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SOME CHEMICAL PROPERTIES OF IRRIGATED SOILS AROUND SOKOTO MODERN ABATTOIR IN NORTH-WESTERN NIGERIA

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ABSTRACT

A study was conducted to determine the physico-chemical properties of irrigated soils of Sokoto Modern abattoir. Soil samples were collected from four identified farms (A,B,C,D) under irrigation that were affected by abattoir effluent. From each farm, three composite samples were collected at the surface (0-15cm) and subsurface (15-30cm) layers. A control sample was collected from an uncultivated land located about 200 meters southwest of the farmlands that was neither affected by abattoir nor fertilizer at the same depths, giving a total of 26 samples. The soils were analyzed for some basic chemical properties following standard methods. The results revealed an alkaline soil with mean pH of 8.6 and 8.5 at surface and subsurface layers, respectively. The organic carbon obtained was high both at the surface (3.72-4.11%) and subsurface (1.08-2.93%) layers, which were about 1.4 to 2.8 times higher than the control values. Total N in surface and subsurface (0.08-0.09% and 0.04-0.07%) and available phosphorus (4.56-5.04 and 3.18-3.56mg kg^{-1}) values were very low in effluent affected soils and even lower in the control samples. Exchangeable potassium was high with a mean value range of 1.14-1.81 cmol(+)kg^{-1} and 0.53-0.73 cmol(+)kg^{-1} for the surface and subsurface layers, respectively. There was a general indication of the effect of abattoir affluent on the levels of chemical parameters analyzed, compared to the control samples, except the pH. The soils were relatively fertile and could sustain effective crop production if the pH could be reduced to the levels favourable to crops and microbial activity.

Key words: Abattoir effluent; Chemical properties; Irrigated soils; Fertility**.**

INTRODUCTION

Present day agriculture requires the supply of additional nutrients for optimum crop performance through complimentary means. Complimentary use of organic and inorganic fertilizers is widely known to be a reliable and sustainable soil fertility management strategy (Frissel, 1978; Powell and Mohammed-Salem, 1987; Murwira *et al.*, 1995).

One of the major sources of nutrient supply to crops is through organic materials. Compost and farm yard manures are highly beneficial, releasing significant quantity of available nutrients (Murwira *et al.*, 1995; Lupwayi *et al.*, 1998). The use of organic manures (especially ruminant dung, poultry droppings, household refuse and effluents) for crop production is an age-long agricultural practice among the subsistence farming communities in West Africa sub-region (Lombin *et al.*, 1991). The inventory of urban and industrial wastes in Nigeria as compiled by Sridar (2006) showed that millions of tons of industrial, domestic and animal wastes are produced annually in the country and that these wastes can be utilised effectively for agriculture.

Abattoir effluent is a liquid or solid waste released from the industry that consists of blood, urine, manure, digesta and non-edible parts that are important sources of nutrients. Areas around abattoirs are used to grow crops through irrigation as sources of food. This contributes not only to health and quality of life, but it also enhances the economic and social status of the producers (Gura, 1996). According to Osemwota (2010), abattoir effluent is the residual material obtained from the abattoir after the slaughter of animals such as cattle, sheep, goats, etc. The effluent comprises materials such as blood, urine, faeces, water, etc. of such slaughtered animals. The application of rice husk and abattoir affluent at 100kg ha^{-1} and 75L ha^{-1}, respectively, in a greenhouse experiment has been reported to have increased the organic carbon content of the soil from 1.51 to 3.51% (Ogboghodo *et al*., 2008).

In the recent past, there has been series of campaigns for organic agriculture through the use of organic sources of plant nutrients, of which abattoir effluent is a good example. Farmers around the Sokoto modern abattoir use the abattoir effluent as a source of nutrient for their crops, but to what extent abattoir effluent has affected the fertility of the soils requires investigation, which forms the basis of this research.

MATERIALS AND METHODS

Study Site

The experiment was conducted in irrigated farms near the Sokoto modern Abattoir. Sokoto State is located between latitudes $11^o\ 30^1$N and $13^o\ 50^1$N and longitudes $4^o\ 0^1$E and $6^o\ 0^1$E, at 315m above sea level. Sokoto falls in the Sudan savanna agro-ecological zone of Nigeria that is characterized by erratic and scanty rainfall that lasts for about four months (mid June-September). The dry period lasts from October to May. The annual rainfall of the area is highly variable over the years and averages around 700mm (Singh, 1995), with minimum and maximum temperatures of 15^oC and 40^oC (Arnborg, 1988).

Soil Sampling, Sample Preparation and Analyses

A total of 24 soil samples were collected from four selected farms (A, B, C and D). From each farm, three composite samples were collected at the depths of 0-15 and 15-30cm. A control sample was collected from an uncultivated land located about 200 meters southwest of the farmlands. This land was neither affected by abattoir effluent nor fertilizer. The samples were labeled as appropriate and taken to laboratory, air dried, crushed and sieved through a 2mm sieve for chemical analysis. The following chemical properties of the soils were analyzed using standard methods: pH was determined using glass electrode pH meter in 1:2 soil:water ratio (Mclean, 1982). Total N was analyzed by micro-Kjedahl method (Jackson, 1962), and organic carbon determined by dichromate oxidation method as described by Nelson and Sommers (1982). Available phosphorus was analyzed by Bray No.1 method (Bray and Kurtz, 1945) and exchangeable potassium determined by flame photometry (Rich, 1965).

Data Analysis

Data generated were subjected to simple descriptive statistics (Steel and Torrie, 1980). Mean, frequencies, percentages and standard deviation were used to present the results.

RESULTS AND DISCUSSION

Hydrogen Ion

The results of chemical analyses obtained are shown in Tables 1 and 2, which indicate high pH values of the soils both at the surface and subsurface layers. The mean pH values ranged between 8.3 to 8.8 at the surface layer and 8.1 to 8.8 at the subsurface layer. The control sample had pH values of 8.7 and 8.4 at the surface and subsurface layers, respectively. The highest pH value of 8.8 was obtained at surface layer of farm plot D and subsurface layer of plot C. The influence of abattoir effluent was not observed in the pH values relative to the control sample, since the pH of the effluent affected soils and the control were within the same levels (Tables 1and 2). The soils can be described as strongly alkaline (Michael and Donald, 1999) which is quite different from the result obtained by Osemwota (2010), who reported a mean pH value of 6.4 in abattoir effluent soils at Ambrose Alli University Teaching and Research Farm in Ekpoma, Nigeria. High pH may result in build-up of sodium and a tendency of boron toxicity as reported by Landon (1991), as well as development of salinity/sodicity (Graff and Patterson, 2001). These values may be as a result of organic materials from abattoir (bones, flesh, blood) that are rich in base cations like Ca, Mg and Na.

Organic Carbon and Organic Matter

The organic carbon content was found to be relatively high compared to the standard ratings of Esu (1991),who gave the limits for low, medium and high as <1.0, 1.0-1.5, and >1.5g/100g respectively. The average organic carbon obtained at the surface layer was 3.82, 4.11, 3.84 and 3.72% in farm plots A,B,C and D, respectively, which were about 1.8 times higher than those of the subsurface layer. Abattoir effluent enhanced the organic carbon content of the soils when compared to the results obtained in the control samples at the surface (2.73%) and subsurface (0.78%) layers (Tables 1 and 2).

The organic matter content was also high as it is always a direct translation of the organic carbon content of the soil. The highest organic matter content of 7.10% was obtained in farm plot B which was 34% higher than the control value (4.71%) (Table 1). The organic matter content of the subsurface layer was relatively low compared to the surface. The highest value of 5.05% was obtained in farm plot D in the subsurface soil which was 73% higher than the control value (1.34%) (Table 2). The high level of organic matter obtained could be as a result of the influence of abattoir effluent.

Table 1. Some chemical properties of soils as affected by abattoir effluent at 0-15cm depth

Farm Plot	Depth (cm)	Rep.	Properties					
			pH	Org. Carbon (%)	*Org. matter (%)	Total N (%)	Avail. P, (mg kg^{-1})	Exch. K, (cmol kg^{-1})
A	0-15	$A_1$1	8.2	3.96	6.80	0.09	4.17	1.07
		A_1*2*	8.5	3.59	6.19	0.08	4.61	1.15
		$A_1$3	8.5	3.91	6.74	0.09	4.90	1.20
		Mean	8.4	3.82	6.58	0.09	4.56	1.14
		SD	0.17	0.201	0.336	0.006	0.368	0.066
B	0-15	$B_1$1	8.6	4.09	7.06	0.08	4.82	1.30
		$B_1$2	7.9	4.07	7.02	0.09	4.68	1.38
		$B_1$3	8.4	4.18	7.22	0.08	4.63	1.23
		Mean	8.3	4.11	7.10	0.08	4.71	1.30
		SD	0.36	0.059	0.106	0.006	0.098	0.075
C	0-15	$C_1$1	8.6	3.76	6.48	0.09	4.82	1.71
		$C_1$2	8.6	3.24	5.58	0.08	4.79	1.58
		$C_1$3	8.9	4.53	7.80	0.10	4.80	1.61
		Mean	8.7	3.84	6.62	0.09	4.80	1.63
		SD	0.10	0.204	0.557	0.012	0.066	0.040
D	0-15	$D_1$1	8.8	3.72	6.41	0.08	5.07	1.66
		$D_1$2	8.7	4.26	7.34	0.07	5.04	1.84
		$D_1$3	9.0	3.18	5.48	0.07	5.00	1.92
		Mean	8.8	3.72	6.41	0.08	5.04	1.81
		SD	0.15	0.015	0.025	0.010	0.102	0.036
Con trol	0-15		8.7	2.73	4.71	0.06	3.87	1.23

*Org. Matter = Org. C x 1.723 (constant)

Total Nitrogen

Nitrogen levels for all the soil samples were generally low (Tables 1 and 2), which is the most prominent characteristics of tropical soils (Young, 1976). Another possible reason for the low nitrogen levels maybe that the high pH (Table 1) increased bacterial activity, and hence mineralization and nitrification of organic matter which increases the rapid rate of nitrogen loss in soils (Brady and Well, 2002). There is an indication of the influence of abattoir effluent in the levels of total nitrogen relative to control. Singh *et al*. (2002) reported 0.17g kg^{-1} of total nitrogen content of irrigated fadama soils of Sokoto State, while Audu *et al*. (2009) reported 0.46mg kg^{-1} total nitrogen in Wurno Irrigation Project. The standard values for low, medium and high total nitrogen in soils are <0.15, 0.15-0.20 and >0.20%, respectively (Adepetu *et al.*, 1979; Esu, 1991).

Table 2. Some chemical properties of soils as affected by abattoir effluent at 15-30cm depth

Farm Plot	Depth (cm)	Rep.	Properties					
			pH	Org. Carbon (%)	*Org. matter (%)	Total N (%)	Avail. P, (mg kg^{-1})	Exch. K, (cmol kg^{-1})
A	0-15	$A_1$1	8.5	1.16	2.00	0.06	3.43	0.58
		$A_1$2	8.4	1.08	1.87	0.06	3.48	0.61
		$A_1$3	8.5	1.01	1.74	0.06	3.50	0.53
		Mean	8.5	1.08	1.87	0.06	3.47	0.57
		SD	0.06	0.075	0.130	0.000	0.036	0.040
B	0-15	$B_1$1	8.7	2.27	3.92	0.04	3.51	0.58
		$B_1$2	8.7	2.20	3.79	0.04	3.16	0.46
		$B_1$3	8.5	2.04	3.52	0.05	3.09	0.56
		Mean	8.6	2.17	3.74	0.04	3.25	0.53
		SD	0.12	0.118	0.204	0.006	0.225	0.064
C	0-15	$C_1$1	8.7	2.61	4.49	0.06	3.12	0.71
		$C_1$2	8.8	2.23	3.48	0.08	3.25	0.74
		$C_1$3	8.9	2.55	4.39	0.06	3.17	0.66
		Mean	8.8	2.46	4.12	0.07	3.18	0.70
		SD	0.10	0.204	0.557	0.012	0.066	0.040
D	0-15	$D_1$1	8.3	2.95	5.08	0.07	3.68	0.74
		$D_1$2	8.0	2.93	5.03	0.06	3.49	0.69
		$D_1$3	8.1	2.92	5.05	0.05	3.52	0.76
		Mean	8.1	2.93	5.05	0.06	3.56	0.73
		SD	0.15	0.015	0.025	0.010	0.102	0.036
Control	0-15		8.4	0.78	1.34	0.04	2.10	0.51

*Org. Matter = Org. C x 1.723 (constant)

Available Phosphorus

The phosphorus levels in the soils were generally low. However, the values were relatively higher in effluent affected soils than in the control soils. The results obtained showed higher concentration of phosphorus in the surface layer than the subsurface layer (Tables 1 and 2) with the values of 4.56 to 5.04 mg kg^{-1} in the surface layers and 3.18 to 3.56 mg kg^{-1} in the subsurface layers. The control samples had 3.87 and 2.10mg kg^{-1} P in the surface and subsurface layers, respectively. The control values for low, medium and high P contents in soils are <10, 10-20 and >20mg kg^{-1}, respectively, (Adepetu et *al*., 1979; Esu, 1991). High pH value can cause low available phosphorus content because of the presence of calcium, since phosphates tend to be converted to calcium phosphate at high pH levels, thereby reducing its availability (Landon, 1991; Tisdale and Nelson, 1994). Jones and Wilds (1975) reported that the West African savanna soils are generally low, and sometimes very low, in phosphorus content. They gave the phosphorus content values of the region as 1.43 mg kg^{-1}. The amounts were highest in Vertisols and Hydromorphic soils with a mean of 1.94 and 1.82mg kg^{-1}, respectively, and lowest in brown and reddish brown sub-arid soils with a mean of 0.92mg kg^{-1}. Singh and Tsoho (2001) reported available P content for soils around river Rima and river Sokoto to be 0.3 - 6.01mg kg^{-1} and 0.01-0.07mg kg^{-1}.

Exchangeable Potassium

Potassium content was high in soils of the study area compared to the ratings of Adepetu *et al.* (1979) and Esu (1991), in which values of <0.15, 0.15-0.30 and >0.30 $cmolkg^{-1}$ were considered as low, medium and high, respectively. The highest value (1.81$cmolkg^{-1}$) was recorded in farm plot D followed by plots C, B and A with values of 1.63, 1.30 and 1.14, respectively, in the surface layer. The subsurface layer also had high values of exchangeable potassium compared to the standards, but the absolute values were about 2-3 times lower than the values obtained in the surface layer. The control samples had relatively high values too, although lower than the values obtained in the effluent affected farms. This indicates that the soils were generally rich in exchangeable bases, and as proven by the pH levels strongly alkaline (Michael and Donald, 1999) of the soils.

CONCLUSION

The study revealed that the soil was strongly alkaline, rich in organic matter and exchangeable potassium content, and low in total nitrogen and available phosphorus attributed to high pH. Abattoir effluent contributed to the enrichment of the soils in all the parameters studied, except pH. However, the absolute values reduced with increased soil depth. There was the likelihood of salinity/sodicity build-up since the soils were strongly alkaline. Therefore, there is need for effective management strategies that will reduce the pH levels of the soils in order to achieve maximum benefit of the effluent for high crop yields and safe environment. Further study is also recommended to evaluate the influence of the abattoir effluent on crop performance.

REFERENCES

Adepetu, J.A., A.Adebayo, E.A. Aduayi and C.O. Alofa (1979). A preliminary survey of fertility status of some soils in Ondo State under traditional cultivations. *Ife Journal of Agriculture,* 1: 134-140.

Arnborg, T. (1988). *Where Savanna Turn into Desert.* Rural Development Studies, No 24. Swedish University of Agricultural Science, Uppsala, Sweden.

Audu, M.**,** A. A. Abdullahi and S. Abdulaziz (2009). Fertility status of soils of Wurno Irrigation Project, Sokoto, Nigeria. In: A.S. Fashina, O.J. Ayodele, A.E. Salami and S.O. Ojeniyi (eds). *Management of Nigerian Soil Resources for Enhanced Agricultural Productivity*. Proceedings of the 33rd annual conference of the Soil Science Society of Nigeria, University of Ado Ekiti, Ado-Ekiti, Nigeria. March 9 - 13, 2009. pp 81-87.

Brady, N.C. and R.R.Well (2002). The *Nature and Properties of Soil.* 13th ed. Pearson Prentice Hall, Pearson Education, Delhi, India, 976p.

Bray, R.H. and L.T. Kurtz (1945). Determination of total organics and available forms of phosphorus in soils. *Soil Science,* 59:39-45.

Esu, I.E (1991). *Detailed Soil Survey of NIHORT FARM at Bunkure, Kano State, Nigeria*. 72 P.

Frissel, M.J. (1978). *Cycling of Mineral Nutrients in Agricultural Agro-ecosystems*. Elsevier, Amsterdam, The Netherlands, 356p.

Graff, V. and R.A. Patterson (2001). Explaining the mysteries of salinity, sodicity, SAR and ESP. In: R.A. Patterson and M.J. Jones (eds). *Advancing On-site Wastewater Treatment and Disposal*. *Proceedings of On-site 2001 Conference*, held at University of New England**,** Armidale, Australia. 27 Sep 2001. pp 361-368.

Gura, S. (1996). Vegetable production, a challenge for urban and rural development. *Agriculture and Rural Development*, 2 (1): 42-48.

Jackson, M.L. (1962). *Soil Chemical Analysis*. IITA. Manual Series No.1 70p

Jones, M.J. and A. Wild (1975). *Soils of the West African Savannah, the Maintenance and Improvement of their Fertility*. Commonwealth Agricultural Bureau, Farmhand Royal Slough, England 246p.

Kowal, J.M. and D.J. Knabe (1992). *An Agro-climatological Atlas of the Northern States of Nigeria with Explanatory Notes*. Ahmadu Bello University Press, Zaria. 147p.

Landon, J.R. (1991). *Booker Tropical Soil Manual. A Handbook for Soil Survey and Agricultural Land Evaluation in the Tropics and Subtropics*, Longman New York. 474p.

Lombin, L. G., J. A. Adepetu and K. A. Ayotade (1991). Complementary use of organic manure and inorganic fertilizers in arable crop production. *Proceedings of a National Organic Fertilizer Seminar,* Kaduna, Nigeria. pp. 146–162.

Lupwayi, N.Z., M. Girma and I. Haque (1998). Plant nutrient contents of cattle manures from small-scale farms and experimental stations in the Ethiopian highlands. *Journal of Agriculture, Ecosystems and Environment*, 78 (200): 57-63

Mclean, E.O. (1982). Soil pH and lime requirements. In: *Methods of Soil Analyses Part II*. *Chemical and Microbial Properties*. Page A.L.(ed) American Society of Agronomy, Madison, Wisconsin, USA pp 199-220.

Michael, J.S. and N.M. Donald (1999). *Soils, an Introduction*. 4th ed. Macmillan Prentice Hall, Upper Saddle River, NJ, 527p.

Murwira, H.K., M.J. Swift and P.G.H. Frost (1995). Manure as a key resource in sustainable agriculture In: Powell, J.M., T.O. Fernanddez-Rivera, T.O. Williams and C. Renard (eds.). *Livestock and Sustainable Nutrient Cycling in Mixed Farming Systems of Sub-Saharan Africa*. Proceedings of International Conference, International Livestock Center for Africa (ILCA), Addis Ababa, Ethiopia, 22-26 November, 1993 pp.131-148.

Nelson, D.W. and L.E. Sommers (1982). Total carbon, organic carbon and organic matter. P. 530-577. In: Page A.L.*et al*.(ed). *Methods of Soil Analyses*. Part II. 2nd Monogr.9. ASA and SSSA, Madison , Wisconsin USA.

Ogboghodo, I.A., U.B. Ohenztwa and J.U. Chokor (2008). The effects of rice husk and abattoir effluent on soil properties, nutrient uptake, microbial species and some maize (Zea mays L.) growth parameters I: Greenhouse experiment. *Nigerian Journal of Soil Science*, 18: 31-38

Osemwota, O. I. (2010). Effect of abattoir effluent on the physical and chemical properties of soils. *Journal of Environmental Monitoring and Assessment*, 167:399–404

Powell, J.M., M.A. Mohammed-Saleem (1987). Nitrogen and phosphorus transfers in a crop-livestock system in West-Africa. *Agriculture System*, 25: 261-277.

Rich, O.L. (1965). Elemental analysis by flame photometry. In: *Methods of Soil Analyses* Am. Soc. of Agron. C.A. Black (ed.).No. 9 part II pp 849-860.

Singh, B.R (1995). Soil management strategies for the semi-arid ecosystem in Nigeria. The case study of Sokoto and Kebbi States. *Africa Soils*, 28: 320-327

Singh, B.R. and H.K. Tosho (2002). Fertility and salinity/sodicity status of fadama soils in northwestern Nigeria III. In: Sokoto State along the perennial surface water bodies. *Nigerian Journal of Basic and Applied Sciences*, 11 (1 and 2): pp 21-30.

Singh, B.R., S.A.Ibrahim and M.A. Augie (2002). Quality of fadama soils irrigated with tubewell water in Sokoto State, Nigeria. *Journal of Agriculture and Environment*. 3: 175-182.

Sridar, M. K. C. (2006). Solid waste management in the twenty first century in Nigeria, In: *Proceedings of the Fourth Annual Conference of Senate on the Nigerian Environment*. Organised at Portharcourt by Senate Committee on Environment and Ecology, National Assembly, July 5–7 Abuja, Nigeria, pp 1–11.

Steel, R.G. and J.H. Torrie (1980). *Principles and Procedures of Statistics*. 2nd ed. Mcgraw-Hill, New York, 633p.

Tisdale, L.S. and W.L. Nelson (1994). *Soil Fertility and Fertilizers*. Pretence hall Inc: India 699p.

Young, A. (1976). *Tropical Soils and Soil Survey*. Cambridge University Press, London 486p.