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Effects of Rice mill wastes on Soil properties in a Rice-producing State of South-eastern Nigeria

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ABSTRACT

A research was conducted in 2015 and 2016 in Abakaliki, Ebonyi State, South-eastern Nigeria, to determine the effects of heavy dumping of rice mill wastes on soil properties. Samples were collected from soils in Abakaliki rice mill industry. Auger and core samples were collected from Faculty of Agriculture and Natural Resources Management, FARM (control) and at Abakaliki rice milling industry in hilly terrain at three sites namely: crest (S_1), mid-slope (S_2) and lower slope (S_3). The result showed that respective soil bulk density for S_1, S_2 and S_3 were 1.14 gcm^{-3}, 1.44 gcm^{-3} and 1.31 gcm^{-3} in 2015 and 1.58 gcm^{-3}, 1.61 gcm^{-3} and 1.50 gcm^{-3} in 2016 against control (1.64 gcm^{-3} and 1.66 gcm^{-3}) for the two years. Soil organic carbon was higher in Crest (30.30 gkg^{-1}) compared to control (5.10 gkg^{-1}), mid-slope (17.0 gkg^{-1}) and lower slope (22.20 gkg^{-1}) in 2015. In 2016, soil organic carbon was higher in S_1 (30.50 gkg^{-1}) compared to control (5.10 gkg^{-1}), S_2 (18.30 gkg^{-1}) and S_3 (25.20 gkg^{-1}). The results indicate that the soil properties studied were higher in rice mill dumpsite except for BD than control. Different sampling point in most cases did not vary among themselves. It is recommended that rice mill wastes should be used in farms as soil amendment and generation of farm energy.

1. Introduction

Rice is a major staple food in Nigeria. The rice growing areas like Ebonyi (Abakaliki), Kano and Jigawa States are faced with problems associated with the disposal of the silica-rich husk. The rice mill is one of the oldest and largest agro-processing industries in Nigeria (Kiattisak and Thanatchai, 2011). Milling is the process wherein the rice grain is transformed into a form suitable for human consumption. It has to be done with utmost care to prevent breakage of the kernel and improve the recovery. Brown rice is milled further to create more visually appealing white rice. After harvesting and drying, the paddy is subjected to the primary milling operation which includes de-husking as well as the removal of bran layers (polishing) before it is consumed. In this process, the rice which is obtained after milling is called raw rice.

The city of Abakaliki reflects an agrarian society typically, as the majority of the inhabitants are farmers while a smaller percentage are businessmen who are non-indigenes. The agrarian nature of the state has made it known popularly as the "Food basket of the nation" (Idike, 1999). The major cash crop planted in Abakaliki is rice which covers about 50 - 60 % of the total available agricultural land (Auburn, 2003). The only well-developed industry in the town to date has been the rice processing industry. The rice mill industry is located along old Abakaliki – Ogoja road on the outskirts of the town and close to the Ebonyi State University. The milling machines are housed in stalls which are arranged in rows. Altogether, there are about six rows of stalls separated by access roads about 10 m wide which allows for the convenient transportation of paddy rice from the neighbouring villages and also for the transportation of the milled rice to commercial outlets. There is a mini-market at the west end of the rice mill which is mostly patronized by the locals who come from nearby villages as well as casual rice mill workers. About 200 m away from the market lays the rice husk waste dumps. The dumps are about 100 m in diameter and heaped up to a height of 15 m above the ground level.

Rice milling in Abakaliki is undertaken by centralized mechanized plants which commonly process about 40 tons of rice per day, thus producing about 10 tons of waste per day. Ironically, tons of husks are openly burnt every day despite the feasibility of briquette as an effective and economical management technique. The ash resulting from the burning is also posing severe environmental problems that require separate management strategies. The main problems associated with ash disposal are a loss of land, water and air contamination and eventual pollution (Sridhar *et al.,* 2011).

Obi (2000), noted that soil porosity is inversely related to bulk density. Bulk density and total porosity of soil indicate soil strength and thus, the resistance the soil presents to crop root penetration. Anikwe (2000), obtained significant decreases in soil bulk density in plots of farmland amended with 4.5 and 6.0 t ha^{-1} of rice husk dust at 48 days and 60 days after planting. Nnabude and Mbagwu (1998), noted that rice mill wastes applied to the soil decreased soil bulk density and increased total porosity. Mbagwu (1989), observed that soils differ in their responses to organic waste amendments. Each waste type has a unique property that could be thoroughly investigated. Anikwe and Nwobodo (2002); Mbagwu (1989) and Oguike *et al.* (2006), showed that relative to the control, rice husk dust alone at 30 t ha^{-1} increased total soil porosity, and saturated hydraulic conductivity by 41.1% and 368.2%, and resulted in 20.9% significant decrease in soil bulk density. Rawls *et al.* (1982), compiled values of hydraulic conductivity of 1,323 soils collected from over 32 countries and observed that soils with large pores recorded higher hydraulic conductivity than soils with small pores. Cooper and Warman (1999), observed that plots of farmland with poultry manure amendments recorded higher pH value than those without poultry manure.

Soil nitrogen is absorbed from the soils by plants in the form of $N0_3$ and NH_4^+ except in legumes where it may also be absorbed as elemental nitrogen through the help of rhizobia bacteria (Nnoke, 2001). Mineral Colloids and organic matter constitute the soil exchange complex, being negatively charged and retained nutrient cations (Nwinyi, 1997). Organic wastes contributed very significantly to the soil cation. Recent studies had shown that organic waste (i.e., rice mill wastes) increased soil organic matter, nitrogen, pH, phosphorous, cation exchange capacity (CEC) and reduced soil exchangeable acidity (Adeniyan and Ojeniyi, 2002; Mbah, 2006; Ayeni *et al.*, 2008; Adeleyen *et al.,* 2010**).**

2. Materials and Methods

2.1 Study Area/ Site

The study area is Abakaliki, while the study site is Abakaliki Rice Mill Industry. The area is located in Abakaliki the capital city of Ebonyi State. It is situated in the South eastern part of Nigeria and has a population of about 160 thousand people accounting for about ten percent of the state population (National Population Census, NPC, 2006). Abakaliki rice mill industry is located on latitude $06^0 4^1$N and longitude 8^0 65^1E. The rice mill industry is located along old Abakaliki - Ogoja road on the outskirts of the town and close to the Ebonyi State University. It covers approximately an area of about 500 m^2. Abakaliki, one of the thirteen Local Government Areas in Ebonyi State, was made the state capital in 1996 (Echiegu, 2007). The rainfall pattern is bimodal (April – July and September – November), with a short dry spell in August normally referred to as "August break." The total annual rainfall in the area ranges from 1500 - 2000 mm, with a mean of 1800 mm. At the onset of rainfall, it is torrential and violent sometimes lasting for one to two hours (Okonkwo and Ogu, 2002). The area is characterized by high temperatures with a minimum mean daily temperature of 31^0C throughout the year. According to the Overseas Development of Natural Resources (ODNRI, 1989), humidity is high (80 %). The lowest (60 %) level occurs during the dry season between December and April before the rainy season begins. Geologically, the area is underlain with sedimentary rocks derived from successive marine deposits of the Cretaceous and Tertiary periods. The soil belongs to the order ultisol derived from shale and classified as typic haplustult. According to the Federal Department of Agriculture and Land Resources (FDALR, 1985), Abakaliki agricultural zone lies within "Asu River group" and consists of olive brown sandy shale, fine-grained sandstone, and mudstones. These conditions favour rice cultivation.

Soil sampling

Core and auger samples were collected at 0 – 25cm uniform soil depth in the study site as follows:
Control – Faculty of Agriculture, EBSU
Sample S_1 – Crest
Sample S_2 – Mid slope
Sample S_3 – Lower slope
Core samples collected from the various site were used to determine soil physical properties, while auger (100g) samples were air-dried at room temperature (about 26 ^oC) and passed through a 2 mm sieve for the determination of soil chemical properties.

2.2 Sample Analysis

2.2.1 ***Soil analysis***

Bulk density (Db): Dry bulk density was determined as described by Blake and Hartage (1986). It was calculated as shown in the formula below:
The sample was clamped to a burette stand, and an empty funnel was used to collect the water leachate.

$$\text{Bulk density (Db)} = \frac{\text{Weight of Oven Dried soil}}{\text{Volume of undisturbed soil}} \quad - \quad - \quad - \quad - (1)$$

Total porosity: The method as described by Carter and Ball (1993) was used to measure total porosity and air-filled (macro) and water (micro) porosity. Total Porosity was derived from the measurement of dry bulk density (Db), and soil particle density (Ps) assumed to be 2.65 Mgm^{-3}

$$\text{Thus,} \quad S_t = [1-Db/Ps] \times 100/1 \quad - \quad - \quad - \quad - \quad - \quad - (2)$$

Where: Db = Dry Bulk Density
Ps = Soil Particle Density

Hydraulic conductivity: This was determined as described by Landon (1991). A core containing soil sample was tied to one end with a calico cloth to avoid soil wash, and the sample stood vertically in a basin with the end bearing the cloth downwards. Water was poured into the basin to reach half of the length of the core and allowed to stand for 24 hours. At the end of the 24 hours, the sample was removed and carefully connected to the empty core of the same width using cello-tape to avoid water leakage. The height of 2.5cm was marked within the space in the core. The sample was clamped to a burette stand, and an empty funnel was used to collect the water leachate.

Measuring cylinder was connected under the funnel to measure the volume of water collected. In the attached core, the water was filled to 2.5cm mark height, and this height was maintained constantly for 5 minutes. Thus:

$$K = Q/At \times L/\Delta H \quad - - -- - (3)$$

Where: K = Hydraulic Conductivity
Q = Quantity of water being collected constantly
A = Area of the core containing soil sample
t = Time interval of collection
L= Length of the core containing core sample
ΔH = Constant water level being maintained.

Soil pH: The pH of the soil was determined using a glass electrode pH meter in soil/water, in the ratio of 1:2.5. After stirring for 30 minutes, the pH values were read off (Peech, 1995).

Available phosphorus: This was determined by the Bray method as described by Page *et al.* (1982). The available phosphorus was read off from the standard curve obtained from optical density using a colorimeter.

Total nitrogen: This was determined using the micro Kjeldahl distillation method Bremner (1996). The ammonia from digestion was distilled with 45% NaOH into 2.5% boric acid and determined by titrating with 0.05 N KCl.

Organic carbon: This was determined using the method described by Nelson and Sommers (1982).

Organic matter: The percentage organic matter was calculated by multiplying the value for organic carbon by a factor of 1.724, which is based on the assumption that soil organic matter (SOM) contains 58% C (Allison, 1982).

Exchangeable bases: Calcium (Ca) and magnesium (Mg) were determined by titration method (Mba, 2004). Sodium (Na) and Potassium (K) were extracted with 1N ammonium acetate solution (NH_4OAc) and determined using flame photometer.

Total exchangeable acidity: The titrimetric method using a 1NKCl extract of Mclean (1982) was used in the determination of total exchangeable acidity (Al^{3+} and H^+).

Effective cation exchange capacity (ECEC): This was evaluated by the summation method as follows:

$$ECEC = TEB + TEA \quad -- \quad - \quad - \quad -(4)$$

Where; ECEC = Effective Cation Exchange Capacity (cmol kg^{-1} soil)
TEB = Total Exchangeable Bases (cmol kg^{-1} soil)
TEA = Total Exchangeable Acidity (cmol kg^{-1} soil)

Base saturation (BS): Base Saturation (BS) was calculated by dividing Total Exchangeable Bases (TEB) with Cation Exchangeable Capacity value and multiplying by 100. The expression is thus:

$$\%\,B.S. = \frac{TEB}{CEC} \times 100 \quad - \quad - \quad -(5)$$

Where: BS = Base Saturation

TEB = Total Exchangeable Bases (cmol kg^{-1} soil)

CEC = Cation Exchange Capacity.

2.2 2 Data Analysis

The data collected were analyzed using standard error and coefficient of variation (CV %) as recommended by Steel and Torrie (1980).

3. Results

3.1 *Impact of heavy dumping of rice mill wastes on bulk density, total porosity and hydraulic conductivity of the soil*

The result of the effect of rice milling activities on bulk density, total porosity and hydraulic conductivity of soil is presented in Table 1. Soil bulk density (Db) was 1.64gcm^{-3} and 1.66gcm^{-3} in control area (FAC, EBSU) and higher than S_1 (Crest), S_2 (Mid slope) and S_3 (Lower slope) which had 1.14gcm^{-3}, 1.44gcm^{-3} and 1.31gcm^{-3} respectively in 2015 and 1.58gcm^{-3}, 1.61gcm^{-3} and 1.50gcm^{-3} respectively in 2016. In 2015, control area increased in soil bulk density relative to S_1, S_2 and S_3 by 30, 12 and 20 % respectively; while S_1 decreased relative to control, S_2 and S_3 by 44, 26 and 15 % respectively. In 2016, soil bulk density (Db) was high in control area relative to S_1, S_2 and S_3 by 5, 3 and 10% respectively, while S_3 decreased by 11, 5 and 7% relative to control, S_1 and S_3. The result showed that the different sampling points did not vary in 2015 (CV = 15.22 %) and 2016 (CV = 4.40 %).
Soil total porosity in S_1 (Crest) recorded the highest value of 56.98% relative to control (FAC, EBSU), S_2 (Mid slope) and S_3 (Lower slope) which had 38.11%, 45.66%, and 50.57% respectively in 2015; while in 2016, S_3 recorded the highest value of 43.40 % relative to control, S_1 and S_2 which had 37.36%, 40.38%, and 39.25% respectively. Total porosity for S_1, S_2 and S_3 in 2015 was higher than control by 50, 20 and 33% respectively. In 2016, soil total porosity for S_1, S_2, and S_3 increased relative to control by 8, 5 and 16% respectively. There was no variation in soil total porosity among different sampling points in 2015 (CV = 16.7%) and in 2016 (CV = 6.31%).

Hydraulic conductivity was higher in S_1 (Crest) relative to control (FAC, EBSU), S_2 (Mid slope) and S_3 (Lower slope) in 2015 and 2016 with the values of 0.33cmhr^{-1} and 0.31cmhr^{-1} respectively. In 2015, the order of decrease in soil hydraulic conductivity was control < S_2< S_3< S_1. In 2016, it increased as follows: S_1> S_3> S_2> control. There was no variation among different sampling points in 2015 (CV = 18.44%). There was variation among different sampling points in 2016 (CV= 52.68%).

Table 1: Impact of Heavy Dumping of Rice Mill Wastes on Bulk Density, Total Porosity and Hydraulic Conductivity of Soil

Sample	2015			2016		
	Bulk Density (gcm^{-3})	Total Porosity (%)	Hydraulic Conductivity (cmhr^{-1})	Bulk Density (gcm^{-3})	Total Porosity (%)	Hydraulic Conductivity (cmhr^{-1})
Control	1.64 ± 0.15	38.11 ± 5.61	0.10 ± 0.06	1.66 ± 0.04	37.36 ± 1.58	0.09 ± 0.06
S_1	1.14 ± 0.14	56.98 ± 5.28	0.33 ± 0.07	1.58 ± 0.01	40.38 ± 0.16	0.31 ± 0.07
S_2	1.44 ± 0.04	45.66 ± 1.25	0.15 ± 0.03	1.61 ± 0.01	39.25 ± 0.49	0.13 ± 0.03
S_3	1.31 ± 0.04	50.57 ± 1.58	0.27 ± 0.03	1.50 ± 0.05	43.40 ± 1.91	0.23 ± 0.2
CV (%)	15.22	16.70	18.44	4.40	6.31	52.63

Note: Control = Faculty of Agriculture, EBSU; S_1 = Crest; S_2 = Mid slope; S_3 = Lower slope
Source: Field Work (2015 and 2016).

3.2 Impact of Heavy Dumping of Rice mill wastes on pH, available phosphorus and total nitrogen of soil

The result of the impact of rice mill wastes on pH, available phosphorus and total porosity of soil is presented in Table 2. The result showed that S_1 recorded 6.98 of soil pH which was the highest value relative to control (5.62), S_2 (6.04) and S_3 (6.32) in 2015. Control was lower than S_1, S_2, and S_3 by 24, 7 and 12 % respectively in 2015. S_1 (6.98) recorded the highest value in soil pH relative to control (5.96), S_2 (6.10) and S_3 (6.40) respectively in 2016. Control was lower than S_1, S_2, and S_3 by 17, 2 and 7% respectively in 2016. There was no variation among different sampling points in 2015 (CV = 9.15%) and 2016 (CV = 7.08%).

There was higher value of soil available phosphorus recorded in S_1 (54.96 mgkg^{-1}) relative to control (18.60 mgkg^{-1}), S_2 (19.0mgkg^{-1}) and S_3 (48.50mgkg^{-1}) in 2015. Similarly, S_1 (56.08mgkg^{-1}) recorded higher value than control (19.07mgkg^{-1}), S_2 (21.02mgkg^{-1}) and S_3 (53.50 mgkg^{-1}) in 2016. Soil available phosphorus for S_1, S_2 and S_3 was higher than control by 195, 2 and 161% respectively in 2015; while in 2016 S_1, S_2 and S_3 increased relative to control by 194, 10 and 181% respectively. There was variation among different sampling points 2015 (CV = 54.42%) and 2016 (CV = 53.71%).

Total nitrogen in S_1 recorded 2.80gkg^{-1}which was higher than control (0.60gkg^{-3}), S_2 (0.70gkg^{-1}) and S_3 (1.0gkg^{-1}) in 2015. S_1 (3.0gkg^{-1}) again, recorded the highest value compared to control (0.90gkg^{-1}), S_2 (1.40gkg^{-1}) and S_3 (1.40gkg^{-1}) and S_3 (1.40gkg^{-1}) in 2016. In 2015, the order of increase in soil total nitrogen was $S_1 > S_3 > S_2 >$ control; while in 2016, control was lower than S_1, S_2 and S_3 by 233, 56 and 56% respectively. There was variation among different sampling points for soil total nitrogen in 2015 (CV = 80.47%) and 2016 (CV = 54.76%).

Table 2: Impact of Heavy Dumping of Rice Mill Wastes on pH, Available Phosphorus and Total Nitrogen Content of Soil

Sample	2015			2016		
	pH (H_2O)	Available Phosphorus (mgkg^{-1})	Total Nitrogen (gkg^{-1})	pH (H_2O)	Available Phosphorus (mgkg^{-1})	Total Nitrogen (gkg^{-1})
Control	5.62 ± 0.36	18.60 ± 9.62	0.60 ± 0.39	5.96 ± 0.23	19.07 ± 10.59	0.90 ± 0.45
S_1	6.98 ± 0.43	54.96 ± 11.37	2.80 ± 0.88	6.98 ± 0.36	56.08 ± 10.77	3.00 ± 0.76
S_2	6.04 ± 0.12	19.00 ± 9.39	0.70 ± 0.33	6.10 ± 0.15	21.02 ± 9.47	1.40 ± 0.16
S_3	6.32 ± 0.05	48.50 ± 7.64	1.00 ± 0.16	6.40 ± 0.02	53.50 ± 9.28	1.40 ± 0.16
CV (%)	9.15	54.42	80.47	7.08	53.71	54.76

Note: Control = Faculty of Agriculture, EBSU; S_1 = Crest; S_2 = Mid slope; S_3 = Lower slope
Source: Field Work (2015 and 2016).

3.3 Impact of Heavy Dumping of Rice mill wastes on Organic carbon, C/N ratio and Organic matter content of soil

Table 3 showed that soil organic carbon was higher in Crest (30.30gkg^{-1}) compared to control (5.10gkg^{-1}), mid slope (17.0gkg^{-1}) and lower slope (22.20gkg^{-1}) in 2015. In 2016, soil organic carbon was higher in S_1 (30.50gkg^{-1}) compared to control (5.10gkg^{-1}), S_2 (18.30gkg^{-1}) and S_3 (25.20gkg^{-1}). In 2015, control was lower than S_1, S_2 and S_3 by 494, 233 and 335% respectively. In 2016, control was lower than S_1, S_2 and S_3 by 498, 259 and 394% respectively. Soil organic carbon levels were variable among different sampling points in 2015 (CV = 56.64%) and 2016 (CV = 55.56%).

C/N ratio was high in S_2 (24.29) relative to control (8.50), S_1 (10.82) and S_3 (22.65) in 2015. Control was lower than S_1, S_2, and S_3 by 27, 186 and 166% respectively in 2015. High C/N ratio was obtained in S_3 (18.0) compared to control (5.67), S_1 (10.17) and S_2 (13.07) in 2016. S_3 was higher than control, S_1 and S_2 by 69, 44 and 27% in 2016. Control recorded the least values of 8.50 and 5.67 in 2015 and 2016 respectively. There was no variation among the different sampling points in 2015 (CV= 48.63%) and 2016 (CV= 44.08%).

Soil organic matter was higher in S_1 (52.20gkg^{-1}) compared to control (25.0gkg^{-1}), S_2 (29.30gkg^{-1}) and S_3 (38.30gkg^{-1}) in 2015. Again in 2016, S_1 (53.0gkg^{-1}) recorded the highest value relative to control (25.0gkg^{-1}), S_2 (32.50gkg^{-1}) and S_3 (40.0gkg^{-1}). Soil organic matter content decreased as follows: control < S_2 < S_3 < S_1 in 2015; while in 2016, the order of increase was S_1 > S_3 > S_2 > control. There was no variation among different sampling points in 2015 (CV = 33.20%) and 2016 (CV = 31.73%).

Table 3: Impact of High Dumping of Rice Mill Wastes on Organic Carbon, C/N Ratio and Organic Matter Content of Soil

Sample	2015			2016		
	Organic Carbon (gkg^{-1})	C/N Ratio	Organic Matter (gkg^{-1})	Organic Carbon (gkg^{-1})	C/N Ratio	Organic Matter (gkg^{-1})
Control	5.10 ± 7.82	8.50 ± 4.66	8.79 ± 15.83	5.10 ± 8.48	5.67 ± 3.50	8.79 ± 16.65
S_1	30.30 ± 6.73	10.82 ± 3.32	52.20 ± 9.24	30.50 ± 6.19	10.17 ± 0.90	53.00 ± 8.87
S_2	17.00 ± 0.95	24.29 ± 4.46	29.30 ± 3.98	18.30 ± 0.85	13.07 ± 0.77	32.50 ± 2.96
S_3	22.20 ± 2.05	22.65 ± 3.51	38.30 ± 1.21	25.20 ± 3.13	18.0 ± 3.62	40.00 ± 1.37
CV(%)	56.64	48.63	33.20	55.56	44.08	31.73

Note: Control = Faculty of Agriculture, EBSU; S_1 = Crest; S_2 = Mid slope; S_3 = Lower slope
Source: Field Work (2015 and 2016).

3.4 Impact of Heavy Dumping of Rice mill Wastes on Soil exchangeable bases

Calcium (Table 4) was higher in S_1 (13.60cmol (+) kg^{-1}) compared to control (5.60cmol (+) kg^{-1}), S_2 (12.00cmol (+) kg^{-1}) and S_3 (9.0cmol (+) kg^{-1}) in 2015. Control was lower than S_1, S_2 and S_3 by 143, 114 and 61% respectively in 2015. S_1 (14.60cmol (+) kg^{-1}) also recorded a high value than control (5.60cmol (+) kg^{-1}), S_2 (12.0cmol (+) kg^{-1}) and S_3 (11.50cmol (+) kg^{-1}) in 2016. S_1, S_2 and S_3 were higher than control by 161, 114 and 105% respectively in 2016. There was variation among different sampling points in 2015 (CV=35.63%) and 2016 (CV = 34.77%).

Magnesium (Mg^{2+}) was higher in S_1 (7.40cmol (+) kg^{-1}) in 2015; and in 2016 (7.40cmol (+) kg^{-1}) relative to control, S_2 and S_3. In 2015, the order of decrease was control < S_3 < S_2 < S_1. In 2016, control area (3.20cmol (+) kg^{-1}) was lower than S_1, S_2 and S_3 by 131, 38 and 109% respectively.

There was no variation among different sampling points in 2015 (CV= 38.59%) and 2016 (CV = 36.10%).

Potassium (K^+) was higher in S_2 (0.20cmol (+) kg^{-1}) in 2015 while in 2016, control was highest with 1.30cmol (+) kg^{-1}. S_2 was higher than control, S_1 and S_3 in 2015 by 50, 50 and 50% respectively; while in 2016, the order of increase was control > S_1 > S_2 > S_3. There was no variation among different sampling points in 2015 (CV = 34.40%). There was variation among different sampling points in 2016 (CV = 64.0%).

Sodium (Na^+) recorded significantly higher value in S_3 (0.19cmol (+) kg^{-1}) relative to control (0.09 cmol (+) kg^{-1}), S_1 (0.16cmol (+) kg^{-1}) and S_2 (0.18cmol (+) kg^{-1}) in 2015. S_3 was higher than control, S_1 and S_2 by 53, 16 and 5% respectively. But in 2016, S_2 (0.20cmol (+) kg^{-1}) and S_3 (0.20cmol (+) kg^{-1}) recorded the highest values in Na^+ compared to control area (0.10cmol (+) kg^{-1}) and S_1 (0.16cmol (+) kg^{-1}). There was no variation among different sampling points in 2015 (CV= 27.95%) and 2016 (CV = 29.41%).

Table 4: Impact Heavy Dumping of Rice Mill Wastes on Soil Exchangeable Bases (cmol (+) kg^{-1})

Sample	2015				2016			
	Ca^{2+}	Mg^{2+}	K^+	Na^+	Ca^{2+}	Mg^{2+}	K^+	Na^+
Control	5.60 ± 2.57	3.20 ± 0.89	0.10 ± 0.02	0.09 ± 0.04	5.60 ± 3.08	3.20 ± 1.29	1.30 ± 0.32	0.10 ± 0.04
S_1	13.60 ± 2.05	7.40 ± 1.53	0.10 ± 0.02	0.16 ± 0.00	14.60 ± 2.12	7.40 ± 1.14	1.00 ± 0.14	0.16 ± 5.77
S_2	12.00 ± 1.13	4.40 ± 0.20	0.20 ± 0.04	0.18 ± 0.01	12.00 ± 0.62	4.40 ± 0.59	0.40 ± 0.20	0.20 ± 0.02
S_3	9.00 ± 0.64	4.00 ± 0.43	0.10 ± 0.02	0.19 ± 0.02	11.50 ± 0.33	6.70 ± 0.73	0.30 ± 0.26	0.20 ± 0.02
CV(%)	56.91	38.59	34.40	27.95	34.77	36.10	64.00	29.41

Note: Control = Faculty of Agriculture, EBSU; S_1 = Crest; S_2 = Mid slope; S_3 = Lower Slope
Source: Field Work (2015 and 2016)

3.5 Impact of Heavy Dumping of rice mill Wastes on exchangeable acidity (EA), effective cation exchange capacity (ECEC) and base saturation (BS) of soil

The result (Table 5) showed that there was higher value of EA in control (1.90cmolkg^{1}) relative to S_1 (0.70cmolkg^{-1}), S_2 (0.80cmolkg^{-1}) and S_3 (1.60cmolkg^{-1}) in 2015. Control (2.0cmolkg^{-1}) was higher than S_1 (0.90cmolkg^{-1}), S_2 (1.80cmolkg^{-1}) and S_3 (1.60cmolkg^{-1}) in 2016. The order of increase in 2016 was control > S_2 >S_1 >S_3. In 2016, control was higher than S_1, S_2 and S_3 by 55, 10 and 20% respectively. There was no variation among different sampling points in 2015 (CV = 47.33%) and 2016 (CV = 30.38%).

Effective Cation Exchange Capacity (ECEC) was higher in S_1 (21.97cmolkg^{-1}) relative to control area (4.85cmolkg^{-1}), S_2 (17.78 cmolkg^{-1}) and S_3 (14.95cmolkg^{-1}) in 2015. Again in 2016, S_1 (6.69cmolkg^{-1}) was also higher compared to control (4.55cmolkg^{-1}), S_2 (6.05 cmolkg^{-1}) and S_3 (6.28 cmolkg^{-1}). In 2015, control was lower than S_1, S_2 and S_3 by 353, 267 and 208 % respectively. There was no variation among different sampling points in 2015 (CV = 48.93 %) and 2016 (CV = 15.79 %).

Base saturation was 97.0 %, 95% and 89% in 2015 and 86.55%, 70.25% and 74.44% in 2016 for S_1, S_2 and S_3 respectively. These were higher than control for the two years (63% and 56.04%) respectively. The order of decrease in 2015 was control < S_3< S_2 <S_1; while in 2016, base saturation increased as follows: S_1 > S_3 > S_2 > control. There was no variation among different sampling points in 2015 (CV= 18.26 %) and 2016 (CV = 17.53 %).

Table 5: Impact of Heavy Dumping of Rice Mill Wastes on Exchangeable Acidity (EA), Effective Cation Exchange Capacity (ECEC) and Base Saturation (BS) of Soil

Sample	**2015**			**2016**		
	EA (cmolkg^{-1})	**ECEC (cmolkg^{-1})**	**BS (%)**	**EA (cmolkg^{-1})**	**ECEC (cmolkg^{-1})**	**BS (%)**
Control	1.90 ± 0.38	4.85 ± 5.80	63.00 ± 13.28	2.00 ± 0.24	4.55 ± 0.77	56.04 ± 9.11
S_1	0.70 ± 0.32	21.97 ± 4.09	97.00 ± 6.35	0.90 ± 0.39	6.69 ± 0.46	86.55 ± 8.50
S_2	0.80 ± 0.26	17.78 ± 1.67	95.00 ± 5.20	1.80 ± 0.13	6.05 ± 0.09	70.25 ± 0.91
S_3	1.60 ± 0.20	14.95 ± 0.03	89.00 ± 1.73	1.60 ± 0.01	6.28 ± 0.23	74.44 ±1.51
CV (%)	47.20	48.93	18.26	30.38	15.79	17.53

Note: Control = Faculty of Agriculture, EBSU; S_1 = Crest; S_2 = Mid slope; S_3 = Lower slope
Source: Field Work (2015 and 2016)

4. DISCUSSION

Mbah and Nwite (2008) observed that management practices such as, continuous tillage and removing or burning residues increase bulk density, while such practices as the addition of organic wastes or amendments decrease soil bulk density. According to Obi (2000), bulk density and total porosity of soil indicate soil strength, and thus the resistance the soil presents to crop root penetration. Soil porosity is inversely related to bulk density. The result (Table 1) showed that soil bulk density was higher in control (FAC, EBSU) relative to the rice mill site on Crest (S_1), Mid slope (S_2) and Lower slope (S_3) in 2015 and 2016. The value ranged from 1.14gcm^{-3} to 1.44gcm^{-3} in 2015, and 1.50gcm^{-3} to 1.61gcm^{-3} in 2016. Low soil bulk density values observed in S_1, S_2, and S_3 might be as a result of dumping activities in the site which had reduced bulk volume of soil. The presence of rice husk dust rich in organic matter (OM) reduces soil compaction (Anikwe and Nwobodo, 2002). Soil total porosity followed a similar trend as soil bulk density but in reverse order as shown in Table 1. As soil bulk density increased, total soil porosity decreased. Mbagwu (1989) observed that organic wastes in soils reduced soil bulk density and increased soil total porosity. According to Nnabude and Mbagwu (1998), low bulk density and higher total porosity increased water transmissivity, root penetration, and hence cumulative feeding area of crops which would translate to better yield. Results of the study (Table 1) also showed higher values of saturated hydraulic conductivity in S_1, S_2, and S_3 relative to control in 2015 and 2016. According to Rawls *et al.* (1982), soils with large pores recorded higher hydraulic conductivity than soils with small pores. Higher saturated hydraulic conductivity means better water transmission and hence reduction in waterlogging (Anikwe, 2000). As shown in Table 2, rice milling activities increased soil pH of the rice mill site (S_1, S_2, and S_3) relative to control. This increase in soil pH could be attributed to the effect of the milling activities and the rice mill waste on soil chemical properties. According to Cooper and Warman (1999), higher pH in soil might partly be due to the calcium supplied to the soil by organic wastes. Oguike *et al.* (2006) observed that the presence of organic matter in soils influenced their pH value. Higher values of available soil phosphorus (Table 2) were obtained in S_1, S_2 and S_3 relative to control. The pH of the soil (Table 2) influenced the level of availability of phosphorus since the availability of phosphorus, and its solubility is pH dependent. Available phosphorus was relatively higher on the Crest (S_1) in rice mill site followed by S_3 and S_2 relative to control in 2015 and 2016. This could be attributed to the high amount of rice husk dust from the rice mill industry. Mbagwu (1992), observed that the presence of rice husk dust in soil increased soil available phosphorus. Soil total nitrogen was higher in S_1 relative to control, S_2 and S_3. Furthermore, higher values of soil organic carbon (SOC), C/N ratio and organic matter (OM) were obtained in S_1, S_2 and S_3 relative to control (Table 3). The result of the study (Table 4) showed higher values of soil exchangeable bases (Ca^{2+}, Mg^{2+}, K^{+}, and Na^{+}) in S_1, S_2 and S_3 relative to control. This higher value showed that the rice mill waste increased the levels of exchangeable soil bases of the industrial site. According to

Nwinyi (1997), organic wastes serve as a nutrient store from which basic cations are slowly released and constitute the soil exchange complex, being negatively charged and retained nutrient cations. Table 5 showed that rice milling activities increased effective cation exchange capacity (ECEC) and base saturation (BS), but decreased exchangeable acidity (EA) relative to control. Adeleye *et al.* (2010) observed that rice mill waste increased soil total exchangeable bases and lowered exchangeable acidity. Adeniyan and Ojeniyi (2003); Mbah (2006); Ayeni *et al.* (2008) and Adeleye *et al.* (2010) also reported that rice mill wastes increased soil organic matter, total nitrogen, pH, soil available phosphorus, ECEC, BS, and reduced soil exchangeable acidity.

5. Conclusion

The results indicated that the soil properties studied were higher in rice mill dumpsite except for BD than control. Different sampling point in most cases did not vary among themselves. Rice mill waste should be used in farms as soil amendments, as well as biomass to generate energy and briquette. This will help to reduce the mountainous heaping of these wastes.

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