+) were extracted in neutral normal ammonium acetate (1N-NH4OAc); where calcium and magnesium was determined using Atomic Absorption Spectrophotometer, while Potassium and Sodium was determined in flame photometer (Schollenberger and Simon, 1945). Exchangeable acidity (Al3+and H+) was determined titrimetrically (Tan, 1998). Base saturation was calculated on percentage basis,

$$\%BS = \frac{\text{Total Exch.Basis} \times 100}{\text{ECEC}} \qquad (1)$$

Effective cation exchange capacity was determined by summation of Exchangeable bases and Exchangeable acidity. Available phosphorus was determined by Bray (I) method (Bray and Kurtz, 1945).

Data Analysis

Data collected were subjected to two-way analysis of variance (ANOVA) to determine the variation between soil under agrochemical cultivation and control on the parameters studied. The significant difference on the properties studied was determined using Least significant difference (LSD) at 5% probability ($p \leq 0.05$). The data package used was Excel 2010.

RESULTS AND DISCUSSION

The selected chemical properties of the studied soils are shown in Table 1. Figure 1 and 2 showed the selected heavy metals (Arsenic and lead) studied. Table 1 showed mean values of selected chemical properties. pH across the tested soils were strongly acidic to moderately acidic (FAO, 2004), with pH values ranging from 5.12 to 5.41, control and soil that had agrochemicals respectively. Pesticides and herbicides are easily degraded at alkaline soils or soils with high pH (Raeder *et al*., 2015; Schilder, 2008), the moderate acidic soil (pH 5.41) recorded at STHA could be encouraging persistence of pesticides and herbicides in the soil. Organic carbon was high at the control having 1.90% and moderate at rice field (soils that had agrochemicals) which has 1.01%, which is in tandem with Baboo *et al*., (2013); even though there was no significant difference between the control and the STHA. Total nitrogen showed a range of 0.09% to 0.16% with the control recording the highest and the soils that had agrochemicals (STHA) recording the lowest; although there was no significant difference on total nitrogen between control and STHA, but the 56% decrease in Total nitrogen at STHA was in consonant with (Damin and Trivelin, 2014) . Calcium was generally low, with control recording 4.80cmolkg^{-1} while soils that had agrochemicals recorded 2.27cmolkg^{-1}, which was contrary to Bulu *et al*., (2019); calcium showed significant difference at 0-15cm depth between soils that had agrochemicals and control. Potassium was very low with a range of 0.14 to 0.19cmolkg^{-1}.

Sodium on the hand was also very low with control recording 0.15cmolkg^{-1} and soils that had agrochemicals showing 0.14cmolkg^{-1}. Available phosphorus was low to medium and showed significant difference at 0-15cm depth, with the control recording more available phosphorus 10.4mgkg^{-1} over soils that had agrochemicals which had 3.39mgkg^{-1} which was contrary to Ghosh *et al*., (2014), where insecticides, fungicides and pesticides caused significant enhancement in the level of available phosphorus. Figure 1 and 2 showed the effect of agrochemicals on arsenic and lead concentration levels respectively.

Table 1. Mean chemical properties of studied soil

Treatment	Soil depth (cm)	pH	Org. Carbon (%)	Tot.N (%)	Al3+	H+	Ca2+	Mg2+ (Cmol/kg)	K+	Na+	ECEC	BS (%)	Av.P (mg/kg)
STHA	0-15	5.41	1.11	0.09	1	0.23	2.27	1.2	0.14	0.09	4.93	75.5	3.63
	15-30	5.35	1.01	0.09	0.73	0.33	2.67	1.47	0.19	0.13	5.52	81.1	3.39
Control	0-15	5.12	1.9	0.16	1.33	0.47	4.8	2.27	0.16	0.14	8.95	81.7	10.4
	15-30	5.23	1.55	0.13	0.7	0.33	3.33	2.03	0.16	0.15	6.74	83.3	6.23
LSD ($p \leq 0.05$)		*	NS	NS	NS	NS	*	NS	NS	NS	NS	NS	*

Al^{3+}= Aluminium, Tot. N = Total nitrogen, H^{+} = hydrogen, Ca = Calcium, Mg = magnesium, K = potassium, Na = sodium, BS = Base saturation, ECEC = effective cation exchange capacity, Av.P = Available phosphorus, STHA = soils that had agrochemicals (rice field), * = significant difference, NS = not significant difference.

In figure 1, soils that had agrochemicals (STHA) showed almost the same arsenic (As) content 0.16mgkg^{-1}, and 0.01 to 0.02mgkg^{-1} for the control. However, there were significant different of arsenic content between soils that had agrochemicals (STHA) and control at 15-30cm depth, the concentration however, was below the (FAO/WHO) permissible limit of 1-30mg/kg.

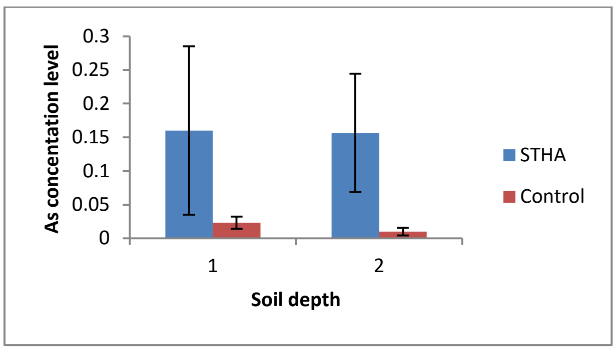

Figure 1. Arsenic content of STHA and Control at different depth (1 = 0-15cm, 2 = 15-30cm)

In figure 2, Lead (Pb) recorded highest value 0.22mgkg^{-1} at 0-15cm depth in STHA and lowest 0.13mgkg^{-1} at 0-15cm depth in control. However, there was no significant difference of lead (Pb) content between STHA and control. The concentration levels at the soil that had agrochemical and control were drastically below the (FAO/WHO) permissible limit.

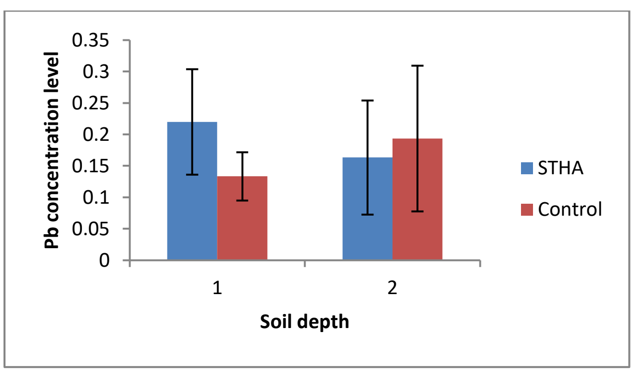

Figure 2. Lead (Pb) content of STHA and Control at different depth (1 = 0-15cm, 2 =15-30cm)

CONCLUSION

The soils were strongly to moderately acidic and showed significant difference between soils that had agrochmeicals and control, which could mean that agrochemicals that were applied in the soil have effect on soil pH. Percentage organic carbon was high at the control in comparison with STHA but has no significant difference on the studied soils. Calcium was generally low but showed significant difference. Potassium and sodium was very low, all showing no significant difference on the studied soil. Available phosphorus maintained high level at the control over soils that had agrochemicals and showed significant difference only at 0-15cm depth. The values of the heavy metals studied did not reach the FAO permissible limits in the soil (0.3mgkg^{-1} and 1-30mgkg^{-1}) for Pb and As respectively, however, the significant difference shown by arsenic content could be that the agrochemicals applied in the soil increases arsenic content.

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