ENVIRONMENTAL ANALAR

A Journal of Environmental Analysis

No.3, Sept., 1999

ISSN 1595 - 0174

ENVIRONMENTAL SYSTEMS CLUB INC.

Env. Anal. 3 (1999) pp 226-233

ENVIRONMENTAL ANALAR

EFFECTS OF DEFORESTATION ON THE CHEMICAL PROPERTIES OF SOILS IN OSHIMILI LOCAL GOVERNMENT AREA OF DELTA STATE, NIGERIA

I. E. Ukpong, C. A Okafor and E. M. Akpabio

Department of Geography and Regional Planning

University of Uyo, Nigeria

Accepted 10th August, 1999

Abstract

The aim of this study is to determine the effects of deforestation on the chemical elements of soils based on a side-by-side comparison of the soils from deforested and forested areas in Oshimili, Delta State. The essential elements in soils such as organic carbon, total nitrogen, available phosphorus, exchangeable cations and the macronutrients have observably higher concentrations and values in forested soils than in deforested soils. These observations are viewed in their implications to forest ecosystem management and conservation.

1. Introduction

Deforestation entails indiscriminate cutting down of tress for purposes such as fuelwood, stakes for building construction, timber for furniture making and the gathering of fruits for consumption. About 50 years ago, forest vegetation covered much of southern Nigeria, but logging, farming - particularly of the bush burning fallow and land rotation type, urban and infrastructural development and conversion to plantations have reduced the true forest areas to patches found in forest reserves (NEST 1991). Outside the reserves, the vegetation in the forest zone is a mosaic of farms, fallow vegetation of various ages and degraded or converted land. Nowadays, relics of forest maintained as sacred groves are to be found scattered among farmlands, but these are usually small, often less than one hectare.

Forest clearance on a massive scale for agricultural development, urban growth, industrial expansion and general pressure from an increasing population has reduced the extent, diversity and stability of the Nigerian forest. The general effect of timber exploitation mostly from the high forests which cover only about 12.41 million hectares of the country's 91.1 million hectares of land space, is that the forest stability is disrupted and its ecosystem seriously disturbed (Aina and Ademola 1992). The disturbance is not only in terms of its inability to regenerate through the natural process, but some species and fauna are being endangered. Similar danger of extinction is faced by wildlife for which the forest provides natural habitat. Probably the clearest indication of the danger faced by wildlife is that even the Savanna environment which has given them some cover is disappearing and giving way to desert or near desert condition.

As soon as deforestation occurs, agricultural lands become depleted of nutrients by surface wash. The top soil is removed and the soil structure deteriorates (Kinnell et al 1990). Consequently the chemical properties of the soils are affected (Lal *et al* 1989). Since soil nutrient loss results from deforestation, this study aims to investigate the level of nutrient loss to the soil environment in Oshimili, a highly deforested area in Delta State, Nigeria.

Methodology

Forests located in Asaba, Ila and Okpanam settlements were sampled for Soil data. The soils samples were collected among forested and deforested areas at two depths: 0-15cm (surface), 15-30cm (subsurface). The deforested area was defined as secondary

bushes that had been under cultivation with evidence of recent farming activities, while a forested area was defined as that which had been relatively undisturbed for at least the past six years. A total of 48 soil samples were collected from each settlement, 24 each from the forested and deforested soils. As a cost saving measure, the soil sample were later bulked to obtain 12 samples for each layer in each settlement. This means that a total of 72 samples were analysed. A side-by-side comparison of soil values from forested and deforested areas was made to observe variations in the characteristics of the soils.

The following laboratory methods were employed in the analysis of the soils: pH was determined in 1:2.5 soil/water suspension using glass electrode; electrical conductivity was measured with a conductivity metre in extracts obtained from the soil/water suspension. Organic carbon was determined by the oxidation method of Walkley and Black (1934); total nitrogen, by the macro Kjeldhal digestion and distillation method (Jackson 1964); available phosphorus, by the Bray method (Bray and Kurtz 1945); exchangeable bases by extraction with 1 N ammonium acetate: K and Na in the extracts were determined by flame spectrometry and Ca and Mg by atomic absorption. Exchangeable acidity was extracted with 1 N kcl and the acidity determined by titration with NaOH. (I.I.T.A. 1979). Effective cation exchange capacity (ECEC) was the summation of exchangeable bases and exchange acidity. percentage base saturation was the proportion of exchangeable cations to ECEC. The micro nutrients were measured with atomic absorption spectrophotometer after total elemental digestion.

Results and Discussion

Table 1 shows that the pH values of deforested and forested areas indicate moderate acidity although forested soils tend to a greater acidity condition. This is probably because organic matter accumulation on the forested soils are higher and decompose to release organic acids which reduce soil pH.

Table 1. Soil acidity, electrical conductivity, organic carbon, total nitrogen and available phosphorus levels in deforested and forested soils at 0-15cm depth.

Sample Location	pH (water)		EC (ds/m)		Organic C (%)		Total N (%)		Available P (mg/kg)	
	Deforested	Forested	Deforested	Forested	Deforested	Forested	Deforested	Forested	Deforested	Forested
Asaba	5.54	5.22	0.1089	0.1126	0.64	0.78	0.06	0.09	13.99	16.66
Ila	5.00	4.88	0.0650	0.1026	1.89	1.96	0.14	0.18	12.33	15.33
Okpanam	5.28	5.00	0.7230	0.1012	1.56	1.95	0.08	0.16	11.56	13.99
$\bar{X}$	5.27	5.02	0.2989	0.1054	1.3633	1.56	0.09	0.14	12.61	15.34
SD	0.27	0.17	0.3678	0.005	0.6478	0.67	0.04	0.05	12.42	13.35
CV	5.12	8.54	123.08	4.74	47.51	43.48	0.46	33.8	9.84	8.7

Organic carbon, total nitrogen and available phosphorus have higher mean values in forested soils than in deforested soils. The accumulation of organic carbon, nitrogen and phosphorus reaches an equilibrium in an undisturbed ecosystem. Therefore forested soils have a higher value of organic carbon than deforested areas. Likewise electrical conductivity, total nitrogen and available phosphorus vary more in deforested soils than in forested soils due to the varying age of the fallows.

Soil properties in the second soil layer (15-30cm) is shown in Table 2. In this layer, pH values in deforested and forested areas also indicate moderate acidity. The mean pH value is 4.55 and 4.82 for deforested and forested soils respectively.

Table 2. Soil acidity, electrical conductivity, organic carbon, total nitrogen and available phosphorus in deforested and forested soils at depth 15-30cm

Sample Location	pH (water)		EC (ds/m)		Organic C (%)		Total N (%)		Available P (mg/kg)	
	Deforested	Forested	Deforested	Forested	Deforested	Forested	Deforested	Forested	Deforested	Forested
Asaba	4.88	4.86	0.0643	0.0984	0.12	0.68	0.03	0.06	9.33	10.33
Ila	4.68	4.72	0.1192	0.0942	1.34	1.92	0.13	0.18	5.99	12.66
Okpanam	5.00	4.88	0.8964	0.0866	1.30	1.80	0.05	0.09	8.33	11.33
$\bar{X}$	4.85	4.82	0.359	0.093	0.920	1.47	0.070	0.110	7.883	11.440
SD	0.16	0.09	0.465	0.006	0.693	0.68	0.059	0.624	1.714	1.168
CV	3.33	1.81	129.63	6.43	75.32	46.5	75.6	56.8	21.7	10.2

Organic carbon, total nitrogen and available phosphorus have higher mean values in forested than deforested soils for reasons earlier discussed concerning the 0-15cm layer. Higher acidity in forested sub-surface soils could be explained by the injection of more nitric acid into the topsoil by the litter components and root exudates (Faniran and Areola 1978).

Table 3 indicates a higher mean surface values for exchangeable bases in forested soils than in deforested soils. The decomposition of dead plants and animals releases exchangeable bases and increase their levels in the forested soils. As the bushes are cleared, these elements are rapidly leached away.

Table 3. Exchangeable bases, exchangeable acidity and effective cation exchange capacity in forested and deforested soils at depth 0-15cm.

Sample Location	Ca (Mg/100g)		Mg(Mg/100g)		Na (Mg/100g)		K(Mg/100g)		EA (Mg/100g)		ECEC(Mg/100g)	
	Deforested	Forested	Deforested	Forested	Deforested	Forested	Deforested	Forested	Deforested	Forested	Deforested	Forested
Asaba	2.60	3.65	1.20	1.45	0.29	0.34	0.17	0.19	1.07	1.18	5.33	6.57
Ila	2.40	2.84	1.68	1.75	0.35	0.45	0.56	0.48	1.34	1.88	6.33	6.45
Okpanam	2.80	3.12	1.10	1.10	0.24	0.26	0.42	0.38	1.22	1.32	4.96	5.12
$\bar{X}$	2.60	3.20	1.32	1.43	0.29	0.35	0.38	0.35	12.10	1.46	5.54	6.05
SD	0.20	0.41	0.31	0.32	0.06	0.09	0.19	0.15	13.52	0.37	0.71	0.80
CV	7.69	12.85	23.48	22.74	18.99	27.25	51.99	42.09	1.12	25.37	12.79	13.30

Organic matter content of forested soils permits aggregation and contributes to the cation exchange capacity. It holds such important cations as Ca^{++}, Mg^{++}, K^{+} and NH_4^{+} to its colloidal surface and exchanges them with other elements of like charges.

Table 4. Exchangeable bases, exchangeable acidity and effective cation exchange capacity in forested and deforested soils at depth 15-30cm

Sample Location	Ca (Mg/100g)		Mg(Mg/100g)		Na (Mg/100g)		K(Mg/100g)		EA (Mg/100g)		ECEC(Mg/100g)	
	Deforested	Forested	Deforested	Forested	Deforested	Forested	Deforested	Forested	Deforested	Forested	Deforested	Forested
Asaba	2.16	3.42	1.44	1.52	0.56	0.62	0.56	0.42	1.07	1.19	6.79	6.84
Ila	2.64	2.95	0.96	1.12	0.33	0.38	0.28	0.31	1.16	1.85	5.37	5.43
Okpanam	2.60	3.00	1.52	1.42	0.29	0.32	0.44	0.46	1.18	1.30	5.85	5.98
$\bar{X}$	2.46	3.12	1.31	1.35	0.39	0.44	0.42	0.39	1.14	1.45	6.00	6.08
SD	0.27	0.26	0.30	0.21	0.15	0.16	0.14	0.08	0.06	0.35	0.72	0.71
CV	10.83	8.27	23.12	15.42	37.36	36.08	32.66	19.9	5.14	24.38	12.04	11.69

The mean values of exchangeable bases in sub-surface soils (16-30cm) are higher in forested soils than in deforested soils (Table 4). Through deforestation, plants that could have released the bases to the soils are removed, thus making the soils to be deficient in organic matter.

Table 5 shows that the mean values of micro-nutrients in forested surface soils are higher than in deforested surface soils. This higher values are probably due to the protection of the surface soil by vegetation which reduces leaching of the elements to lower depths.

Table 5. Micronutrients in Deforested and Forested Soils at depth 0-15cm

Sample Location	Fe (ppm)		Zn (ppm)		Cu (ppm)		Mn (ppm)	
	Deforested	Forested	Deforested	Forested	Deforested	Forested	Deforested	Forested
Asaba	1537.4	1853.6	45.6	55.4	30.7	42.7	650.2	872.5
Ila	1651.8	2441.8	57.6	63.8	37.8	38.6	588.2	740.2
Okpanam	1592.7	1983.6	58.4	72.9	62.5	42.1	578.3	620.8
$\bar{X}$	1593.9	2093.0	53.8	64.0	43.7	41.1	605.5	744.5
SD	57.2	308.9	7.2	8.8	16.7	2.2	38.8	125.9
CV	3.5	14.8	13.3	13.7	38.2	5.4	6.4	16.9

A similar trend was observed in the subsurface soil (Table 6). Soils in deforested areas are intermittently exposed to runoff and leaching with a cumulative effect of lowering micronutrient levels. In addition, previous cultivation activities might have exhausted soil fertility before the farms were abandoned to become regrowth.

Table 6. Micronutrients in Deforested and Forested Soils at depth 15-30cm

Sample Location	Fe (ppm)		Zn (ppm)		Cu (ppm)		Mn (ppm)	
	Deforested	Forested	Deforested	Forested	Deforested	Forested	Deforested	Forested
Asaba	1486.2	1862.4	49.8	51.2	31.4	40.3	598.4	801.2
Ila	1542.7	2831.4	48.2	56.5	34.2	47.8	542.6	760.4
Okpanam	1564.2	2012.1	62.5	81.6	66.8	39.5	674.6	630.4
$\bar{X}$	1531.0	2235.3	53.5	63.1	44.1	42.5	605.2	730.7
SD	40.3	521.6	7.8	16.2	19.7	4.6	66.3	89.2
CV	2.6	23.3	14.6	25.7	44.6	10.8	10.9	12.2

Summary and Conclusion

This study has shown that soil chemical nutrients required by plants for growth e.g organic carbon, total nitrogen and phosphorus occur with higher levels in forested soils than in deforested soils.

The accumulation of these elements is apparently enhanced in an undisturbed ecosystem as exemplified by forest vegetation. The study has also shown that forested soils are more acidic than deforested soils consequent to the decomposition of organic matter which releases organic acids into the soil system. Exchangeable bases, exchangeable acidity, ECEC and the micronutrients also achieve higher values in forested than deforested soils. The higher values are associated with relatively high organic matter content of the forested soils which create an effective nutrient cycle.

The overall conclusion of the study is that deforestation is detrimental to soil quality in terms of nutrient build-up (Ukpong 1997). To reduce deforestation, extension services, conservation practices and sustainable system of farming need to be introduced as a forest ecosystem management practice. Once the people are convinced that deforestation is the cause of soil degradation and consequently food shortage, the remedial measures will be accepted.

Environmental education and awareness campaign could be introduced into all levels of the national education system such that conservation practices could replace traditional values. Since it is inevitable that agriculture and farming must be practised and timber exploited, this approach should be given serious consideration. Extension services should recommend mulching, cover cropping and application of organic manures to improve soil structure. Intelligent lumbering habit of afforestation should be the condition for giving out rights to loging companies. If the habit of planting tress is imbibed then deforestation and its associated environmental problems will cease in the near future.

References

Aina, T. A. and T. S. Ademola 1992. The challenge of sustainable development in Nigeria. *Nigeria Environmental Study/Action Team.* Intec Printers, Ibadan P. 38

Bray, R. H. and L. T. kurtz 1945. Determination of total, organic and available forms of phosphorus in soils. *Soil Sci.* 519:39-45.

Faniran, A. and O. Areola 1978. *Essentials of Soil Studies.* Heinemann, London.

International Institute for Tropical Agriculture 1979. Selected methods for soil and Plant Analysis. manual Series No. 1. *I. I. T. A.*, Ibadan, Nigeria.

Jackson, M. L. 1964. *Soil Chemical Analysis* Prentice-Hall, Englewood Cliffs, N.Y. 498 pp.

Kinnell, P. I. A., C. Chartres. and C. L. Watson (1990) Edaphic effects of prescribed burning on a red earth soils in Semi-arid woodlands: the effect on erosion susceptibility. *Austr. J. Soil Resources*, 28 (Cited in Akpabio E. M. (1998) *Effects of Bush Burning on Soil Fertility,* Unpublished B.Sc. dissertation, Dept. of Geography/Regional Planning, Univ. of Uyo. Nigeria).

Lal, G. F., G. F. Hall and P. Miller 1989. Soil degradation I. Basic Processes. In *Land Degradation and Rehabilitation* Vol. 1: pp. 51-69. John Wiley, N. Y.

Nigerian Environmental Study/Action Team 1991. *Nigeria's Threatened Environment.* Intec Printers, Ibadan, Pp. 137.

Ukpong, I. 1997. Nutrient build-up in bush fallow soils and its implication to subsistent agriculture in Akwa Ibom State. *Ibom Journal of Social Issues* 4:82-89.

Walkley, A. and I. A. Black 1934. An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Sci.* 37:29-38.