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The effect of rice husk dusts treated with urine on soil fertility status and yield of upland rice in Abakaliki, Southeastern, Nigeria

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ABSTRACT

To enhance nutrient release by rice husk dusts, it was treated with human urine, swine slurry and water; with an untreated rice husk dust and control (no rice husk dust) as standards. These treatments were laid out in the field in a Randomized Complete Block Design (RCBD) replicated four times. The result show that human urine decomposed material recorded pH of 5.89 (medium acid); total organic carbon and total organic matter of 215 and 370.7g kg^{-1} respectively, which are rated as high. The exchangeable K, Ca, Mg, and Na were 34.29; 46.28; 34.8 and 21.4 cmol kg^{-1} respectively which are high. The swine slurry and water decomposed rice husk dust recorded similar properties. The nutrient release was more in human urine and swine slurry decomposed rice husk dusts plot compared to control. For example, rice grain yield were 3.5, 4.03 and 4.17 t ha^{-1} for three years of study in human urine plot, and 3.30,3.35 and 4.02 t ha^{-1} in swine slurry plot. Hence, urine decomposition was good option for converting lignin high rice husk dust to nutrient rich organic amendment in tropical Nigeria. The pre-treatment of human urine before application was recommended to allay health and environmental scare by farmers/agriculturists and consumers.

1.0 Introduction

Tropical soils are beset with multiple challenges ranging from continuous decline in soil fertility, productivity, erosion, acidity, salinity, sodicity to ravaging pests and diseases, global warming and climate change (Ifejimalu, 2021; Aya, 2021; Obazi, 2021). In addressing soil fertility and productivity continuous use of organic and inorganic fertilizers has been recommended by many researchers (Okey, 2019; Okeke 2021; Imachi, 2021, Nwokwu, 2021). The problem in use of inorganic fertilizers lies with incessant losses of the nutrients via leaching, ammonification, denitrification and that most of the inorganic fertilizers can lead to soil acidity, alkalinity, salinity and sodicity (Kalueni, 2020; Anozie, 2020). The alternative to inorganic fertilizer is the use of organic fertilizers namely: animal dung, animal wastes, animal urine, human urine, agricultural field and processing wastes, selective municipal wastes (Anozie, 2020, Okey, 2019). Organic wastes or fertilizers are gradually degraded and released to the soil, improves soil physico-chemical properties over longer period of time and reduces the problems associated with the use of inorganic fertilizers (Anozie, 2020; Abdel-Haliem, *et al.,* 2017).

The use of organic fertilizers depends on availability in the right quality and quantity in various agro-ecological regions as most of them are either burnt in the course of land preparation or dumped in landfill sites (Anozie, 2020; Abdullahi and Kutama, 2012).

In Abakaliki South Eastern Nigeria, the major occupation is farming in rice, yam, cassava, cocoyam, bambaranut, cowpea, and vegetables which generate agricultural wastes. One of this waste is rice mill husks that are found in large quantity in the area but not popular as organic manure (Nwokwu, 2021, Obiodu, 2019).

The rice husk dusts is not popular because it is very hard to degrade and release nutrients. Researchers at Department of Soil Science and Environmental Management, Ebonyi State University Abakaliki, Nigeria have been researching for long time on what makes rice husk dusts difficult to degrade and release soil nutrients particularly N,P,K, Ca and Mg (Nwite, 2012; Okonkwo *et al.,* 2011; Mbah and Mbagwu, 2003; Nnabude and Mbagwu, 2001). The Scientists have discovered high ligmin content in rice husk dusts which hinder mineralization. They have been testing several approaches to degrade this element such as using inorganic fertilizers, animal dung and other agricultural wastes (Okey, 2019).

In 1998 the researchers started pot experiments using water and animal urine to degrade the rice husk dust before field application. This yielded positive results (Onyibe, 2014). Subsequently, attempts have been made to extrapolate the works to field conditions and popularize them among farmers of Abakaliki and Ebonyi State. This lead to cases of how to generate enough animal urine to be used in pre-treating the rice husk dusts for nutrient release as cattle, goat, sheep, pig and other animal are very difficult to be tamed and their urine collected. This led to the option of using human urine since man can generate urine in buckets and pots at will. The next challenge lay on farmers and consumers acceptability on the use of human urine in boosting soil fertility and crop production. The University researchers started with pot experiments using human urine without any form of pre-treatment; as certain pre-treatment can trigger chemical reactions that can lead to volatilization of nutrients. The researchers believed that such pre-treated rice husk dusts once applied to the soil can easily be denatured by soil microbes, thereby proving that human urine cannot transfer pathogens to seeds or crops when incorporated in the soil. Hence the objective of current work was to use harvested human urine, swine or pig slurry, in addition to water to pre-treat rice husks dust and quicken mineralization for certain weeks before incorporating the rice husk dust in the field, followed by soil and crop assessment. This is geared towards monitoring nutrient release, crop growth and yield (with upland rice) as a test crop that is also popular in the area.

2.0. Materials and Methods

2.1. Site Description

The study was carried out in the Research and Teaching Farm of Department of Soil Science and Environmental Management; Ebonyi State University, Abakaliki. It lies by latitude $06^0 04'$N and longitude $08^0 65'$E. The area is referred to as derived savannah belt of Southeastern Nigeria. The annual rainfall ranges from 1700 – 2000mm with a mean of 1800mm spread from April – November. There is a dry spell in August popularly known as “August Break” The mean annual temperature during rainy and dry seasons are 27^0C and 31^0C respectively. Relative humidity during rainy and dry season are between 80% and 60% respectively (NiSMet, 2020).

2.2. Experimental design/layout and treatment applications

The rice husk dusk was sourced from Abakaliki rice mill. Swine slurry was collected from the Department of Animal Science, Ebonyi State University, Abakaliki. Human urine was collected from student’s hostels. Fresh water was from pipe-borne water at Ebonyi State University, Abakaliki. The test crop (rice), Farrow 55 (Nerrica) was sourced from Ebonyi State Agricultural Development Programme, Abakaliki. Twenty buckets of $6232.94cm^3$ volume was used for the decomposition; while a wire mess of $750m^2$ (30mx25m) that was used to drive away flies was procured from Abakaliki International Market.

To each bucket was measured 4t ha^{-1} or $64kg^{-1}$ plot rice husk dusts, followed by application of 5 litres of human urine, swine slurry and water respectively. The contents were mixed together and confined in an open space with wire-mess for three months before field application.

The site measuring 22m x 20m ($440m^2$), approximately 0.05 ha was cleared of vegetation and debris removed without burning. The area was then mapped into plots measuring 4m x 4m ($16m^2$) with 0.5m spacing between plots and 1m spaces between blocks.

The experiment was laid out in a Randomized Complete Block Design (RCBD). The treatments were: 4t ha^{-1} each of human urine, swine slurry and water decomposed rice husk dusts, with undecomposed rice husk dust and no application as reference.

The treatments were replicated four times to give 20 treatments in the experiment. These treatments were incorporated into the soil during seedbed preparation (beds). The rice seeds were sown at a spacing of 25cm x 50cm at 5cm depth. Supplying of missing stands was done at 2 weeks after planting. This gave a plant density of 160 stands per plot or 100,000 stands per hectare. Weeds were removed manually at three weekly intervals until harvest. The second and third year were residual experiment (no rice husk dust application).

2.3. Soil Sampling

Composite soil sampling was collected with soil auger randomly at 20 points from the site at a depth of 0-20cm before land clearing and seedbed preparation. Similarly, core and auger samples were collected at 2 points in each plot after planting for post harvest analysis. The auger samples were used for assessment of particle size distribution, moisture, aggregate stability and chemical properties of soil. Core samples were used for determining of total porosity, bulk density, hydraulic conductivity, infiltration rate; while penetration resistance was recorded with pocket penetrometer.

2.4. Laboratory Methods

Soil pH was determined in soil: water ratio of 1:25 using a glass pH meter as described by Maclean (1982). 10g of soil sample was weighed into a 50ml beaker, 25ml of distilled water was added to the soil sample and was stirred with a strong rod and allowed to stand for 30 minutes. Then, pH meter was put into use and allowed to stabilize for about 3 minutes. Then, the glass electrode of pH meter was inserted into the partly settled suspension and the reading of the pH meter was taken.

Total nitrogen was determined using modified micro-kjeldahl disgestion procedure as described by Bremner and Mulvancy (1982). A catalyst mixture of $CuSO_4/Na_2/Na_2SO_4$ was used. The ammonia from the digestion was distilled with 45% NaOH into 2.5% boric acid and determined by titration with 0.05N KCl.

Total organic carbon was determined using Walkely and Black method as described by Nelson and Sommers (1982). Organic matter was calculated from the organic carbon using a constant 1.724 often called the Van-Bremmer Factor; which is based on the assumption that soil organic matter contains 58% C (Allison, 1982).

Available phosphorus was determined by the Bray-2 method described by Page *et al* (1982). The 3.0g of air dried soil was weighed (passed through 2mm sieve) into a 50ml centrifuge tube, plus 20ml of extracting solution. The mixture was shaken for 1 minute on a mechanical shaker, centrifuged at 2000 rpm for 15 minutes. The sample mixture was filtered through Whatman No 42 filter paper into acid-washed container. Also, 8ml of stannous Chloride reagent was added to the extract and mixed thoroughly. It was left for 10 minutes, followed by taking of absorbance reading at 882nm wavelength. Then the plot was read off with reference to standard phosphorus solution. The quantity of phosphorus in ppm corresponding to absorbance transmittance was recorded from the standard curve obtained from optical density using a colorimeter.

Exchangeable bases: Ca, Mg were determined by titration (Mba, 2004). Na and K were extracted with 1N ammonium acetate solution (NH4OAc) and measured using flame photometer. 5g of air dried soil was weighed and transferred into 250ml plastic container, 10ml of NH4OAc at pH7, cap secured tightly. The plastic container was placed horizontally in a reciprocating shaker and shaken vigorously for 2 hours before the cap was removed and washed into the container with NH4OAc. The soil mixture was filtered into 10ml volumetric flask through Whatman No 42 filter paper before the solution was brought to the brim with NH4OAc. To titrate for Mg^{2+}, 10ml of aliquot of extract was pipetterd into 100ml volumetric flask, plus 2ml of hydroxyl-amine hydrochloride, a pinch of potassium or sodium cyanide and potassium ferrocyanide. Then buffer solution to pH 7 with ammonia buffer solution, followed by 2 drops of erichrome T indicator and titrated with 0.02N EDTA solution.

For Ca^{2+}, 10ml of aliquot was pipette into another 100ml volumetric flask, plus 2ml of hydroxylamine hydrochloride; Na or K cyanide and K-ferrocyanide. The mixture was buffered to pH 7 with 10 ml of 10% NaOH solution, 2 drops of calcein indicator and titrated against 0.02N EDTA solution.

Total exchangeable acidity was determined using IN KCl extract of Mclean (1982) for total exchangeable Al^{3+} and H^+. Effective cation exchange capacity (ECEC) was obtained by summation (ECEC = TEB + TEA) where ECEC is Effective Cation Exchange Capacity; TEB = Total exchangeable bases and TEA is Total Exchangeable Acidity.

Cation Exchange Capacity (CEC) was determined by ammonium-acetate (NH_4OA_c) displacement method (Jackson, 1958). Based saturation was calculated by dividing total exchangeable bases (TEB) with Cation Exchange Capactiy and multiplying by 100%.

Bulk Density (BD) was determined using the core method as described by Stolte (1997). Undisturbed core sample was collected by clearing about 12cm soil surface from the spot where sample was taken with minimum disturbance to the soil surface. Five centimeter (5cm) diameter core sample of known weight was inserted into the soil to a depth of 10cm. The soil was loosened around the core samples and cut beneath the core tube. The excess soil was removed from tube with sharp knife, oven dried at 105^0C for 48hrs, then weighed after. Bulk density was calculated following the procedure of Stolte (1997).

Total porosity was determined using the following formular:

$$TP = 1 - \frac{Bd}{pd} \times 100$$

Where Tp = total porosity, Bd = Bulk Density and pd = particle

Density (assumed to be 2.65gcm^3).

Gravimetric moisture content was measured by direct method as described by Klute and Dirksen (1986). 250g of wet soil collected at 0-10cm soil depth was weighed into a known weight of a container and then dried in an oven at 105^0C for 48 hrs. Then reweighed to get the dry weight. Soil moisture was calculated as ratio of wet soil minus weight of dry soil minus weight of core sampler multiplied by 100%.

Hydraulic conductivity was determined by the Klute and Dirksen (1986) method and calculated mathematically using the equation.

$K = Q/At \times L/\Delta H$ where K = Hydraulic conductivity; Q = Amount of water being collected; A= area of core containing soil sample, T = time interval of collection, L = length of the corer ΔH = constant water level height maintained.

Aggregate stability of soil was determined using the procedure described by Kemper and Rosenau (1986) and calculated as follows:

$$AS = \frac{Ma+b - Ms}{Mt - Ms} \times 100$$

where AS = aggregate

Stability of soil, Ma+ b = mass of resistant aggregates plus sand, Ms = mass of sand fraction alone and Mt = total mass of sieved soil.

Penetration resistance was measured using a pocket penetrator (Black and Hartage, (1998). This was taken at soil depth of 0.05m and angle 90^0. Infiltration rate was determined using the double ring infiltration method (Bouwer, 1986). This involved use of double ring cylindrical metals of diameter 30cm and 40cm for inner and outer ring and height of 30cm driven into the soil. Water was pounded at constant depth inside the two rings (10cm) and the rate at which water moved into the soil was determined. The cumulative infiltration, final infiltration and time to reach final infiltration were recorded. Particle size distribution was determined using the hydrometer method as described by Gee and Bauder (1986). The textural class of the soil was determined using textural triangle.

2.5. Data Analysis

The data generated were subjected to Analysis of Variance (ANOVA) for Randomized Complete Block Design (RCBD). Means that were significant were separated with

Fishers' Least Significant Difference (FLSD) – (Steel and Torrie, 1982) and significance accepted at 5% probability level. The standard deviation and coefficient of variation were obtained following the statistical procedure for computing variance (S), standard deviation (SD) and coefficient of variation (CV) by Steel and Torrie (1982).

3.0. Results

3.1. Chemical Properties

The pH highest pH of 5.89 was in human urine decomposed rice husk dust plot; while the least pH of 5.62 was in control during the first year of cropping with coefficient of variation (CV) of 2.09%. During the second and third year residual cropping the highest soil pH were 6.10 and 6.24 in same human urine decomposed rice husk dust plots the lowest pH of 4.86 and 4.65 were in control plots with CV of 0.60% and 10.96% respectively (Table 1).

3.1.1. Available Phosphorus

During the first year of cropping, the highest available phosphorus (AP) of 21.57 mg kg was in human urine plot and the least AP of 17.01 mg kg^{-1} in control with CV of 9.58%. In the remaining two years of residual cropping the highest AP were 23.95 and 25.90mg kg^{-1} in human urine plots and lowest AP of 16.79 and 15.04 mg kg^{-1} in control with CV of 28.13% and 20.57% respectively (Table 1)

3.1.2. Organic Carbon

The highest organic carbon of 25.90 g kg^{-1} was in human urine plot and lowest 0C of 5.50 g kg^{-1} in control with CV of 10.48% during the first year of application. During the remaining two years of cropping the highest OC of 6.90 and 10.60 g kg^{-1} were in human urine plots and least OC of 4.3 and 4.30 g kg-1 in control with CV of 22.89%- and 32.17% respectively (Table 1).

Table 1: Soil chemical properties for three years of study (Part 1)

	pH			AP (mg kg^{-1})			OC (g kg^{-1})		
Treatments	**Y1**	**Y2**	**Y3**	**Y1**	**Y2**	**Y3**	**Y1**	**Y2**	**Y3**
Control	5.62	4.86	4.65	17.04	16.79	15.04	5.50	4.30	4.30
Human urine	5.89	6.10	6.24	21.57	23.93	25.90	6.30	6.90	10.60
Swine slurry	5.84	5.93	6.02	19.91	20.93	22.90	6.40	6.80	10.10
Water	5.69	5.91	5.98	18.25	18.65	19.30	6.90	7.80	11.50
Undecomposed	5.63	5.70	5.83	17.82	18.10	18.53	7.30	8.40	12.10
Mean	5.73	5.70	5.74	18.97	16.41	20.33	6.48	6.84	9.72
SD	0.12	0.49	0.62	1.82	4.62	4.18	0.68	1.57	3.12
CV(%)	2.09	8.60	10.96	9.58	28.13	20.57	10.48	22.89	32.17
FLSD(P≤0.05)	0.19	ns	0.22	1.77	1.82	1.86	0.71	1.49	1.12

*Human urine, swine slurry, water decomposed rice husk dust, pH = Soil pH, AP = Available Phosphorus, OC = Organic Carbon. Y1 = Year 1; Y2 = Year 2; Y3 = Year 3. Aweto (1980) CV ranking: 0≤20% (Little); 20≤50% (Medium) and >50% (High).

Table 1: Soil chemical properties for three years of study (Part 1)

	TN (g kg-1)			EZ (cmol kg^{-1})		
Treatments	**Y1**	**Y2**	**Y3**	**Y1**	**Y2**	**Y3**
Control	5.10	5.80	6.10	0.71	0.71	0.69
Human urine	8.30	8.90	14.00	0.54	0.61	0.54
Swine slurry	7.50	8.50	11.00	0.59	0.65	0.59
Water	6.70	7.60	9.00	0.62	0.67	0.63
Undecomposed	6.60	6.30	9.00	0.67	0.69	0.66
Mean	6.84	7.42	9.82	0.63	0.67	0.62
SD	1.19	1.35	2.92	0.07	0.04	0.06
CV(%)	17.42	18.16	29.71	10.59	5.92	9.40
FLSD(P≤0.05)	ns	0.91	1.04	Ns	0.06	0.03

*Human urine, swine slurry, water decomposed rice husk dust, TN = Total Nitrogen, TEA = Total Exchangeable Acidity. Y1 = Year 1; Y2 = Year 2; Y3 = Year 3. Aweto (1980) CV ranking: 0≤20% (Little); 20≤50% (Medium) and >50% (High).

3.1.3. Total Nitrogen

The highest total nitrogen of 8.3g kg^{-1} was in human urine plot with lowest TN of 5.1 g kg^{-1} in control with CV of 17.42%7 during the first year of cropping. During the subsequent two years of residual cropping the highest TN of 8.9 and 1.0g kg^{-1} were in human urine plots; while the lowest TN of 5.8 and 6.1 g kg^{-1} were in control with CV of 18.16% and 29. 71% respectively (Table 2).

3.1.4. Total Exchangeable Acidity

The highest exchangeable acidity (EA) of 0.71 cmolkg^{-1} in human urine decomposed rice husk plot during the first year of cropping with CV of 10.59%. During the two years of residual cropping the highest EA of 0.71 and 0.69 cmol kg^{-1} in human urine treated plot with CV of 5.92% and 9.0% respectively (Table 2).

3.1.5. Total exchangeable bases

The highest exchangeable Ca^{2+} of 1.80 cmol kg-^{1} was in human urine plot during the first year of cropping and lowest exchangeable Ca^{2+} of 0.60 comel kg^{-1} in control with CV of 37.27%. During the two years subsequent residual cropping the highest echangeable Ca^{2+} of 2.10 and 2.30 cmol kg^{-1} were in human urine plots and least exchangeable Ca^{2+}% 0.60 and 0.90 cmolkg^{-1} were in control plot with CV of 38.19% and 33.75% respectively (Table 3).

During the first year of cropping, the highest exchangeable Mg^{2+} of 1.30 cmol kg^{-1} was in human urine plot and lowest exchangeable Mg^{2+} of 0.50 cmol kg^{-1} in control plot with CV of 37.27%. During the two years residual cropping the highest exchangeable Mg^{2+} of 1.90 and 2.00 cmol kg^{-1} were in human urine plots, with least values of 0.60 cmol kg^{-1} in control for the two years of residual cropping with CV of 26.66% and 3.06% cmol kg^{-1} respectively (Table 3).

Table 3: Soil chemical properties for three years of study (Part 3)

	Exch. Ca (cmol kg^{-1})			Exch. Mg (cmol kg^{-1})			Exch. K (cmol kg^{-1})			Na (cmol kg^{-1})		
Treatments	**Y1**	**Y2**	**Y3**	**Y1**	**Y2**	**Y3**	**Y1**	**Y2**	**Y3**	**Y1**	**Y2**	**Y3**
Control	0.60	0.60	0.90	0.50	0.60	0.60	0.10	0.10	0.10	0.10	0.10	0.10
Human urine	1.80	2.10	2.30	1.30	1.90	2.00	0.10	0.10	1.30	0.40	0.20	0.20
Swine slurry	1.40	1.90	2.00	1.00	1.50	1.50	0.10	0.10	1.20	0.10	0.20	0.40
Water	1.20	1.60	1.80	0.70	1.30	1.50	0.10	0.10	1.20	0.10	0.10	0.20
Undecomposed	1.00	1.40	1.30	0.70	1.30	1.40	0.10	0.10	0.60	0.10	0.10	0.10
Mean	1.20	1.52	1.66	0.84	1.33	1.44	0.10	0.10	0.88	0.16	0.14	0.40
SD	0.48	0.58	0.56	0.31	0.48	0.49	0.00	0.00	0.53	0.57	0.05	0.46
CV(%)	37.27	38.19	33.75	37.27	36.66	34.06	0.00	0.00	60.72	356.30	39.12	45.92
FLSD(P≤0.05)	0.14	0.26	0.12	0.08	0.18	0.91	Ns	ns	ns	Ns	ns	ns

*Human urine, swine slurry, water decomposed rice husk dust, Exch. Ca = Exchangeable Calcium; Exch. Mg = Exchangeable Magnesium; Exch. K = Exchangeable Potassium; Exch. Na = Exchangeable Sodium. Y1 = Year 1; Y2 = Year 2; Y3 = Year 3. Aweto (1980) CV ranking: 0≤20% (Little); 20≤50% (Medium) and >50% (High).

Table 4: Soil chemical properties for three years of study (Part 4)

	ECEC(cmol kg-1)			BS (%)		
Treatments	**Y1**	**Y2**	**Y3**	**Y1**	**Y2**	**Y3**
Control	2.11	2.16	2.43	59.40	72.20	71.50
Human urine	3.44	4.56	7.51	82.90	84.20	91.60
Swine slurry	2.55	3.72	5.98	75.60	80.20	88.50
Water	2.19	3.42	5.48	75.20	79.10	84.40
Undecomposed	2.15	3.10	4.26	72.90	78.50	82.00
Mean	2.49	3.39	5.13	73.20	78.54	83.60
SD	0.56	0.88	1.52	8.58	4.34	7.71
CV(%)	22.53	25.91	29.59	11.72	5.52	9.22
FLSD(P≤0.05)	ns	0.89	1.26	Ns	ns	ns

*Human urine, swine slurry, water decomposed rice husk dust, ECEC = Effective Cation Exchange Capacity, BS = Base Saturation. Y1 = Year 1; Y2 = Year 2; Y3 = Year 3. Aweto (1980) CV ranking: 0≤20% (Little); 20≤50% (Medium) and >50% (High).

During the first year of cropping, the highest exchangeable Na of 0.0 cmol kg^{-1} was in human urine plot, while least exchangeable Na^{+} of 0.20 and 1.20 cmol kg^{-1} were in human urine plots; while least value of 0.10 cmol kg^{-1} were in control plots with CV of 39.12% and 115.92% respectively (Table 3).

3.2. Effective cation exchange capacity and base saturation

The highest ECEC of 3.44 cmol kg^{-1} was in human urine plot during the first year of cropping, while the least value of 2.11 cmol kg^{-1} was in control with CV of 22.53%. During the rest of the two years residual cropping the highest ECEC of 56 and 7. 51 cmol kg^{-1} were in human urine plots and lowest value of 2.16 and 2.3 cmol kg^{-1} in control plots during the two years residual cropping with CV of 25.91% and 29.59% respectively (Table 4).

The highest base saturation of 82.90% was in human urine plot, with least value of 59.40% in control plot during the first year of cropping with CV of 11.72%. During the subsequent two years residual cropping the highest base saturation (BS) of 8.20 and 91.60% were in human urine plots, with lowest BS of 72.20 and 71.50% in control during the same period with CV of 5.52% and 9.22% respectively (Table 4)

3.3. Physical Properties

3.3.1. Bulk Density

The highest soil bulk density (BD) of 1.62 g cm^{3} was in control plot during the first years of cropping and least BD of 1.35 g cm^{3} in undecomposed rice husk dust with CV of 6.93%. The highest BD of 1.6 and 1.67 g mc^{3} were in control plots during the two years residual cropping with CV of 23.8% and 24.71% respectively (Table 5).

3.3.2. Aggregate Stability

The highest soil aggregate stability of 56% was in undecomposed rick husk dust plot and the lowest AS of 46% in control plot with CV of 7.3% during the first year cropping. During the two years residual studies the highest AS of 61 and 59% were in undecomposed rice husk dust plots and lowest AS of 40 and 36% in control plots with CV of 15.14% and 17.28% respectively (Table 6).

3.3.3. Infiltration Rate

The highest soil infiltration rate (IR) of 410 cm hr^{-1} was in swine slurry plot with lowest IR of 110 cm hr^{1-} in control plot during the first year of cropping. During the two years of residual cropping the highest IR of 430 and 428 cm hr^{-1} were in swine slurry plots with CV of 37.35% and 37.22% respectively (Table 6).

Table 5: Soil physical properties for three years of study (Part 1)

	BD (g cm^{-1})			TP (%)			GMC (%)		
Treatments	**Y1**	**Y2**	**Y3**	**Y1**	**Y2**	**Y3**	**Y1**	**Y2**	**Y3**
Control	1.62	1.64	1.67	38.90	38.13	36.98	37.00	39.00	36.00
Human urine	1.58	1.47	1.55	40.40	44.60	41.73	43.50	52.00	48.00
Swine slurry	1.49	1.37	1.44	43.80	48.30	45.65	45.60	55.00	50.00
Water	1.42	1.33	1.38	46.40	49.83	47.90	42.00	50.00	45.00
Undecomposed	1.35	1.33	1.33	47.20	50.95	49.80	44.00	49.00	46.00
Mean	1.49	1.42	1.47	43.34	46.37	44.41	42.42	49.00	45.00
SD	0.10	0.12	0.14	3.64	5.57	5.13	3.29	6.04	5.39
CV(%)	6.93	8.73	9.31	8.39	12.02	11.55	7.76	12.33	11.97
FLSD(P≤0.05)	0.17	0.11	0.14	2.41	3.06	2.72	1.14	1.92	1.68

*Human urine, swine slurry, water decomposed rice husk dust, BD = Bulk Density; TP = Total Porosity, GMC = Gravimetric Moisture Content. Y1 = Year 1; Y2 = Year 2; Y3 = Year 3. Aweto (1980) CV ranking: 0≤20% (Little); 20≤50% (Medium) and >50% (High).

Table 6: Soil physical properties for three years of study (Part 2)

	HC (cm hr^{-1})			PR (Kg cm^{-2})			HC (cm hr^{-1})			AS (%)		
Treatments	**Y1**	**Y2**	**Y3**	**Y1**	**Y2**	**Y3**	**Y1**	**Y2**	**Y3**	**Y1**	**Y2**	**Y3**
Control	20.06	19.54	19.98	3.19	3.08	3.19	110.00	118.00	118.00	46.00	40.00	36.00
Human urine	31.56	30.73	32.12	2.26	2.15	2.08	311.00	398.00	385.00	49.00	48.00	48.00
Swine slurry	31.25	37.37	39.88	1.76	1.68	1.72	410.00	430.00	428.00	49.00	49.00	46.00
Water	30.22	35.28	37.64	2.06	1.97	1.92	395.00	398.00	398.00	49.00	54.00	50.00
Undecomposed	30.82	37.97	39.68	1.84	1.77	1.86	390.00	415.00	410.00	56.00	61.00	59.00
Mean	23.10	32.42	33.86	2.22	2.13	2.15	323.20	351.80	347.80	49.80	50.40	47.80
SD	4.81	7.61	8.37	0.57	0.56	0.59	65.85	131.40	129.40	3.70	7.77	8.26
CV(%)	20.81	23.48	24.71	25.84	26.35	27.51	20.38	37.35	37.22	7.43	15.41	17.28
FLSD(P≤0.05)	2.76	2.72	2.69	1.67	1.55	1.81	79.99	ns	62.80	1.87	1.61	1.48

*Human urine, swine slurry, water decomposed rice husk dust, HC = Hydraulic Conductivity; PR = Penetration Resistance; IR = Infiltration Rate; AS = Aggregate Stability. Y1 = Year 1; Y2 = Year 2; Y3 = Year 3. Aweto (1980) CV ranking: 0≤20% (Little); 20≤50% (Medium) and >50% (High).

Table 7: Soil chemical properties for three years of study (Part 3)

	Sand (g kg^{-1})			Silt (g kg^{-1})			Clay (g kg^{-1})		
Treatments	**Y1**	**Y2**	**Y3**	**Y1**	**Y2**	**Y3**	**Y1**	**Y2**	**Y3**
Control	691.00	672.00	668.00	196.00	160.00	193.00	113.00	168.00	139.00
Human urine	591.00	639.00	638.00	220.00	227.00	244.00	189.00	134.00	118.00
Swine slurry	608.00	647.00	647.00	213.00	225.00	241.00	179.00	128.00	112.00
Water	575.00	649.00	649.00	203.00	217.00	240.00	222.00	134.00	111.00
Undecomposed	641.00	652.00	659.00	202.00	197.00	254.00	159.00	151.00	101.00
Mean	369.00	652.00	652.00	207.00	205.00	234.00	172.00	143.00	116.00
SD	19.21	12.28	11.56	9.58	16.40	11.76	11.23	16.40	14.13
CV(%)	5.21	1.88	1.77	4.63	8.00	5.02	6.53	11.50	12.18
FLSD(P≤0.05)	Ns	ns	ns	Ns	ns	ns	ns	ns	ns

*Human urine, swine slurry, water decomposed rice husk dust, Y1 = Year 1; Y2 = Year 2; Y3 = Year 3. Aweto (1980) CV ranking: 0≤20% (Little); 20≤50% (Medium) and >50% (High).

3.3.4. Particle Sizes

The highest soil sand fraction of 691 g kg^{-1} was in control and lowest soil sand fraction in water decomposed rice husk dust plot during the first year of cropping with CV of 5.21%. During the two years residual cropping, the highest soil sand fraction of 672 and 668 g kg^{-1} were in control plots and lowest sand fraction of 639 and 638 kg^{-1} in human urine plots with CV of 1.88% and 1.77% respectively (Table 7).

The highest soil silt fraction of 220 g kg^{-1} was in human urine plot and lowest of silt fraction of 196 kg^{-1} in control plot with CV of 4.63% during the first year cropping the highest soil silt fraction of 227 and 254 g kg^{-1} were in human urine and undecomposed rice husk dusk plots and the lowest value of 160 and 193 g kg^{-1} in control plots with CV of 8.0% and 5.02% respectively.

The highest soil clay fraction of 222g kg^{-1} was in water decomposed rice husk dust plot and lowest value of 113 g kg^{-1} in control with CV of 6.53% during the first year of cropping. During the two years residual cropping the highest soil clay fraction of 168 and 139 g kg^{-1} were in control and lowest value of 128 and 101 g kg^{-1} in swine slurry and undecomposed rice husk dusts plots with CV % 11.5% and 12.18% respectively (Table 7).

3.4. Agronomic Parameters

3.4.1. Percentage germination

The highest germination percentage (GP) of 98 was in human urine, and swine slurry plots and lowest GP of 88 in water decomposed rice husk dust and undecomposed rice husk dust plots with CV of 7.27% during the first year of cropping. During the two years residual cropping the highest PG of 99.8 and 100 were in swine slurry and human urine decomposed rice husk dusk plots and lowest PG of 81.9 and 81.9 in control plots with CV of 7.16% and 7.56% respectively (Table 8).

Table 8: Agronomic parameters for three years of study (Part 1)

	PG (%)			PH (cm)			RD (0 —5) cm			RD (6—10) cm		
Treatments	**Y1**	**Y2**	**Y3**	**Y1**	**Y2**	**Y3**	**Y1**	**Y2**	**Y3**	**YI**	**Y2**	**Y3**
Control	83.30	81.90	81.90	34.73	32.21	30.90	19.10	18.70	19.20	19.10	19.40	18.50
Human urine	98.00	99.80	100.00	58.95	59.01	62.90	22.60	24.20	30.80	22.80	25.70	25.90
Swine slurry	98.00	98.30	99.30	48.30	51.35	52.01	21.90	22.70	27.60	21.60	23.70	24.80
Water	88.00	96.30	98.10	38.80	44.85	48.70	20.70	20.90	26.20	20.00	22.40	21.90
Undecomposed	88.00	92.70	97.10	36.80	41.32	48.40	20.20	20.50	24.60	19.90	21.60	20.00
Mean	91.06	93.80	95.28	43.52	45.75	47.78	20.90	21.40	25.68	20.68	22.56	22.22
SD	6.62	7.16	7.56	10.07	10.14	11.66	1.38	2.11	4.28	1.49	2.35	3.12
CV(%)	7.27	7.64	7.94	23.14	22.15	24.40	6.62	9.88	16.67	7.21	10.41	14.06
FLSD(P≤0.05)	8.31	3.75	ns	72.00	7.92	5.19	1.30	1.31	2.85	Ns	1.80	0.68

*Human urine, swine slurry, water decomposed rice husk dust, PG = Percentage Germination; PH = Plant Height; RD(0 – 5 cm) = Root Density at 0 – 5 cm Soil Depth; RD(5 – 10 cm) = Root Density at 5 – 10 cm Soil Depth. Y1 = Year 1; Y2 = Year 2; Y3 = Year 3. Aweto (1980) CV ranking: 0≤20% (Little); 20≤50% (Medium) and >50% (High).

Table 9: Agronomic parameters for three years of study (Part 2)

	SDW (t ha^{-1})			RDW (t ha^{-1})			Grain yield (t ha^{-1})		
Treatments	**Y1**	**Y2**	**Y3**	**Y1**	**Y2**	**Y3**	**Y1**	**Y2**	**Y3**
Control	6.88	11.90	12.50	6.88	8.75	9.38	1.24	1.42	1.62
Human urine	21.30	22.50	23.80	17.50	17.50	20.00	3.50	4.03	4.17
Swine slurry	15.60	21.30	22.50	14.40	16.30	18.80	3.30	3.35	4.02
Water	14.40	18.90	21.30	13.10	13.80	16.90	2.48	3.06	3.35
Undecomposed	14.40	15.00	16.30	10.00	11.30	16.90	2.08	2.01	3.17
Mean	14.52	17.92	19.28	16.67	13.53	16.40	2.52	2.77	3.27
SD	5.13	4.42	4.74	4.08	3.58	4.14	0.86	1.05	1.01
CV(%)	35.36	24.66	24.56	24.49	26.48	25.22	33.93	37.94	30.95
FLSD(P≤0.05)	Ns	3.86	3.87	Ns	ns	ns	ns	0.27	2.17

*Human urine, swine slurry, water decomposed rice husk dust, SDW = Straw Dry Weight; RDW = Root Dry Weight. Y1 = Year1; Y2 = Year 2; Y3 = Year 3. Aweto (1980) CV ranking: 0≤20% (Little); 20≤50% (Medium) and >50% (High).

Plant Height

The highest rice height (PH) of 58.95 cm was in human urine plot and lowest PH pf 3.73cm in control during the first year of planting with CV of 23.14%. During the next two years residual planting, the highest PH 59.01 and 62.9 cm were in human urine plots and lowest value 32.21 and 30.9cm in control plots with CV of 22.15% and 24.40% respectively (Table 8).

Root Density

The highest rice root density at 0 – 5 cm soil depth of 22.6cm was in human urine plot and lowest value of 19.1cm in control with CV of 6.62% during the first year planting. During the two years residual planting, the highest root density at same soil depth of 2.2 and 30.8cm were in human urine plots and the lowest value of 18.7 and 19.2cm in control plots with CV of 2.11% and 4.28% respectively (Table 8).

The highest rice root density at 5 – 10 cm soil depth of 22.8cm and lowest value of 19.1cm were in human urine and control plots with CV of 7.21% during the first year of planting. During the two years residual planting, the highest rice rot density at 15 – 10 cm soil depth of 25.7 and 25.9 cm were in human urine plots and lowest value of 19.4 and 18.5 cm in control plots with CV of 10.41% and 14.06% respectively (Table 8).

Straw Root and grain yield

The highest rice straw dry weight of 21.3t ha^{-1} was in human urine plot and lowest rice straw dry weight of 6.88t ha^{-1} in control plot with CV of 35.36% during the first year of cropping. During the two years residual cropping, the highest rice straw dry weight of 22.5 and 23.8t ha^{-1} were in human urine plots and lowest value of 11.9 and 12.5 t ha^{-1} in control plots with CV of 2.66% and 24.56% respectively (Table 9).

The highest rice root dry weight of 17.5 t ha^{-1} was in human urine plot and lowest value of 6.88 t ha^{-1} in control plot with CV of 24.49% during the first year of cropping. During the two years residual cropping the highest, rice root dry weight of 17.5 and 20 t ha^{-1} were in human urine plots and the lowest value 8.75 and 9.38 t ha^{-1} in control plots with CV of 26.48% and 25.22% respectively (Table 9).

The highest rice grain yield of 3.5 t ha^{-1} was in human urine decomposed rice husk dust plot and the lowest 1.24 t ha^{-1} in control plot with CV of 33.93% during the first year of cropping. During the two years residual cropping the highest rice grain yield of 4.03 and 4.17 t ha^{-1} were in human urine plots and the lowest 1.42 and 1.62 t ha^{-1} in control plots with CV of 37.94 and 30.95% respectively (Table 9).

4.0 Discussion

Chemical Properties

The soil pH was little in variation according to Aweto (1980) CV ranking showing the low impact amongst the studied forms of rice husk dust decomposition with reference to control in raising or lowering the pH status of the test soil.

The available phosphorus variation during the first year is rated little; while for the two years residual studies were medium according to Aweto (1980) CV ranking. This implies the rising gap in available soil phosphorus with reference to control during the two years residual cropping especially in human urine decomposed rice husk dust plots.

The same trend, little variation during first year and medium variation amongst treatments during two years residual cropping were observed for soil total carbon according to Aweto (1980) CV ranking. This supports the rise gap in total carbon amongst treatments in favour of human urine plots.

When it came to soil total nitrogen, there were medium variation for first two years and high variation for last year of cropping according to Aweto (1980) CV ranking, signifying the level of volatility associated with soil nitrogen level that are subject to various losses and additions through volatilisation, ammonification, nitrification.

The soil total exchangeable bases rated little in variation amongst treatments according to Aweto (1980) CV ranking showing the capability of the test soil to retain Ca, Mg, K and Na at nearly uniform rates over periods of cropping seasons.

The exchangeable cations variation amongst treatment except K were rated medium in variation according to Aweto (1980) CV ranking signifying the wide gap in losses and gains of basic cations in test soil media according to various conditions and environment, with K remaining at zero level of variation which is good for the test soil health (as excess K is detrimental to soil). Excess Na^+ also causes soil dispersion or deflocculation which is not desirable in crop production.

The effective Cation Exchange Capacity of the soil variation amongst treatments were rated medium; while the base saturation variation amongst treatments were rated little according to Aweto (1980) CV ranking, suggesting low gap in gains and lossess of basic cations over period of time and scarcely no changes in base saturation over time irrespective of the treatments tested which is good for soil nutrient availability and soil productivity.

Isirimah (2000) reported that organic wastes reduces acidity, while Akubugwo *et al.,* (2007) agreed that increased pH enhances microbial activities. The recommended soil pH ideal for soil health according to Obasi *et al.,* (2012), Uba *et al.,* (2008) and Eliagwu *et al.,* (2007) is 6.5 – 8.5.

Njoku *et al.,* (2015) observed increased available phosphorus in organic amended soils, while Okonkwo *et al.,* (2011) reported decomposed rice husk dust improves soil available phosphorus. Sridha and Adeoye (2003) noted that phosphorus was increased in the soil following organic manure addition. These helps to break immobile phosphorus in soil. Obasi (2020) also reported increased phosphorus in waste dump soil.

Obot and Hanson (2013) also noted increased soil organic carbon in organic waste treated soil. Similar findings were reported by Badmus *et al*., (2014); Adesodum and Mbagwu (2007) and Okolo *et al.,* (2013). Obot and Hanson (2013) and Obasi *et al* (2015) observed increased soil total nitrogen following organic amendment.

Ubuoh *et al* (2012) and Obazi (2020) noted increases in exchangeable Ca, Mg, K, following organic matter addition of the soil. Davies *et al.,* (2003) observed increased cations especially Ca, Mg and K in organic treated soil.

Physical Properties and agronomic parameters

The variation in soil bulk density (BD) among treatments was rated little according to Aweto (1980) CV ranking which is good for the various forms of rice husk dust decomposers relative to control.

The variation in soil total porosity (TP) amongst treatments was also little according to Aweto (1980) CV ranking which is good for soil moisture retention across farming season.

The soil hydraulic conductivity amongst treatments was rated medium, penetration resistance amongst treatments was rated medium, infiltration rate amongst treatments was rated medium and aggregate stability amongst treatments was rated little according to Aweto (1980) CV ranking. This shows that hydraulic conductivity, penetration resistance and infiltration rate were affected by treatments, with human urine treated plots giving better results; while aggregate stability remained more stable over years irrespective of structural stabilization.

The soil particle size distribution for sand, silt and clay amongst treatments rated little according to Aweto (1980) CV ranking which supports the fact that soil texture does not change over a short period of time. Hence, the sandy loam characteristics of test soil capacity for supporting the test upland rice.

The rice percentage germination variation across treatments rated little; its height variations amongst treatments rated medium; its root density variation at two soil depths across treatments rated little according to Aweto (1980) CV ranking. This is good for the test upland land “Erica” which is popular in Abakaliki and do no lodge or experience germination failures. The dense roots are capable of mining and utilizing available soil nutrients for crop growth and productivity.

The rice straw dry weight variation across treatments rated medium; the rice root dry weight variation across treatments rated medium; while grain yield variation across treatments rated medium as well. Hence, all yield parameters were affected to significant proportions by the various forms of rice husk dust decomposition, with human urine leading in highest soil and crop productivity.

Anikwe (2000) and Okolo *et al.,* (2013) observed increases in soil volume arising from loosening effect of waste materials thereby reducing soil BD and increasing TP. Nnabude and Mbagwu (2000) Adele *et al.,* (2010), Asadu *et al.,* (2008) and Mba and Mbagwu (2006) had earlier reported reduced BD and increased TP with waste materials.

Increased GMC in waste treated soils has been reported by

Obazi (2020). Obasi *et al.,* (2015). These authors reported an inverse relationship between BD and TP. Njoku *et al.,* (2011) noted increases in hydraulic conductivity of soil associated with increase in TP and decreases in BD. Enhanced transmission reduced water-logging. The same authors observed increases in AS of soil as desirable for cementing of soil aggregates and OM. Nwite *et al.,* (2013) reported increased AS in soil amended with different animal wastes in a Abakaliki Ultisol.

Obot and Hanson (2013), Obi (2002) noted that soil texture is a permanent property of the soil, not immutable by any cultural practice, and hence used for soil classification and soil quality assessment. Ubuoh *et al.,* (2012) observed top soil transformation following addition of organic matter. Virtually, all authors supported increases in agronomic parameters following organic matter addition.

5.0 Conclusion

Human urine decomposed rice husk dust when applied to the field for upland rice production boosted both soil physico-chemical properties and rice growth and yield; followed by swine slurry. Harvesting and treatment of human urine with methods and resources that will not affect the nutrient content was suggested before their small scale and commercial use in crop production.

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