International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2020): 7.803

Physicochemical Properties of the Soils of Yankari Game Reserve and Environs A Comparative Analysis

Mohammed, I.[1], Abubakar, I. M[2]

[1]Department of Environmental Management Technology, Faculty of Environmental Technology, Abubakar Tafawa Balewa University, Bauchi

[2]Department of Agricultural Education, Federal College of Education Yola, Jimeta, Adamawa State
Email; [*]*Isahyankari68[at]gmail.com; kautenkoae[at]gmail.com*

Abstract: ***The study investigated the trend of changes occurring on the physical and chemical properties of the soil in Yankari Game Reserve and 2km around the reserve perimeter with the view to compare the impact of conservation on the soil properties. Soil samples from Yashi, Tonlong and Karyo range of the reserve were randomly collected from three selected sub - points along established transects at 2km and 4km inside and 2 km outside the reserve, using soil auger at a depth of 0 - 30cm and mixed up to produce one composite sample for each point. Sample obtained were analyzed using standard laboratory techniques. Data obtained was analyzed using one way analysis of variance (ANOVA). Soil textural classes for soils at the three sites 2km outside and 2km inside as well as the core area of the reserve were found to be sandy loam for 2km outside and loamy sand for 2km inside the reserve and the core area. Physicochemical analysis revealed that Sodium (1.75mg/100g) and total nitrogen (0.67%) were significantly higher ($P < 0.05$) in the core area soils while zinc (0.40ppm) was significantly ($P < 0.05$) higher in the 2km inside the reserve soil. Bulk density (3.48g/cm^2) was significantly ($P < 0.05$) higher in the soil collected 2km outside the reserve perimeter. The study concluded that there is high soil perturbation through land clearing ploughing and trampling by livestock's of the soil outside the reserve.***

Keywords: Soil, Conservation, Perturbation, Perimeter and Game Reserve

1. Introduction

Yankari Game Reserve is one among many protected areas in Nigeria suffering from lack of an established buffer zone; "a buffer is an Areas peripheral to a specific protected area, where restrictions on resource use and special development measures are undertaken in order to enhance the conservation value of the protected area". Absent of these zone makes the Yankari Game Reserve vulnerable to numerous human intimidations and environmental degradation. Notably among them include; wild fire, fuel wood collection, logging for timber, grazing, mining, settlement expansion and pollution of water resources. Besides, there is the continuous expansion of agricultural activities and its subsequent transformation from manual agriculture to mechanical and in most recent years to chemical agriculture around the fringes of the Game Reserves and many other Game Reserves and National Parks boundaries in Nigeria. This phenomenon predisposes the adjoining reserves' bio - resources and their supporting systems (soils and water) to serious degradation.

Studies have revealed that land use intensities around PAs soon after their establishment has the effect of altering ecological stability, through reduction in their effective size and fragmentation of the system (IUCN, 2010). In a study conducted by Sanderson *et al*. (2002), entitled "measuring human footprint on biological resources", it was observed that humans have modified over 83% of the Earth's land surface due to land - use. Thus, changes in land - use practices, and more specifically, conversion of land from more natural conditions to less natural conditions is one of the main threats to biological diversity (Fischer, 2007; Vitousek, 1997). Intensifying land uses around PAs often threaten their ecological integrity and effectiveness of PAs as a conservation tool (Joppa *et al*., 2008).

These threats therefore, forced many of the Nigerian Game Reserves and Forest Reserves to exist only on paper due to increasing pressure of land uses while many were degazatted and converted to farmlands, settlements and or grazing reserves. The few that can be seen, Yankari Game Reserve inclusive are becoming islands of forest between human settlements and farmlands and have continued to receive such pressure.

The study investigated the chemical characteristics of the soil of Yankari Game Reserve and the adjoining communities with the view to comparing the variation between the two in relation to the effectiveness of conservation.

2. Method of Data Collection

Study Area

The research was conducted at Yankari Game Reserve (YGR) and 2km around the reserve boundary in Pali, Gwana and Duguri District of Alkaleri Local Government Area of Bauchi State. The reserve is located at Latitude 09^0 45$^{''}$.131$^{'}$ N and Longitude 010^0 30$^{''}$.746$^{'}$ E. It was established as Game Reserve in 1955 and upgraded to a National Park status in 1991 under the management of the National Parks Service. In 2006, the Bauchi State Government reclaimed it from the Federal Government, thus, reversing its status from Yankari National Park to Yankari Game Reserve. The reserve falls entirely within Bauchi State and occupies a total land area of 2, 244.10 km^2.

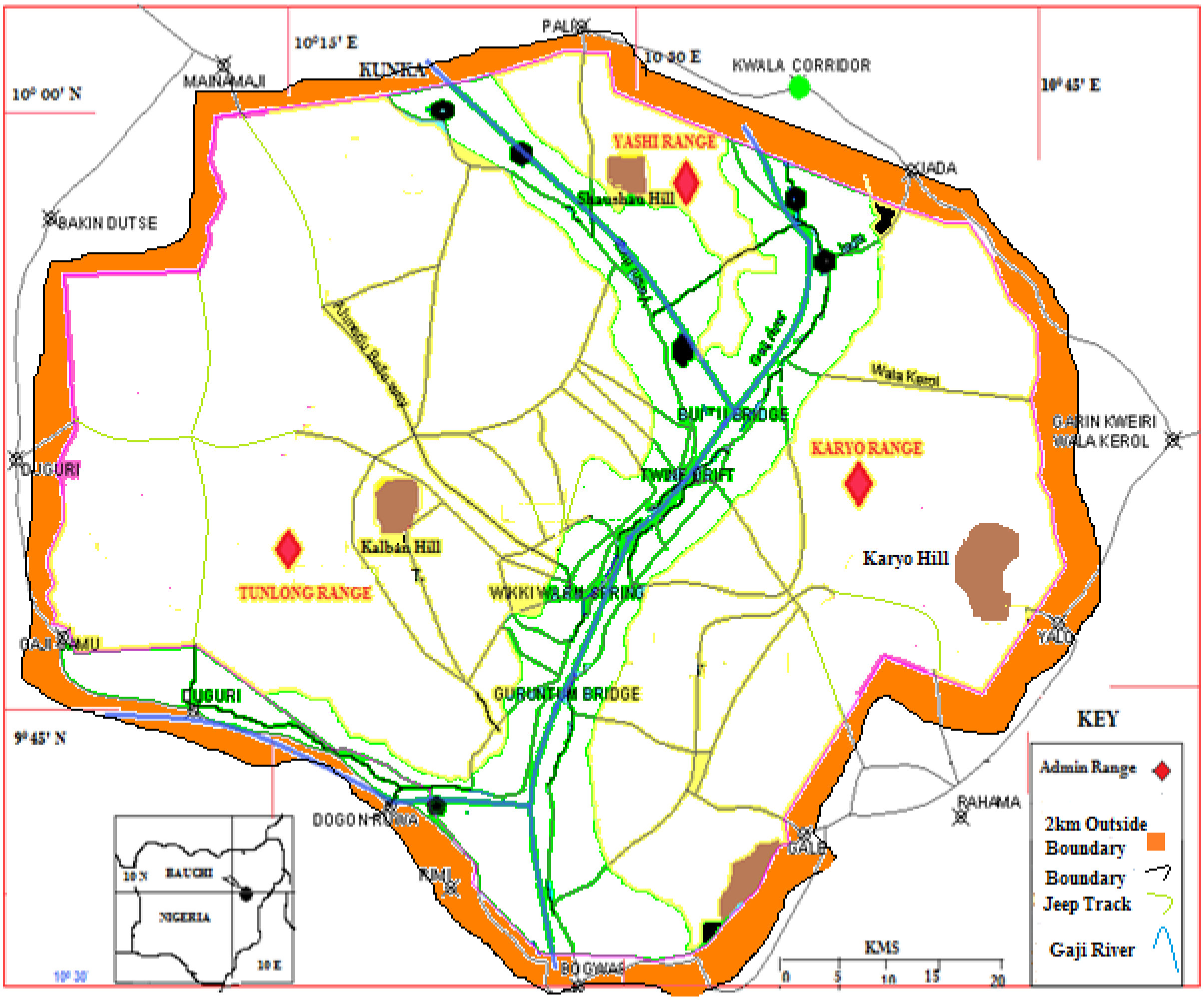

Figure 1: Yankari Game Reserve and 2km Beyong Boundary

Soil Sampling

The study area (YGR) was divided according to the three major administrative sectors (Ranges) of the reserve namely; Karyo, Yashi and Tunlong range. Soil samples from each range were randomly collected from three selected sub - points along established transects at 2km and 4km inside the reserve and mixed up to produced one composite sampled. The same procedure was repeated simultaneously in 2km outside the reserve in each administrative range.

Three (3) Soil sub - samples were collected from randomly selected points along established transects at 2km and 4km inside the reserve and 2km outside the reserve using soil auger at a depth of 0 - 30cm. The three samples from each study point (2km, 4km inside and 2km outside the YGR) were air dried, and mixed up to produced one composite sample. The composite soil samples were packaged in polythene bags, labeled and taken to an accredited laboratory for analysis.

Soil physical analysis

The three composite soil sample textural classes were determined using textural triangle methods, while bulk density was estimated using excavation method and water holding capacity of the soil sample was determined using gravimetric method described by Jaiswal, (2004)

Soil chemical analysis

pH; the soil pH was analyzed using potentiometric meter using glass electrode and pH meter. About 10g of air dried soil was put into clean beaker and 25ml of distilled water was added into the beaker and the suspension was stirred for 15 minutes and allowed to stand for 30 minutes. The two electrodes were inserted into the suspension and pH meter reading was recorded. The meter detects the potential difference between the two electrodes, which is directly proportional to the pH.

Electrical conductivity

The EC is the ability of the soil solution to carry electricity between two metal surface 1m apart, each with an area of $1m^2$. The EC of the soil sample was determined using KCL extraction method (Jaiswal, 2004).

Organic carbon

The soil organic carbon of the sample was analyzed using Walkley - Black method. In this method, 0.5g of the soil sample was sieved into 500ml conical flask.10ml of 1N KCO solution was added and shaken thoroughly to form a mixture. The sample was kept in the flask undisturbed for 30 minutes.3g of NaF and 10ml of distilled water was added and thoroughly shaken.10 drops of diphenylamine indicator was added which turned the solution violet. The violet solution was titrated against 0.5N FAN solution until the colour changed from violet to bright green and the volume of the solution used was noted. Similar titration was carried with a soil solution (blank titration). The soil organic matter was therefore calculated using the following formula; - % of organic carbon in the soil = { (X - Y) /2 x 0.003 x 100}/S (Weiner, 2000).

Where:
S = Sample weight (g)
X = Volume of FAS used in blank (g)
Y = Volume of FAS used to oxidized SOC (g)
N = normality of FAS

Effective cation exchange capacity (ECEC)

The ECEC was determined by summation of exchangeable bases and exchangeable acidity. (Jaiswal, 2004).

Potassium

The ammonium ethanoate leached out during the determination of CEC was used to determine exchangeable potassium by flame analysis, using flame photometer. (Jaiswal, 2004)

Calcium

Using the ammonium acetate leachate during the determination of CEC, exchangeable calcium was determined using atomic absorption spectrophotometer. (Jaiswal, 2004)

Magnesium and Sodium

Using the ammonium acetate leachate during the determination of CEC, magnesium and sodium was determined using atomic absorption spectrophotometer. (Jaiswal, 2004)

Net nitrogen

Total Nitrogen was determined by analyzing NO_3^- N and NH_4^- N using micro - Kjeldehl digestion method. (Jaiswal, 2004)

Available phosphorous

The available phosphorous was determined colorimetrically using photoelectric colorimeter after developing molybdenum blue colour as described by Jaiswal, (2004).

Exchangeable acidity

Exchangeable acidity was determined by extracting the H^+ and Al^{3+} with potassium chloride (KCl) solution, the extract is titrated with NaOH and back titrated with HCL using phenpolpthelein as indicator (Jaiswal, 2004).

Sulphate

Sulphate was determined by extracting sulphur with potassium orthophosphate solution where the sulphate was obtained by turbid metric method (Weiner, 2000).

Heavy metals (Pb, Cd, Zn, Co, Ni, and Cu)

The heavy metals of the soil sample were extracted with 2M nitric acid and determined by Atomic Absorption spectrophotometer (AAS) and flame photometer

Soil data analysis

Data obtained was analyzed using one way analysis of variance (ANOVA).

The statistical model used was as follows; -

$Y_{ij} = \mu + T_i + e_{ij}$

Where:
μ = the overall mean of various elements in the study sites
Y_{ij} = the j^{th} observation under the i^{th} treatment of the factor
T_i = the effect of the i^{th} treatment of the factor (soil element analysis)
e_{ij} = the random error associated with j^{th} observation of treatment i. (Panneerselvam, 2008)

3. Results

Changes in Soil Physical and Chemical Properties

Table 1 shows some soil physical properties of Yankari Game Reserve and its environment. Soils are sondy loam in texture 2km outside the reserve, loamy sand outside and core area of the reserve. Low water holding capacity value of 0.07, 0.08 and 0.13% were recorded for 3km outside, 2km inside and the core area of the reserve respectively. Bulk densities of 1.49g/cm^3 for 2km inside and outside and 1.49g/cm^3 for core area were recorded. Bulk density was significantly ($p<0.05$) higher in the core area of the reserve than in the 2km outside and 2km inside the reserve.

Some soil chemical properties of YGR and environment.

Table 2 shows mean values of some soil chemical properties of Yankari Game Reserve and its environment. pH value recorded 6.33, 6.00 and 6.33 for 2km outside, 2km inside and core area of the reserve respectively. Electrical conductivity value of 32.20, 27.20 and 46.33µS were recorded for 3km outside, 2km inside and core area respectively. organic carbon and total nitrogen content value range from 5.7 to 17.3 and 2.30 to 6.70 for organic carbon and total nitrogen respectively with a highest of both total nitrogen and organic carbon recorded in the core of the reserve and the least outside the reserve. However, Total nitrogen was significantly higher ($p<0.05$) in the soil sample of the core area than 2km inside reserve and 2km outside reserve from the boundary. Available phosphorous content value of 30ppm and 28.50ppm each for outside and the core area were recorded. Total exchangeable bases (TEB); calcium, magnesium, sodium and potassium were highest (4.85TEB and least (1.75TEB) in the core area of the reserve and 2km outside the reserve respectively. Sodium was significantly higher ($P< 0.05$) in the core area than in the 2km inside and outside the reserve. Exchangeable acidity value of 0.56 and 0.33 were recorded for 2km outside the reserve and 2km inside and core area of the reserve respective.

Heavy metals; copper, cadmium, cobalt, lead and zinc content values ranged from 0.10 to 0.30 in all the areas sampled. CEC values of 2.93, 5.13 and 2.93cmol/kg were recorded for 2km outside, 2km inside and core area of the reserve respectively.

Table 1: Soil Physical Properties of Yankari Game Reserve (YGR) and its Environment

Soil particle	2km outside YGR boundary	2km inside YGR boundary	Core area of YGR
Sand (%)	78.70	78.70	65.3
Silt (%)	8.67	10.00	18.73
Clay (%)	12.63	11.30	15.97
Texture	Sandy loam	Loamy sand	Loamy sand
Water Holding Capacity (%)	0.07	0.08	0.13
Bulk Density (g/cm^3)	1. .49	1.49	2.48

Source: Field survey, 2014

Table 2: Some Soil Chemical Properties of Yankari Game Reserve and its Environment

Soil parameters	2km outside reserve	2km inside reserve	Core area of reserve	Stde error of mean (SEM)
Ph	6.33	6.00	6.37	0.13
Electrical Conductivity (µS)	32.20	27.20	46.33	11.55
Organic carbon (g/kg)	5.7	7.7	17.3	0.27
Total Nitrogen (g/kg)	2.30	2.70	6.70	0.87
Available Phosphorus (ppm)	30.00	28.50	28.50	5.57
Calcium (cmol/kg)	0.87	0.68	2.26	0.37
Magnesium (cmol/kg)	0.04	0.37	0.56	0.16
Sodium (cmol/kg)	0.60	0.68	1.75	0.21
TEB	1.75	1.90	4.85	NA
Potassium (cmol/kg)	0.24	0.17	0.28	0.05
Exchangeable Acidity (cmol/kg)	0.56`	0.33	0.33	0.08
Cation Exchange Capacity (cmol/kg)	2.93	5.13	2.93	0.53
Heavy Metals				
COpper (ppm)	0.24	0.15	0.24	0.24
Cadmium (ppm)	0.13	0.20	0.30	0.04
Cobalt (ppm)	0.17	0.15	0.20	0.03
Lead (ppm)	0.16	0.06	0.26	0.05
Zinc (ppm)	0.04	0.40	0.10	0.12

Source: Field Survey, 2014

4. Discussion

Soil physical characteristics of YGR

The characterization of the soils into Loamy Soil (for soils inside the reserve) and of Sandy Loam (for soils outside the reserve) may not be unconnected with the formation of the soils, which had their origin from sandstone parent materials as reported by Green (1987). The protection of the soil inside the reserve against agricultural activities of any forms, incessant fire and trampling of all sort perhaps accounted for its loamy sand nature as against the Sandy Loam textural class of the soil outside the reserve significant difference ($p<0.05$) occurred in bulk density between site. Similar observation was made by Akosim (1997) in a study in Pandam Wildlife Park.

High soil bulk density is an indication of degradation through anthropogenic activities such as deforestation, ploughing and trampling. Findings from this study showed a relatively high level of bulk density in the core area of the reserve (2.48g/cm^3), which was found to be significantly ($P < 0.05$) high than those of 2km inside the reserve and 2km outside the reserve, with mean value of 1.49g/cm^3 each. It is therefore, expected that the soil in 2km outside the reserve will be sandy, porous and deficient in both micro and macro - nutrients relative to the soils in the 2km inside the reserve and the core area. Mohammed (2011) reported that soils along river Delimi in Lame Bura Game Reserve was found to possess high bulk density than the adjoining riparian vegetation soil because of protection.

Some soil chemical characteristics of YGR

Physico - chemical analysis carried out on soil samples of both inside and outside the reserve indicated the presence and variations in the parameters measured between soil samples of 2km outside the reserve, 2km inside the reserve and the core area of the reserve. However, significant difference ($P < 0.05$) occurred only in sodium, zinc, net nitrogen between the sites.

Sodium (Na) is the most abundant of all the alkali elements in the soil, and constitutes 2.6% of the earth crust (Weiner, 2000). Findings indicated a significant ($P < 0.05$) higher level of sodium in the soil samples of the core area of the reserve than in the soil samples of 2km inside and 2km outside the reserve. The high level of sodium in the core area of the reserve may not be unconnected with the high level of salt - lick deposits in the area. The high concentration of mineral licks in the core area may be the consequence of the topography of the reserve and its environs, in which the entire area of the reserve is like a basin resulting in the net flow of minerals from the outside the perimeter of the reserve to the core area. Green (1987) reported that the prevalence of salt lick in the central area of YGR is an attribute of high mineral accumulation along the Gaji river complex.

The implication is obvious, when examined in relation to the distribution of mammalian populations in the reserve. In view of the requirement of salt by mammals, it is expected that most mammalian populations will be attracted to the core area; where they may be found forming clusters around the salt - licks. Such sports serve as attractions to tourist and are usually used for wild animals censuses (Sutherland, 1999).

Chemical analysis of soil samples also indicated presence of zinc in the core area and in the 2km inside the reserve and 2km outside the reserve. The result further indicated that the zinc content of the soil of the 2km inside the reserve was significantly ($P < 0.05$) higher than those of the core area of the reserve and 2km outside the reserve, while that of 2km outside the reserve been the less. The mean value (0.04ppm) recorded for zinc in the 2km outside the reserve is the least. This could be the result of high soil perturbation through land clearing and ploughing as well as trampling by livestock's, which resulted in the pulverization of the soil, because of its sandy nature and consequently leaching of the soil minerals, which also affected the available zinc in the soil. The low level of available zinc in the core area may not be unconnected with the incessant flooding in the area, which results in the leaching of available zinc.

The low level of available zinc in the soils of the core area and the 2km outside the reserve may likely result in low quality forage and crops in these areas. This is because the low levels of available zinc will impair electron transfer mechanisms and protein synthesis as reported by Vass

(1998) in a separate study. For wild animal populations this could affect their protein intake and consequently productivity. However, the high mobility of mammals could make it possible for them to move into the perimeter area outside the reserve to feed, thus compensating for the protein deficiency of forage resources in the core area. This observation goes in consonance with Ibrahim (2005) Studies on Human Elephant Conflict outside the perimeter of the reserve (YGR) as a result of their migration for high quality forage material.

In this study the total nitrogen mean value obtained for soils of 2km outside the reserve, 2km inside the reserve and the core area were 2.30g/kg, 2.7g/kg and 6.70g/kg respectively. That of the core area was found to be significantly ($P < 0.05$) higher than those of the 2km outside the reserve and 2km inside the reserve. The higher level of net nitrogen (2.30g/kg) outside the reserve may not be unconnected with the high utilization of organic fertilizer containing high level of nitrogen. The higher level of net nitrogen in the reserve (2.70g/kg for 2km inside the reserve and 6.70g/kg% in the core area) could be as a result of litter accumulation (dead plants and animals) resulting from protection against fire, farming and grazing. The high content of organic nitrogen in the litter is returned to the soil after the decomposition of the litter deposits. The implication of high net nitrogen content of the soil in the reserve is high protein content of the forage resource and high productivity of the wild animal populations. The observations are in line with the report of Akosim (1997) on a study in Pandam Wildlife Park who reported high nutritive forage material in the Park due to absolute protection and high litter accumulation.

Generally the results indicated steady decline in soil fertility from the core area of the reserve to areas outside the reserve (2km outside). pH, organic carbon and total nitrogen value indicated a negative shift from the core area to 2km outside the reserve. This shifts in soil fertility may not be unconnected to the protection of the reserve against anthropogenic factors which lead to the increased in soil fertility hence, the luxuriant vegetation cover inside the reserve compared to outside. This finding was rightly supported by the similar shift in the values of exchangeable bases from the core area of the reserve to the perimeter of the reserve and outside the reserve respectively. The consequence of anthropogenic activities outside the reserve boundary and the emergence of similar pressure toward the perimeter of the reserve from the support zones communities for livelihood sustenance over the years account for the loss of soil fertility outside the reserve and 2km inside the reserve from the boundary. The prevalence of heavy metal in the reserve soils sampled of copper, cadmium, cobolt, lead, and zinc. Although their quantities are very limited and do not constitute any health hazard to humans or wild animals, yet their presence could endanger the health and wellbeing of the wildlife species as well as the tourist after a long period of accumulation. However, occurrence of this heavy metal could be attributed to industrial activities taking place outside the game reserve boundary.

5. Conclusion

The study concluded that there is high soil perturbation through land clearing and ploughing as well as trampling by livestock's, which resulted in the pulverization of the soil outside the reserve and vice - vasa in the protected area. However, the low level of available zinc in the soils of the core area and the 2km outside the reserve may likely result in low quality forage and crops in these areas there by compelling larger mammals of the reserve to migrate at certain period of the year to move into the perimeter area outside the reserve to feed, thus compensating for the protein deficiency of forage resources in the core area. In the same vein, the higher level of net nitrogen in the reserve could be as a result of litter accumulation (dead plants and animals) resulting from protection against fire, farming and grazing. the study further conclude that the prevalence of heavy metal in the reserve although not in large quantity in the soils sampled of copper, cadmium, cobolt, lead, and zinc could be attributed to industrial activities taking place outside the game reserve boundary.

6. Recommendation

1) The traces of heavy metal recorded inside the reserve soils and support zone communities are within the threshold limit and therefore do not constitute any health hazard for now but should be monitor regularly to avoid lethal effect in both human and animals over a period of time.
2) The low level of available zinc in the soil of core area of the reserveis an indication of excessive flooding in the reserve due to high level of deforestation outside the perimeter of the reserve, there should be properly coordinated afforestation programme in the support zone communities back up by well - articulated agricultural programme that will in cooperate the concept of agroforestry.

References

[1] Akosim, C. (1997). Evaluation of Biodiversity Conservation and Management in Pandam Wildlife Park. Nigeria. Unpublished Ph. D Thesis, University of Ibadan, Ibadan. Njgeria.
[2] Fischer, J., Lindenmayer, D. B. (2007) Landscape Modification and Habitat Fragmentation: A Synthesis. Global Ecology and Biogeography 16: 265–280. Retrieved June 15, 20013. URL: www.http/; 10.1111/j.1466 - 8238.2007.00287. x.
[3] Green, A and Amance, S. A. (1987). Management Plan for Yankari Game Reserve Bauchi, Nigeria. WWF Tech Report 2.
[4] Ibrahim, D. C. and Mohammed, I. (2005). Controlling Human - elephant Conflict in Alkaleri Local Government Area Bauchi, Nigeria. *International journal of Environmental issues* Vol.3 Nov.1 Pp 203 - 210.
[5] International Union of Conservation of Nature (IUCN) (2010). "Red List of Threatened Species: Nigeria".

[6] Jaiswal, P. C, (2004) Soil, Plant and Water Analysis. Kalyani Publishers. Ludhiana –New Delhi - Noida (U. P) Hyderabad - Chennai - Kolkata - Cuttak. Pg 1 - 130
[7] Joppa, L. N., Loarie, S. R., and Pimm, S. L. (2008). On the Protection of "Protected Areas". In Proceedings of the National Academy of Sciences of the United States of America 105: 6673–6678. Retrieved November 15, 2013. doi: 10.1073/pnas.0802471105.
[8] Mohammed, I., Aishatu, I and Adamu, M. B. (2011). Comparative Analysis of Fauna Numerical characteristics of Yankari Game reserve from 1980 - 2008. *Environmental Research Journal* 4 (2); 177 - 181, (2010). *Medwell Journals, 2010.* Pakistan, ISSN; 1994 - 5396.
[9] Panneerselvam, R. (2008). Research Methodology. Publ. Asoke k. Ghosh Printice –Hall of India. New Delhi 1100001; 2008. ISBN 978 - 81 - 208 - 2452. Pp 45 - 86.
[10] Sanderson, E. W., Jaiteh, M., Levy, M. A., Redford, K. H., Wannebo, A. V. (2002). The Human Footprint and the Last of the Wild. Bioscience 52: 891–904. Retrieved June 5, 2014. doi: 10.1641/0006 - 3568.
[11] Sutherland, J. W. (1999). Ecological Census Techniques. A Hand Book Cambridge Unversity Press. London. Pp 1 - 336.
[12] Vass, R. (1998) Micronutrients. Publication of Department of Agronomy. Lowa State University, USA.
[13] Vitousek, P. M and Mooney, H. A. (1997) Human Domination of Earth's Ecosystems. Science 277: 494. doi: 10.1126/science.277.5325.494.
[14] Weiner, E. R. (2000). Application of Environmental Chemistry: A Practical Guide for Environmental Professionals. Lewis Publishers, Washington, DC.