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Full Length Research Paper

Impact of reforestation in a part of degrading natural ecological system of Ilorin, Kwara State, Nigeria

E. O. Oriola[1]*, I. P. Ifabiyi[1] and A. T. Hammed[2]

[1]Department of Geography, University of Ilorin, Ilorin, Nigeria.
[2]Park and Garden Unit, University of Ilorin, Ilorin, Nigeria.

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This paper examines the response of soils in degraded land to reforestation in Ilorin region. A total of 16 soil samples were systematically collected from two quadrats of 25 × 25 m in each of reforested and deforested sites respectively. Standard laboratory techniques were used to test 8 soil fertility indices on each of the landscapes. Coefficient of variation was used to establish variability or otherwise within the data set. Student's 't' test was used to determine the significance of difference of the sample means of forested and deforested soil parameters. The result of the laboratory test revealed that vegetation cover affects the soil properties. Generally, the physical properties of the soil in this area are homogenous but variations exist in the chemical properties which fundamentally determine soil fertility. At the end, the conclusion was that fertility status of the soil increased under forest cover. It is therefore important for the government to provide adequate awareness and educate the people on reforestation of degraded land and land use and soil properties because they tend to affect each other. Government at local, state and federal levels should intensify effort on afforestation projects and replacement of trees when cut. Forest funding for afforestation has to shift from public to private to enhance community participation and their mobilization for forest conservation and sustainable forest resources and environmental development.

Key words: Deforestation, afforestation, trees, soil fertility status, soil properties.

INTRODUCTION

There is a growing awareness of the role which forest plays in natural ecological systems. Forest is involved in stabilizing soil, conserving nutrients, and moderating water supplies, especially in a world currently threatened with climate change and global warming. Jagger and Pender (2000) reported the importance of forest to include: Provision of biomass, watershed management, soil nutrient and water retention, fodder for livestock, construction materials and source of income. For example, wooded savanna region is a good source for fuelwood and poles (Aruofor, 2001) which sustain the economy. Ward and Robinson (1990) observed that vegetation increases the infiltration capacity of soil by retarding surface water movement, reducing raindrop impact and improving soil moisture. These authors further reported that infiltration rate is generally higher beneath forest due to presence of litter. In the same vein, Ifabiyi (2002) in his work on infiltration rate in Samaru also noted that forest vegetation promotes higher infiltration rate. Therefore, reforestation will result in a reduction of the level of soil erosion, sedimentation, flooding and the accompany consequences. The study also asserts that reforestation will promote soils as in the case of terrestrial carbon sequestration (USGS, 2008) and ground water recharge. In addition, trees also play a crucial role in the global cycling of carbon. The importance of this function has been underscored by the emergence of carbon dioxide induced climate change (Heimann and Reichstein, 2008) and perhaps the most threatening environmental problem of modern times where according to Cambell (2009) climate changes is likely to increase the frequency and severity of extreme climate events.

However, because of the complexity of forested environment in ecological settings, forest depletion has exerted some negative impact on man. For instance, besides diminishing upland productivity through the loss of nutrient by soil, soil erosion transfers sediments from deforested surfaces to river channels, aggravates local

*Corresponding author. E-mail: lolaoriola2003@yahoo.com.

Table 1. Forested area and charcoal production in Nigeria 2003 – 2007.

Year	Production ('000Mtons)	Forested area ('000ha)
2003	3,333,589.00	11,908.20
2004	3,420,800.00	11,498.60
2005	3,510,292.00	11,089.00
2006	3,592,327.00	10,679.40
2007	3,676,300.00	10,269.80

Source: FAO (2009).

flooding and contributes to the premature silting of reservoirs downstream thereby disturbing hydrological settings and encouraging desert encroachment, a condition which also poses serious threat to human life. More consequentially, deforestation renders the soil surface bare thus, increasing the surface albedo and making the earth atmosphere warmer.

Deforestation is essentially an important phenomenon in ecological relationship between man and spatial environment. Man influences forest both directly and indirectly. Man's various activities such as farming and wood harvest have direct impact on land. For instance, evidences abound that charcoal production has been on the increase while the forested area is reducing drastically (see Table 1).

The indirect influences are through the intervening variables such as man's perception of the forests as a vital component that enhance the peoples' livelihood and their lackadaisical behaviour towards reforestation. This has greatly increased forest ecology depletion.

This paper therefore examines the response of soils in degraded land to reforestation in a part of Ilorin environment with a view to assess the fertility status of the soil in the area for future agricultural production.

THE STUDY AREA

Ilorin is located between latitudes 8° 25' 35" and 8°31'30" North of the equator and longitudes 4° 28' 20"and 4° 35' 45" East of the Greenwich Meridian (Figure 1, Esan, 2009). The area is under-laid by pre-Cambrian basement complex rock of porphyritic granite. This type of rock has undergone many processes of metamorphism and magmatite intrusion. It is drained mainly by River Asa on which we have Asa Dam and other rivers that drain into the Asa River. These include Agba, Aluko, Okun, Alalubosa rivers.

The climate is characterized by alternate dry and wet seasons. Each lasting about six months. The wet season usually starts from the end of March and lasts till October. Rainfall ranges between 1120 – 1500 mm during this period. The dry season commences in November and lasts till early March (Emielu, 1991). This area experiences high temperature annual average often reaches 32°c. Rainfall is erratic in its distributions hence the deficiency for optimum growth and development of plants. The mean total annual rainfall is 1,200 mm (Olaniran, 2002)

The soil type in Ilorin is ferruginous tropical soil type existing on crystalline acidic rocks. The soil is uniform in terms of physical characteristics, the fertility of soils is variable and farming activities are enhanced in most parts of the study area. The soil has the tendency of being more productive if not for the water deficiency, thus it demands for adequate water management to attain better productivity (Oriola, 2006).

The vegetation is wooded savanna grass land or termed 'derived' Savanna' because the original vegetation cover has been removed through human activities such as clearing and cattle grazing among others. The common trees are shear butter tree *(Vitalera paradosa)* and locust bean tree *(Parkia biglobosa)*. While the grains grown in the area include millets, maize, sorghum and rice, common root crops found in this area are yam, cassava, potatoes and cocoyam.

MATERIALS AND METHODS

The study sites are located within Sobi area, along Shao Road, Ilorin, Kwara State, Nigeria. The area representing the forested ground is an undisturbed forested vegetation of about 400 m^2 in area. The forested environment has been under permanent forest for about 27 years. Precisely, trees were planted on 5th October, 1977 (Forestry Department, Kwara State Ministry of Environment and Tourism, Ilorin). The trees are of different heights and not in pure stands. Trees include *Gmelina arborea* (Dominant), teak (*Tectona grandis)* and *Cassia* species. Average height is about 10 - 15 m. Huge amount of litter covers the surface area. The deforested zone is the area directly opposite the reforested land which has been exposed to different deforestation activities. The land is devoid of trees except few shrubs which doted the area. Common grasses in the area include elephant grass *(Afzelia africana*) and biam grass (*Clapptonia*).

The experimental site for this study consists of two different land surfaces; reforested and deforested. On each surface, 16 soil samples were collected from 25 x 25 quadrants demarcated in each surface. The samples were selected systematically, (at every other quadrant) under T*. grandis*. A similar exercise was carried out on deforested land surface.

In each of the quadrats composite soil samples were collected from a predetermined depth of 0 - 15 and 15 – 30 cm referred to as the top soil and sub soil respectively. This study confines analysis of soil characteristics to the top 30 cm of the soil profile because the roots of common crops in this area are usually concentrated in the top 30 cm of the soil profile where the bulk of plant nutrients are concentrated. This should be the zones best for testing soil fertility status.

Essential soil properties that directly affect the fertility status and the productivity of the soils (Brady and Weil, 1999) were analyzed. They include particle size composition, bulk density and water holding capacity, soil pH, organic matter, exchangeable cations (ca^{2+}, mg^{2+}, Na^{+}, k^{+}), total nitrogen and available phosphorus.

Particle size analysis was carried out using the hydrometer method as described by Bouyoucos (1951); Bulk density was

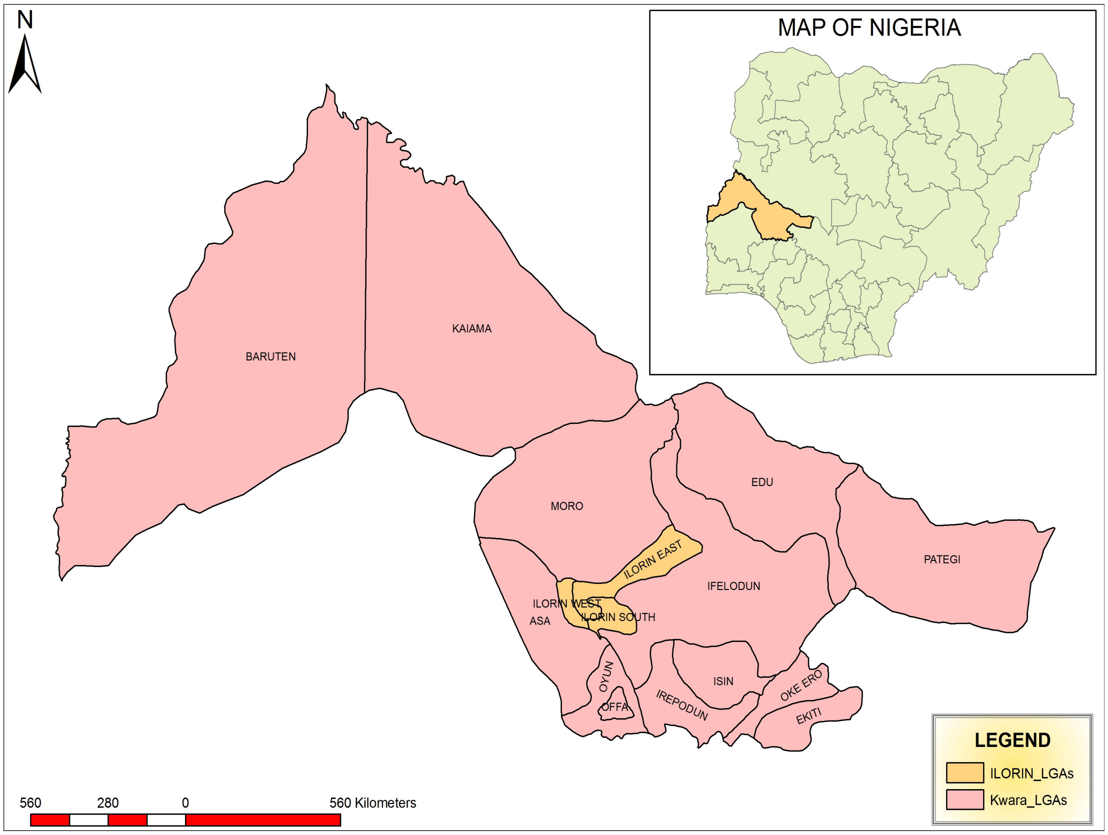

Figure 1. Map of Kwara showing the study area. Source: After Esan (2009).

determined by core method of Black, Water holding capacity was determined by first saturating the soil samples with water and later subjected to gravitational draining for 24 h; organic matter was determined by Walkley and Black method (1934), organic carbon content was determined using the chromic acid digestion method, exchangeable cations by the ammonium acetate method (Chapman, 1965), available phosphorus was determined using Bray no1 method as described by Olsen and Dean (1965) and total nitrogen was determined with Macro-kjedahl digestion distillation apparatus as described by Bremmer (1965).

Coefficient of variation was used to test the variability of the soil nutrients while Student's t- test was employed to test for the significant differences in the mean values of soil nutrients in forested and deforested surfaces. The fertility status of the soils under forested surface was assessed in terms of the level organic matter and exchangeable bases.

RESULTS AND DISCUSSION

Tables 2 and 3 show summary of soil properties of topsoil and subsoil under forested and deforested surfaces respectively while Table 4 shows t-test statistics depicting differences in soil properties between forested and deforested surfaces in the study area.

The results of the analysis carried out on the soils under the two land use categories show no significant difference in the textual properties except for bulk density. The similarity indicates that vegetal cover has no effect on physical properties. Many authors have made similar observations and have concluded that since soil texture is a permanent property, it may not significantly be affected by vegetal cover (Gbadegesin and Olusesi, 1994; Ogidiolu, 1997).

The organic matter content is higher in the top layers of both surfaces with the mean value of 5.21 for forested surface and 4.56 for deforested surface (Tables 2 and 3) but there exists a statistical difference between them (Table 4). The higher organic matter content under forested surface can be attributed to the following:

1. The larger foliage cover of forest helps to reduce the impact of soil erosion in removing surface organic matter.
2. Organic matter that normally accumulates under forest provides conducive environment for higher microbial activities (Simmonds, 1972) and
3. Removal of plant cover as in annual bush fire are protected from this surface.

The above situation is enhanced by the assemblage of trees, herbs and bacteria and other microorganisms found in this environment which facilitates higher productivity with greater biodiversity.

Similarly, other organic nutrients namely available phosphorus 27.52 units, organic carbon 3.1, calcium 2.94, magnesium 1.18 and total nitrogen 0.04 are also

Table 2. Soil properties under forested surface (top and sub soils).

		Forested surface							
	Parameter	**Top soil**				**Sub soil**			
S/N	**Physical property**	**Range**	**$\bar{X}$**	**S.D.**	**C.V.**	**Range**	**$\bar{X}$**	**S.D.**	**C.V.**
1	Particles composition								
	Sand	98.00 - 98.80	98.40	0.86	0.34	98.20 - 98.60	98.35	0.83	0.40
	Silt	0.60 - 1.20	0.90	0.26	28.89	0.60 - 1.20	0.90	0.26	28.09
	Clay	0.60 - 0.82	0.71	0.12	16.90	0.60 - 0.80	0.71	0.12	17.14
2	Bulk density	1.45 - 1.48	1.46	0.01	0.68	1.47 - 1.48	1.48	0.01	0.68
3	W. H. C	22.05 - 25.04	23.04	1.22	5.29	20.01- 23.01	21.00	1.58	7.52
S/N		**Chemical property**							
1	pH	6.00 - 6.50	6.30	0.36	5.71	6.10 - 6.50	6.20	0.01	5.61
2	Organic matter%	4.65 - 6.23	5.21	0.86	36.51*	4.10 - 6.01	5.15	6.83	36.12*
3	Exch.Ca meq/100	2.80 -3.15	2.94	0.17	5.78	3.0 - 3.40	3.15	0.19	6.03
4	Exch. Mg meq/100	0.60 -1.70	1.18	0.61	51.69*	0.60 - 1.20	0.85	0.25	49.41*
5	Exch. Na meq/100	0.15 - 0.033	0.21	0.05	23.81	0.18 - 0.25	0.21	0.03	19.29
6	Exch. K meq/100	0.14 - 0.25	0.21	0.03	14.29	0.17 - 0.25	0.21	0.02	10.52
7	Nitrogen	0.02 - 0.04	0.04	0.01	33.33*	0.02 - 0.03	0.03	0.01	33.33*
8	P (ppm)	14.60 - 34.80	27.52	6.00	22.70	28.50 - 36.50	31.81	4.65	18.71

* = C.V > 33% showing variation in soil properties; SD = standard deviation; WHC = water holding capacity; C.V = co-efficient of variation; X = Mean.

Table 3. Soil properties under deforested surface (top and sub soils).

		Deforested surface							
Parameters		**Top soil**				**Sub soil**			
S/N	**Physical property**	**Range**	**$\bar{X}$**	**S.D.**	**C.V.**	**Range**	**$\bar{X}$**	**S.D.**	**C.V.**
1	Particles composition								
	Sand,	98.40 - 98.80	98.60	0.20	2.07	98.40 - 98.60	98.50	0.17	2.07
	Silt,	0.60 - 0.80	0.75	0.15	20.00	0.80 -1.00	0.85	0.10	11.76
	Clay	0.60 - 0.80	0.70	0.12	17.10	0.60 - 0.80	0.70	0.12	17.14
2	Bulk density	1.41 - 1.49	1.45	0.03	0.68	1.40 - 1.46	1.42	0.03	0.68
3	W. H. C	20.00 - 22.16	21.06	1.48	7.02	17.08 - 20.42	19.28	1.70	8.81
S/N	**Chemical property**								
1	pH	5.7 - 6.00	5.85	0.13	2.22	5.70 - 6.10	6.01	0.20	3.33
2	Organic matter%	3.76 - 5.79	4.56	0.67	19.25	4.13 - 4.55	4.39	0.49	15.01
3	Exch.ca meq/100	3.00 - 3.90	3.45	0.39	11.37	3.20 - 3.70	3.43	0.33	9.57
4	Exch. Mg meq/100	0.60 - 1.50	0.90	0.41	45.56*	0.60 -1.50	0.90	0.41	46.56*
5	Exch.Na meq/100	0.01 - 0.30	0.16	0.09	56.25*	0.15 - 0.22	0.19	0.07	36.84*
6	Exch. K meq/100	0.10 - 0.47	0.46	0.32	59.56*	0.01 - 0.47	0.38	0.17	44.74*
7	Nitorgen	0.02 - 0.04	0.03	0.01	33.33*	0.02 - 0.04	0.02	0.01	58.00*
8	P(ppm)	16.02 - 20.20	20.28	3.95	19.47	14.5 - 16.8	13.13	1.17	8.90

* = C.V. > 33% significant; SD = standard deviation; X = Mean; C.V = co-efficient of variation.

higher under the forested surface as indicated in Table 2. All these elements exhibit significant difference (Table 4). This pattern may be because organic matter is a major source of soil organic nutrients (Olaitan and Lombin, 1988).

Potassium content is higher under deforested surface

Table 4. Student 't'-test statistics depicting differences in soil properties between reforested and deforested surfaces in the study area.

T-Test calculated for both layers			
Parameter		Top soil	Sub soil
S/N	**Physical properties**		
1	Particles composition		
	Sand	-0.45	0.35
	Salt	1.00	0.36
	Clay	0.11	0.12
2	Bulk density	0.63	3.80*
3	Water holding capacity	2.04*	1.95*
S/N	**Chemical properties**		
1	pH	2.35*	2.70*
2	Organic matter%	2.19*	2.58*
3	Exch. Ca. meg/100	2.40*	3.47
4	Exch. Mg. meq/100	3.12*	1.96
5	Na	0.97	0.52
6	K	2.56*	1.99*
7	N	1.56	1.41
8	P(ppm)	10.04*	7.52*

*T calculated > T tabulated at t_x 0.05%(6); Significant level (1.94).

with mean value of 0.46 than the forested which has 0.21. This is because the higher concentration of nitrogen and phosphorus cause the deficiency of the element under forest (Faniran and Areola, 1978), and the burning of deforested surface produces abundant ash on surface thereby increasing the concentration. The ash contains high concentration of potash, which is very high in potassium ion concentration.

There is no significance difference in soil particle size distribution under both land use surfaces (Table 4). The table shows that significant difference exist in chemical properties. These can be explained in the context that the particle size distribution which happens to be a textural property of the soil is more often influenced by parent materials than by vegetal cover. The difference in chemical properties can be attributed to thick weathered soil layer which has increased organic matter content in the soil and promoted activities of soil organism under the protection of the tree canopy. This confirms the observations of Jagger and Pender (2000) in their study of Eucalyptus in Ethiopia that trees can return nutrients such as nitrogen and potassium to the soil. The reestablished vegetation cover slows down the effects of erosion from irregular and severe rainfall.

STUDY AND POLICY IMPLICATIONS

The t-test results indicate that to a large extent there is a difference between both surfaces with respect to organic matter and other exchangeable bases. It thus implies that organic matter is highly influenced by the plant cover as this generates the litter that constitutes its major raw material.

Furthermore, the balance of organic matter can also be easily influenced by biotic interference. Wastes from grazing animals that roam the entire area can raise the level of organic matter, while removal of plant cover through various processes like bush burning and animal grazing could bring imbalances.

The study also implies that the difference in organic matter and other exchangeable bases can therefore be justified by the variations in the major chemical properties of the soils in this area. Since the high concentration of the chemical elements and organic matter determine fertility status of soil, it thus implies that fertility status of soils in the study area improves better in forested soils than the deforested ones.

This occurrence calls for the use of fertilizer in order to improve crop productivity in the deforested area and other similar environment where deforestation process is intense. Therefore, the persistent search for fertilizer by farmers in the deforestation threatened areas is justifiable.

This issue of fertilizer is very important because depletion of soil nutrients often leads to clearing new forest thereby extending agricultural land. Government should therefore double efforts toward meeting this need. It is also important for the government to provide adequate awareness on land use and soil properties depletion because they tend to affect each other.

Realizing the important role trees or forests play in socio-economic life of the nation, it has become necessary to shift funding of afforestation projects from public to private organizations in which private participation is given all the support they need. As rightly observed by Aruofor (2001), such organizations particularly Non- governmental organizations (NGOs) can easily attract foreign fund for afforestation programmes and mobilizing communities for forest conservation and sustainable forest resources and environmental development.

Conclusion

The high varying nature of soil nutrients and organic matter properties between forested and deforested surfaces in the study area is likely to bring about varying degree of soil productivity in this area. This is because the soil properties that exhibit variability were the ones that are essential to plants and they were required in large quantities for growth and development of plants and their productivity. Aside the fact that the soil under reforested land have higher fertility status, they also habour tree species of great economic value often harvested for poles and wood fuel.

REFERENCES

Aruofor R (2001). Forest Sector Outlook Study, FOSA Working Paper 36. FAO. p. 31.

Bouyoucos GH (1951). "A Recalibration of the Hydrometer for Making Mechanical Analysis of Soils" Agro. J., 43: 434-438.

Brady NC, Weil RR (1999). The Nature and Properties of Soil. (12th Edition) Prentice Hall, New Jersey.

Bremmer JM (1965). "Total Nitrogen" in Black, C.A (eds) Methods of Soils Analysis. Am. Soil Agro. Monograph., 9(2): 1162-1164.

Campbell BM (2009). Beyond Copenham: REDD+. Agriculture, adaptation strategies and Poverty: Global Environmental Change: Human and policy Dimension, 19: 397-399. Elsevier.

Chapman HD (1965). "Cation Exchange Black, C.A. (eds) Methods of Soil Analysis. Am. Soil Agro. Monograph. 9(2): 891-901.

Emielu SA (1991). Guide to Kwara State Geographical Bureau Nig. Ltd. p. 10.

Esan AO (2009). Determining the locational Efficiency of Kwara Waste Management Company Waste Bins in Ilorin Metropolis. *An Unpublished MGIS Dissertation,* Department of Geography, University of Ilorin, Ilorin.

Faniran A, Areola O (1978). Essentials of Soils Studies. Heinemann Educational Books Ltd. pp. 47-48, 192.

FAO (2009). Food and Agricultural Organization. Statistics Division. http//faostat.fao.org retrieved on 12th July 2009.

Gbadegesin AS, Olusesi BB (1994). "Effects of Land Clearing Methods on an Afisol in South Western Nigeria". Indonesia J. Geogr. 26: 41-45.

Ifabiyi IP (2000). "Variability of Infiltration Rates in Samaru, Nigeria in GeoStudies Forum: An Int. J. Environ. Policy Issues, 1(1-2): 87-92.

Jagger P, Pender J (2000). The Role of Trees for Sustainable Management of Less Favoured Lands: The Case of Eucalyptus in Ethiopia. EPTD Discussion Paper No 65.IFPRI Washington. D.C.

Ogidiolu A (1977). "Effects of Cassava Cultivation on Soil Properties Under Peasant farming System in Southern Nigeria" Int. J. Environ. Dev., 1: 25-29.

Olaitan SO, Lombin G (1988). Introduction to Tropical Soil Science. Macmillan Hong Kong. p. 126.

Olaniran OJ (2002). "Rainfall Anomalies in Nigeria: The Contemporary Understanding". The Fifty-fifty Inaugural Lecture, University of Ilorin. April. p. 8.

Olsen SR, Dean LA (1965). "Phosphorus" in Black, C.A. (eds) Methods of Soil Analysis. Am. Soc. Agro. Monograph., 9(2): 1035-1048.

Oriola EO (2006). "Exploration of Irrigation Projects: A Panacea for Unemployment" in Saliu HA, Ogunsanya AA, Olujide JO, Olaniyi JO (eds). Democracy and Development in Nigeria. Vol.2 Economic and Environmental Issues. pp. 285-301.

Simmonds NW (1972). The Evolution of the Banannas, Longman Publication, London. p. 48.

USGS (2008). Carbon Sequenstration to Mitigate Climate Change. http://pubs.usgs.gov/ Retrieved 2010-8-15.

Walkley A, Black IA (1934). "An Examination of the Degtjareff Method for Determining Soil Organic matter and proposed Modification for the Chronic Acid Titration Method" Soil Sci., 102: 275-277.

Ward RG, Robinson M (1990). Principle of Hydrology McGraw Hill Book Co. New York.