ISSN 0794 - 1293
www.nsmjournal.org

NIGERIAN JOURNAL OF MICROBIOLOGY

Volume 25, 2011

Editor-in-Chief
Prof Victor Oluoha Nwaugo

Supported by tetfund
TERTIARY EDUCATION TRUST FUND

NIGERIAN SOCIETY FOR MICROBIOLOGY · FOUNDED 1972 ·

Published by the Nigerian Society for Microbiology

Nigerian Journal of Microbiology, Vol. 25: 2345- 2352, 2011
www.nsmjournal.org

EFFECTS OF SAWDUST ASH ON SOIL PHYSICO CHEMICAL AND BIOLOGICAL INDICES

[1]*Asamudo, N.U.*, [1]*Etok, C.A*, [2]*Onwuchekwa, I.S. and* [3]*Nwaugo, V.O.*
[1] Dept of Microbiology, University of Uyo, Uyo
[2] Dept of Geography and Planning, Abia State University, Uturu
[3] Dept of Microbiology, Abia State University, Uturu.

Abstract
The effect of soil amendments with saw dust ash on soil physicochemical properties, microbial diversity and enzyme activities were investigated in Egbema, Southern Nigeria. The ash had high Electrical Conductivity, Cation Exchange Capacity and alkaline earth metals (K, Ca and Mg). Among the heavy metals (Cu, Fe, Mn and Zn) only Zn was significantly high in the ash, which also had very negligible N content ($P<0.05$). Amendment of the soil (1kg) with 3g, 6g, 9g and 12g of the 2mm-sieved ash caused increase in all parameters except NO_3 content which did *not show significant increase in quantity. Microbial diversity of the soil samples showed* that Phosphate solubilizing bacteria(PSB), nitrifying bacteria and total heterotrophic bacteria (THB) had increased rate of multiplication in that order with the highest counts in the 6g ash/kg soil. Though fungal and actinomycetes had their highest counts in the 9g ash/kg soil, there was no statistical difference from their counts in 6g ash/kg soil ($P>0.05$). In each soil sample, the THB had the highest counts followed by the PSB. There was positive correlation ($P<0.05$) between soil enzyme activity and microbial counts. All the enzymes assessed (dehydrogenase, urease, alkaline phosphatase) had their highest activities in the 6g ash/kg soil except acid phosphatase which decreased in activities with the ash amendment. The ash application therefore caused increased microbial growth and enzyme activities, hence enhanced biogeochemical transformation and thereby improving soil health.

Keywords: Microbial diversity, soil fertility, enzymes, amendments.

Corresponding Author: V.O. Nwaugo; **E-mail:** vonwaugo@yahoo.com
Tel: 08063494654

Introduction

Food security and stability in the world are dependent on availability and management of natural resources, especially land. The human population is increasing greatly, such that the available farming space is being over tasked. There is therefore nutrient depletion (Nwaugo *et al.*, 2008a; Monkiedje et al, 2006). Depreciation of plant nutrients in soil does not dependent on agricultural practices alone, as it is affected by other natural and anthropogenic activities like erosion and construction (Montellion and Tauraine,2004, Nwaugo *et al*, 2008b, Etok *et al.*, 2010).

Among the elements required by plants, three stand out clearly and include Nitrogen, phosphorus and Potassium. Most soil management techniques are based on maintenance or improvement of the availability of these elements for plants use (Montellion and Touraine, 2004, Ayeni, 2011, Mbah et al, 2010, Nwaugo *et al.*, 2006). They are therefore the limiting factors in agricultural soil assessments and plant yields. The imput of various forms of these elements in available state therefore determines their uptake by plants.

Nutrients deficient soil has been remediated by application of several substances including organic and inorganic manure (Parham *et al*., 2002,2003, Montellion and Touraine, 2004, Nwaugo *et al*., 2008a). This study was designed to assess the effects of saw dust ash on some soil physicochemical properties of agricultural importance, microbial diversity and enzyme activities. This was done with a view to utilizing the agro-waste (Sawdust) as remediative agent in nutrient depleted agricultural land.

Materials and Methods

Study area: The study area is Egbema, a community in the Southern part of Imo State. The people are mainly farmers but much of the land has been converted into Gmelina and oil palm plantations. This has resulted in much pressure on the available farmland leading to nutrient depletion. (Nwaugo *et al*., 2006, 2008b).

Sample Collection

The top soil (0-30cm) of a fallow farmland was collected using the sheprek soil agar from various points and thoroughly mixed to give a honogenuous sample. The soil was them air-dried and 2mm – sieved. In this study the saw dust ash was obtained by open burning of the sawdust from a timber shed in the study area.

Assessment of Physicochemical Parameters.

The soil pH was determined using the Jenway HANNA 1910 multipurpose tester (HANNA Instruments, Woonsullet, Rhodes Island, USA). The total organic carbon, NO_3, PO_4 and available phosphorous (P) were determined as stated by Pansu and Goutheyrou (2006), while K was assessed using the flame photometer; Ca and Mg were determined by the EDTA titrametric method (UNEP, 2004). The EC and CEC were also determined according to UNEP (2004). The heavy metals Cu, Mn, Zn and Fe were determined after proper digestion according to the description of Pansu and Coutheyrou, (2004).

Microbiological Analysis

Five physiological microbial groups were estimated. These were the total heterotrophic bacteria (THB), the phosphate solubilization of bacteria (PSB) and nitrifying bacteria (N). Others were Fungi (F) and actinomycetes (A). The population of these organisms in the soil was assessed using various selective culture media (Chesbrough, 2002, Nwaugo *et al*., 2008b). The THB were estimated using Tryptone soy agar, PSB with Pikovskaya medium and NB with modified mineral salt agar. The fungi were counted using SDA supplemented with chloramphenicol (antibiotic) while for the actinomyceters, acidified starch nitrate agar was used. The soil sample was spread plated on the various media after ten – fold serial dilution.

Soil Enzyme Activities Analysis

The soil enzymes activities were assessed using soil samples dried for 18h at room temperature and 2mm - sieved. The enzymes were dehydrogenase, urease and phosphatase (acid and alkaline). The dehydrogenase activity was determined as described by Cassida *et al* (1964) as modified by Nanipier and Alef (1995) using Triphenyl tetrazolum Chloride (TTC) amended soil with the formation of Triphenyl formazon (TPF) after 6 hours incubation at 30°C Absorbance was read at 485nM. Urease activity was determined by the colorimetric method of Nanipieri *et al* (1980) based on the formation of NH_3 – N in urea amended soil after 24 hours incubation at 30°C. The phosphatase activities (acid and alkaline) were estimated as described by Alef and Nanaipieri (1995) using P – nitrophenol phosphate amended soil.

Data Analysis

All the results obtained were subjected to statistical analysis to assess the level of significance. Such statistical tools used include ANOVA and Correlation analysis. Standard deviation was used in the physicochemical parameters.

Results

The ash was alkaline (10.2) compared to the slightly acidic control soil (6.8). Most significant variation was observed in the phosphate content which was 2.48 (mg/g) and 39.9g/d (total) in control soil and ash samples respectively (Table 1). The values of alkaline earth metals K, Ca, and Mg were statistically significant in the ash compared to the control soil while heavy metals Cu, Fe and Mn were not significantly different ($P<0.05$). Among the heavy metals only Zn was quite high in the ash (0.47my/g). Amendment of soil with various quantities of the sawdust ash showed a gradient according to the quantity of ash used. All values increased till the 6g/g ash quantity but there was no more significant increase thereafter. i.e. from 9g/kg (Table 1) ($P<0.05$). The total NO_3 content did not show significant increase with the ash amendment of soil.

Table 2 shows the microbial diversity of the various soil samples examined. In all soil samples, the total heterotrophic bacteria (THB) had the highest counts while counts of other bacterial groups varied in each soil sample. All the bacterial groups, THB, PSB, and NB had their highest counts in the 6g/kg ash amended soil while fungi and actinomycetes had their highest counts in the 9g/kg ash amended soil. However, the countss obtained from 6g/kg and 9g/kg soil samples for fungi and actinomycetes were not statistically significant ($P<0.05$). Highest increases in counts were observed between 3-6g/kg ash amendment. PSB showed the highest increase rate followed by the NB (Table 3).

Soil enzyme activities (Table 3) showed significant increase with the ash amendment. Dehydrogenase which had 18.21 mg $g^{-1}6h^{-}$ in the control rose to 35.47mg $g^{-1}6h^{-}$ in 6g/kg ash amended soil but decreased thereafter to 25.08mg $g^{-1}6h^{-}$ in 12g/kg ash amended soil. The same pattern was observed in all the other enzymes assessed except for acid phosphatase which decreased in activity from the first amendment (3g/kg ash) till the last in 12g/kg ash in soil sample. All the enzymes had their highest activities in the 6g/kg ash amended soil sample except acid phosphatase whose highest activity was observed in the control soil sample. Statistical analysis showed positive correlation between the microbial loads and the enzyme activities ie the enzyme activities increased in the same direction as the microbial leads.

Table 1: Effect of saw dust ash on soil physicochemical properties

	Soil	Ash	Saw dust ash amendment of soil 3g/kg	6g/kg	9g/kg	12g/kg
pH	6.8	10.2	7.4	8.2	8.2	9.2
EC ($^{-1}$)	0.28	0.76	0.31	0.36	0.52	0.67
Organ C.	0.68	0.17	0.90	1.24	1.72	1.70
Total P.	3.4	24.9	6.4	8.42	10.64	16.4
Total N.	0.30	0.04	0.53	0.92	1.0 2	1.04
CEC	43.6	93.7	49.3	51.1	73.5	75.7
K mg/g	0.37	2.60	0.71	0.96	1.01	1.27
Mg mg/g	0.23	3.63	0.45	0.70	0.90	1.01
Ca mg/g	2,54	12.82	4,65	7.04	7.22	7.61
Zn mg/g	25.2	31.7	33.4	46.65	65.32	74.8
Fe mg/g	21,62	28.98	23.21	24.46	25.68	26.12
Cu mg/g	0.002	0.003 0.003	0.004	0.004	0.005	0.005

Table 2; Effects of saw dust ash amendment of soil in microbial counts (cfu/g)

Microbial Group	0 Control	3g/kg	6g/kg	9g/kg	12g/kg
THB	4.2×10^5	3.1×10^6	4.3×10^6	4.1×10^6	3.1×10^6
NB	2.5×10^3	1.4×10^4	2.4×10^4	2.1×10^4	1.5×10^4
PSB	4.8×10^3	2.1×10^4	1.2×10^5	1.2×10^5	2.7×10^4
FC	2.1×10^4	2.9×10^4	1.0×10^5	1.1×10^5	2.7×10^4
AC	1.4×10^4	2.1×10^4	1.2×10^5	1.4×10^5	6.7×10^4

Key; THB = Total heterotrophic count; NB= Nitrifying bacteria
PSB = Phosphate solubilizing bacteria; FC = Fungal count
AC = Actinomycetes count.

Table 3; Enzyme activities of the various samples analysed

Enzyme	0g/kg	Soil amendment with wood ash 3g/kg	6g/kg	9g/kg	12g/kg
Dehydrogenase Mg g-1 6h-1	18.21	24.63	35.47	31.27	26.68
Urease Mg g-1 24h-1	12.7	19.4	28.8	21.2	19.1
Alkaline Phosphatase (Umol-p-nitrophenol)	0.97	1.11	2.8	2.2	1.4
Acid Phosphatase (Umol-p-nitrophenol)	1.01	0.96	0.67	0.34	0.21

Discussion

The results obtained in the physicochemical properties of the sawdust ash fall within the values reported by Onwuka *et al*, (2007) and Ayeni *et al* (2008). The ash was alkaline, a property which Odedina *et al*., (2003) had attributed to high alkaline earth metal content of the ash. This shows that ash could be used as a limning agent in acidic soil. The high EC and CEC observed could be attributed to the high metallic content of the ash. These alkaline earth metals include K, Ca and Mg. The sawdust ash was low in heavy metal content (Mn, Cu and Fe) and NO_3 content too. The low NO_3 content could be attributed to the high volatility of N. The N available could have evaporated during the burning process to produce the ash which agrees with Ayeni *et al* (2008). On the other hand the ash contained high amount of available P. This could be attributed to the high ash solubility in water with its high phosphate content. The solubility ensured mobility of the phosphorous hence its availability for plants use.

Soil amendment with the ash showed significant improvement in the physical and chemical properties of agricultural importance. The total phosphate, K and conductivity improved. Inspite of the beneficial effects of ash amendment of soil, results showed that application of ash above 6g/kg did not give any commensurate improvement. This suggests that 6g/kg soil was the optimum amendment and should not go upto 9g/kg. Ayeni *et al.* (2008) had reported 8g to be the best while Onwuka *et al* (2007) adviced caution in the use of fly ash. These therefore suggest that for ash to be used in soil amendment, a preliminary assessment of the soil should be carried out. This is because over application could lead to less value of the applied ash.

Results obtained in the microbial diversity buttressed the results observed in the physicochemical parameters. Though all the physiological microbial groups assessed had their highest populations in the 6g/kg ash amendment of soil, there was no significant increase in the 9g/kg and 12g/kg amendments. The 12g/kg amendment even caused decreased populations in all the groups. Onwuka *et al* (2007) working on cocoa hust ash, Mbah *et al* (2010) and Owolabi *et al*., (2002) using wood ash had reported that over use of ash is detrimental to soil health. Baath and Amebrant (1994) had earlier reported a similar observation.

Results in this study showed that the PSB had the highest increase rate, followed by NB and then the TSB. The increase in fungi and actinomycetes was more gradual but continued above 6g/kg to the 9g/kg ash amendment where it stopped. This indicated that fungi and actinomycetes responded gradually to sawdust ash amendment while bacteria were quick in their response but have lower tolerance level. The observations further suggest that though sawdust ash has low N content it encouraged the growth of NB while its high content of available P was available for plant uptake. The PSB was also high in counts and could combine with NB to make both N and P available to plants hence encouraging plant /crop production. This high microbial counts and diversity observed in the 6g/kg ash amended soil caused high biogeochemical transformations. This could be so as microorganisms have severally been described as mediators of such transformations (Prescott *et al*., 2007, Pelezar *et al*., 2002, Nwaugo *et al*., 2008a, 2010).

Values obtained in the enzyme activities buttressed the microbial diversity results. All the enzymes, whose activities were assessed, had their highest activities on the 6g/kg ash amended soil except the acid phosphatase. This agrees well with the reports of Nwaugo *et al*., (2008b), Li *et al.,* (2005) and Alef and Nanipieri, (1995) that acid phosphatase is very sensitive to pH changes. The amendment of the soil with sawdust ash increased the soil pH from slightly acidic to alkaline which affected the acid phosphatase adversely. Generally results obtained in the enzyme activities indicated a positive correlation with the microbial loads. All the enzymes decreased in activities from 9g/kg to 12g/kg ash amendment. This agrees with the reports of Li *et al*., (2005), Nwaugo *et al*., (2008b) Etok *et al* (2010) and Parham *et al* , (2002) that the soil enzyme activities follow microbial contents while Panmurugan and Gopi (2006) attributed it to feed back inhibition by the ash.

Results obtained in this study therefore suggest that amendment of soil with sawdust ash improved soil agricultural properties up till 6g/kg ash amendment. Observations indicated that the ash was a good liming agent and can enhance the availability of both Nitrogen and Phosphorous with adequate supply of K (Potassium).

References

Alef, K. and Nannipieri, P. (1995). Methods in Applied Soil Microbiology and Biochemistry. Academic Press, London.

Ayeni L.S. (2011) Cumulative effect of combined cocoa pod ash. Poultry manure, NPK 20;10;10 fertilizer on major cations release for crop production in South Western Nigeria. *Int. Res. J. Agric Soil Sc* 1(7);248 - 253

Ayeni, L.S, O.M. Ayeni, O.P., Oso and Ojeniyi S.O. (2008) Effect of saw dust and wood ash application in improving soil chemical properties and growth of Cocoa (*Theobroma cocoa*) seedling in the nurseries. *Agric. J.* 3 (5) : 323-305

Baarth E. and Ambrant K. (1994) Growth rate and response of bacterial communities to pH and ash treatment of soil. *Biochem* 26 995-1001

Cassida, L..E., Klein, J.D. and Santoro, D. (1964). Soil dehydrogenase activity. *Soil Sc*, 98:371-374

Chessbrough, M. (2001). Laboratory Manual for Tropical countries. Vol. II. Microbiology. *Tropical Health Technology*. ELBS, London

Etok, C.A., Asamudo, N.U., Onwuchekwa, I.S. and Nwaugo, V.O. (2010) Effects of Quarry Plant rock dust on soil Phosphate solubilizing Bacteria and enzyme activities in Ishiagu, Ebonyi State, Nigeria. *Nig. J. Microbiol* *24*(1);2207 – 2213.

Li, H., Zhang, Y., Zhang, C.G. and Chen G.X. (2005). Effect of Petroleum containing waste water. Irrigation on Bacteiral diversities and enzymatic activities in a Paddy soil irrigation area. *J. Environ Qual., 34*:1073-1080.

Mbah, C.N Nwife, J.N. Njoku, C. and Nweke, I.A. (2010) Response of maize (Zea mays) to different rates of wood ash application in acid ultisol in South East

Nigerian. *Afr. J. Agric. Res.* 5 (7): 580-513

Monkiedje, A., Spiteller, M., Fotio, D. and Sukul P. (2006) The effect of land use on soil health indicators in Peri-Urban agriculture in the humid forest zone of Southern Cameroon *J. Environ. Qual.* 35: 2402-2410.

Montellin, S. and Tauraine, B. (2004). Plant growth-promoting bacteria and nitrate availability: Impacts on root development and nitrate uptake. J. *Expt. Bot. 55(394)* 27-34.

Nannipieri, P., Crecanti, B, Bianchi, D and Bonmati M (1985) Fractionation of hydrolase humus complexes by gel chromatography. *Boil. Feit Soils 1*:25-29.

Nwaugo, V.O.; Onyeagba, R.A. Obiekezie, S.O. and Ugbogu, O.C. (2006). Effects of Petroleum Produced (formation) water on some farmland soil bacteria in Egbema, Rivers State *Int. J. Biotech. Allied Sc.* 1 (1):32-36.

Nwaugo, V.O.; Elekwa, I.; M.A. Ekpo and Adebayo, B.O. (2008a) Evaluation of soil health following application of fertilizers using bacterial and enzymes as indicators. *J. Appl. Environ. Sc.* 4(2);67 - 72

Nwaugo, V.O. Etok, C.A Obiekeze, S.O and Chinyere, G.C (2008b). Evaluation of the effects of Okigwe cattle market wastes on the surrounding agricultural soil parameters *Bio-Res 6 (11)* 367:370

Nwaugo, V.O., Onyeagba, R.A. Chima. G.N.and Agwananze D.I. (2007) Effects of Drilling wastes on the farmland mircrobial spectrum in Egbema, south-south Nigerian community *Pak J. Appl Sc.* 2(8):632-638

Nwaugo, VO, Onyeogba , R.A , Obiekezie, S.O and Ugbogu. O.C (2007). Effect of petroleum produced (information) water on some farmland soil bacteria species Egbema Rivers State. *Int. J. Biotechnol Allied Sc. 1(1)*:32-36.

. Odedina, S.A. Odedina, J.N. Ayeni, C.S. Arowojolu, S.A. Adeyeye, S.O and Ojeniyi, S.O. (2003). Effects of type of ash on soil fertility, nutrient availability and yield of tomato and pepper. *Nig. J. Soil Sc.* 13: 61-67

Onwuka, M.I. Osodeke, V.E., and Okolo N.A. (2007). Amelioration of soil acidity using cocoa husk ash for maize production in Umudike areas of South Eastern Nigeria. *Trop. Subtrop. Agroecosystem.* 7: 41-45

Owolabi, O.A, Adeyeye, B.T. Oladejo T. and S.O Ojeniyi (2003). Effect of wood ash and soil fertility and crop yield in South Western Nigeria. *J. Soil Sc.* 13: 55-60

Panmurugan, P.and Gopi C. (2006). Distribution pattern and screening of phosphate solubilizing bacteria isolated from different food and forage crops. *J. Agron* 5(4) : 600-604.

Panham, J.A., Deng, S.P., Da, H.N and Sun, D.A.Y. (2002) long term cattle manure application in soil I. Effect on soil, microbial, populations and community structure *Biol. Fertil. Soil.* 38: 209-215.

Parham, J.A., Deng, S.P., Raun W.R and Johnson G.V. (2002). Long term cattle manure application in soil I. Effect on soil Phosphorus level,