The Eurasia Proceedings of Science, Technology, Engineering & Mathematics (EPSTEM)
ISSN: 2602-3199

The Eurasia Proceedings of Science, Technology, Engineering & Mathematics (EPSTEM), 2018

Volume 3, Pages 45-50

ICVALS 2018: International Conference on Veterinary, Agriculture and Life Science

Salinity Status of the Soils of a Sudano-Sahelian Zone of Yobe State, Nigeria

Ibraheem ALHASSAN
Federal University Gashua

Sunday DOGO
Federal University Gashua

Auwalu Garba GASHUA
Federal University Gashua

Abstract: Sustainable agricultural production in fragile soils of the Sudano-Sahelian agro-ecological zone requires a better knowledge of its salinity and sodicity problems for appropriate management practices. The study was carried out to evaluate the salinity indicators of the soils of Bade Local Government Area (LGA), situated in the Sudano-Sahelian ecological zone of Yobe State, Nigeria. Soils were randomly sampled from each of the 10 agricultural areas of the LGA at 0-20cm depth. Samples collected were composite based on location and depth for laboratory analysis. Shapiro–wilks normality test indicated that the data varies significantly from a normal distribution $p<0.05$. Descriptive statistics was carried out on the data and basic salinity parameters were calculated therefrom. The level of soil salinity was measured by electrical conductivity (EC) of the soil/water suspension, while total dissolved solids (TDS) and salinity tolerance rate (EC_{se}) were determined from the soil texture and EC values. Results obtained showed that the soils of the area are small to moderate dispersion existed across the areas for the soil salinity properties studied. The pH values were slightly acidic with a median of 6.45; EC_{se} median value was 1.75dSm^{-1} and a wider inter quartile range (IQR) of 1.54 – 4.76dSm^{-1}. Total dissolved solids (TDS) ranged from very low (44.8 mmol/L) to marginal (908.8 mmol/L). Exchangeable sodium percentage (ESP) ranged from 0.94 to 11.81%, with a median (interquartile range) of 3.99 (1.68 – 6.95%). Medium values were recorded on the salinity indices. Therefore best soil and water management practices such as incorporation of organic residues and manure, efficient use of inorganic fertilizers and improve drainage are required to prevent salts build up in the area.

Keywords: Salinity, Sudan, Sahel, Yobe state, Nigeria

Introduction

Soil salinity is the presence of soluble salts in the soil solution. Excess soluble salts in the root zone reduce plant growth, through either, osmotic stress or specific ion toxicities Vijayvargiya and Kumar, 2011). Salinity generally occurs in arid and semi-arid regions, where leaching of the profile is restricted (Bernstein, 1975). Soil salinity is one of the important soil properties that significantly affect agricultural production and environmental quality especially in the semiarid regions of the world and conventional chemical indicators of soil salinity include; electrical conductivity (EC), total dissolved solids (TDS) – refers to the total amount of soluble salts in a soil-saturated paste extract expressed in parts per million or milligrams per liter (ppm or mg/L). and exchangeable sodium percentage (ESP) is the sodium adsorbed on soil particles as a percentage of the Cation Exchange Capacity (CEC), while electrolyte stability index (ESI) gives a good indication of soil dispersion, although the threshold ESI value below which effective structural breakdown might occur is 0.025, which is twice as small as the expected 0.05 (Lin and Bañuelos, 2015; Odeh and Onus, 2008).

- Selection and peer-review under responsibility of the Organizing Committee of the Conference

Salinity of arable land is an increasing problem of many arid and semi-arid areas of the world where rainfall is insufficient to leach salts from the root zone, and it is a significant factor in reducing crop productivity (Francois and Maas, 1994).

Crop growth response to salinity are in two phases: a continuous osmotic phase that inhibits the water uptake by plants due to osmotic pressure of saline soil solution lowering its potential energy (water always moving from a higher to lower potential energy levels); and a slower ionic phase when the accumulation of specific ions in the plant over a period of time leads to ion toxicity or ion imbalance (Munns and Tester, 2008). For sustainable agricultural production, information on quantitative soil quality, such as salinity, is required for effective land management, crop production and environmental planning (Lin and Bañuelos, 2015).

The study is mainly exploratory to generate baseline information to ascertain the current salinity levels of the soils in order to monitor it and assure sustainability of agriculture production in Bade Local Government Area of Yobe State, Nigeria.

Materials and Methods

Field experiments were conducted in the ten (10) agricultural areas of Bade Local Government Area (LGA) of Yobe State in the North Eastern part of Nigeria. They are: Dagona (Dg), Gwio-Kura (GK), Katuzu (Kt), Lawan-Fannami (LF), Lawan-Musa (LM), Sabon-Gari (SG), Sarkin-Hausa (SH), Sugum-Tagali (ST), Usur-Dawayo (UD) and Zango (Zn). The LGA covers an area of 77200 ha and the main crops grown are millet, sorghum, cowpea, sesame and vegetables. The climate is arid with an average rainfall of 450 mm/year (rainy period range from June to September). The potential average evapotranspiration is 1400 mm/year. The soils are characterized by a sandy loam texture and the altitude varies from 334 to 377m (NPC, 2010; NEAZDP, 2015; Alhassan *et al*., 2017).

Random soil samples were taken from the surface 0-20cm depth with soil auger in each of the agricultural wards of the LGA. Particle size analysis was determined by the hydrometer method, soil pH and EC were determined in water at a soil/solution ratio of 1:2 (weight/volume) with a glass electrode pH meter and conductivity meter respectively, while, organic carbon was determined by the wet oxidation method of Walkley and Black as described by Ryan *et al*. (2001). The Cation Exchange Capacity (CEC) was determined by the summation method after the exchangeable bases were displaced with lN NH_4OAC buffered at pH 7.0; then, Potassium and Sodium in the extract were determined by flame photometry while Calcium and Magnesium were determined by atomic absorption spectrophotometry (Ryan *et al*., 2001). Total Dissolved Solid (TDS) was estimated using the formula below as described by US Salinity Laboratory (Hayward, 1954):

TDS (mg/L or ppm) = EC (mmhos/cm or dS/m) x 640

Electrolyte stability index (ESI) was calculated as ESI = ESP/EC (Odeh and Onus, 2008).
Exchangeable Sodium Percentage (ESP) was calculated as described in Ryan *et al*. (2001):

$$ESP\ (\%) = \frac{[Na^+]}{CEC} X\ 100$$

Statistical Methods

Descriptive statistics was employed to assess the salinity status of the study area. Shapiro-Wilk test for normality was applied to the data distribution among the sites, which indicated non normal distribution. The variability of a properties by location were evaluated by through box plots using R version 3.1.3 (R, 2015)

Results and Discussion

Skewed parameters recorded indicated that the soil properties measured (pH, EC, TDS, ESI and ESP) have a local distribution; where high values were found for the measured properties at some points, but most values were lower than others.

The results in Figure 1, showed that the median of the pH values were mostly slightly acidic with very few at neutral. The interquartile ranges are mostly not similar the wider range were recorded in some sampling sites. The data appear to be right-skewed, but the skewness is not particularly marked in all cases. None of the data set shows any suspiciously far out values which might require a closer look. This revealed that the soils of Bade LGA are within the acceptable range for good crop production (6.00 – 7.50) as reported by Parikh and James (2012)

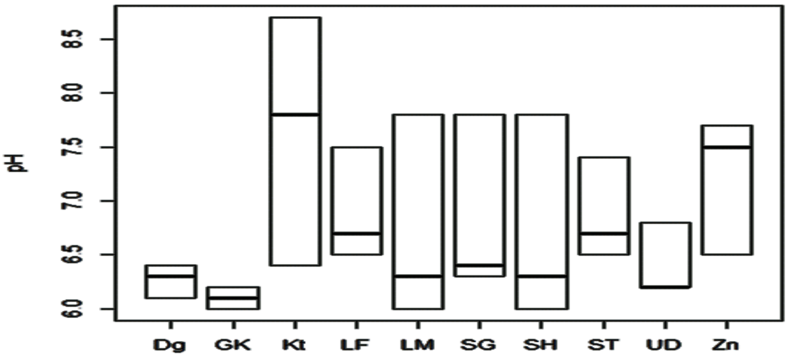

Figure 1. pH level of the soils

Figure 2 indicated results of electric conductivity of the saturated paste extract (ECse) of the soils. The inter quartile range (IQR) was 1.54 – 4.76dSm^{-1} which fall between non saline to moderately saline that yields of many crops will be restricted (Miller and Gardener, 2007). There is wide variation in the values therefore, a need for close monitoring and adoption of best management practices (BMPs) is needed to prevent rapid salinity build up.

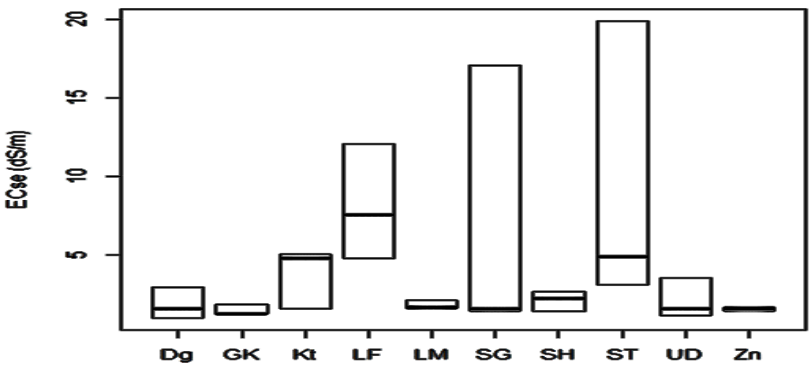

Figure 2. Electric conductivity (ECse) levels

TDS comprise of inorganic salts and small amounts of organic matter that are dissolved in water (USEPA, 2017). The data on TDS (Figure 3) showed a wide range of values from very low (44.8 mmol/L) where no detrimental effects are expected on the crops and salt build up in the soil to a medium hazard (908.8 mmol/L) salinity which may adversely affect crops and require best management practices to control its effect (Hopkins *et al*., 2007).

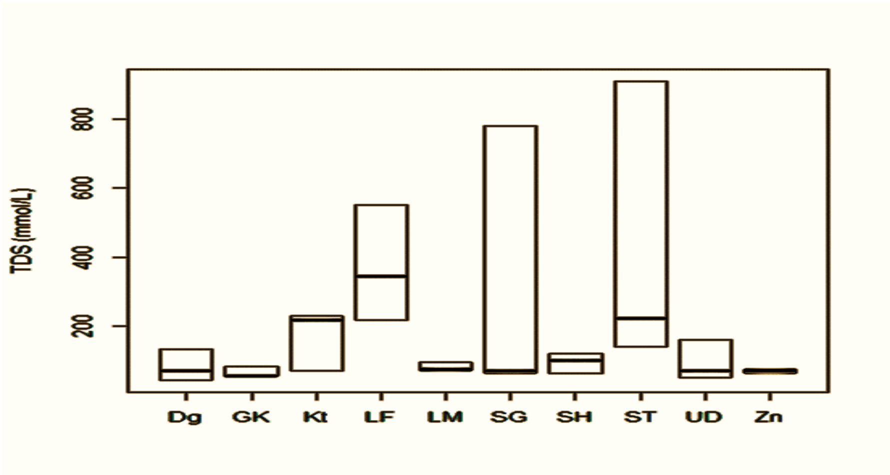

Figure 3. Total dissolved solids (TDS) levels

A recently developed index which is increasingly being used to express the relationship between sodicity and salinity is the Electrochemical Stability Index (ESI). The ESI values of the soils of Bade LGA (Figure 4) indicated wider dispersion (IQR = 0.03 – 0.09) with about half of the sample sites having values below the critical level of 0.05, such types of soil should expect structural decline and negative issues with hydraulic properties. McKenzie *et al*. (2004) reported that a soil with an ESI of less than 0.05 will exhibit structural instability.

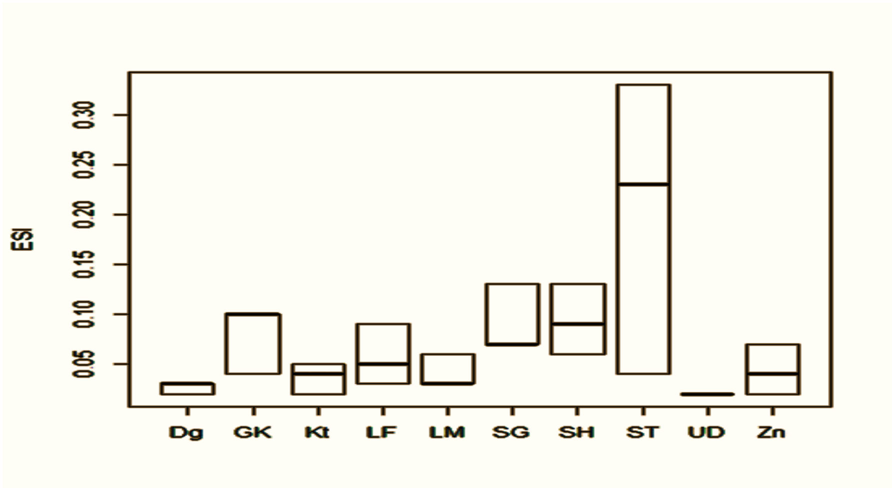

Figure 4. Electrolyte stability ındex (ESI) levels

The exchangeable sodium percentage (ESP) is the amount of sodium on soil exchange sites expressed as a percentage. It is an important feature in ESI determination and prediction of soil structural instability (Hulugalle and Finlay, 2003). The ESP results (Figure 5) ranged from 0.94 to 11.81%, with a median (interquartile range) of 3.99 (1.68 – 6.95%). These values indicate medium level of ESP according to Beernaert and Bitondo, (1992) ratings as such the soils need close monitoring and practices that prevents sodicity and aggravate the whole salinity problem.

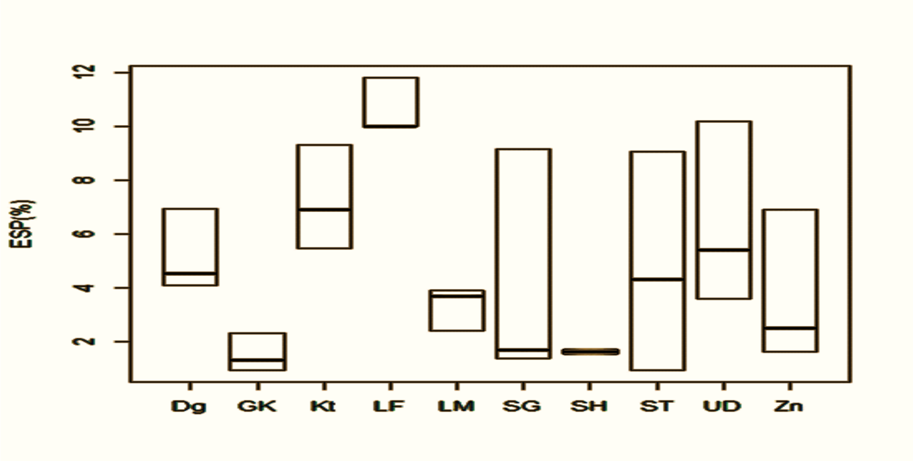

Figure 5. Exchangeable sodium percentage (ESP)

Conclusion

This study showed that soils of Bade LGA are slightly acidic, medium in ECse, TDS, ESI and ESP. the medium values are indication of marginal hazard that may need close monitoring and best soil and water management practices such as minimum tillage, incorporation of crop residues and organic matter, proper drainage and efficient use of inorganic fertilizers to prevent/control salinity related problems in the area.

Acknowledgments

This work was part of a project funded by the Institute based Research Grant (IBR), of the Tertiary Education Trust Fund (tetfund) of the Federal Government of Nigeria under the approval of the Federal University Gashua, Nigeria.We deeply acknowledged tetfund for providing financial support for the study.

References

Alhassan, I., Gwio-Kura, K. K., Gashua, A. G., Dantata, I. J. and Sani, M. (2017). The impact of climate change on soil moisture and water requirements of some vegetable crops in Bade LGA, Yobe State, Nigeria. In Ekenta, C. M., Opoola, E. and Owolabi, J. F (Eds.), Proceedings of the 35th Conference of the Horticultural Society of Nigeria (HORTSON), Kabba College of Agriculture, Division of Agricultural Colleges, Ahmadu Bello University, Zaria, Nigeria from 29th October – 3rd November, 2017, pp. 253 – 257

Bearnaert F, Bitondo D (1992). A Simple and Practical Method to Evaluate Analytical Data of Soil Profiles. CUDs, Soil Science Department. Belgian Cooperation Dschang Cameroon. 65 p.

Francious, L. E and Maas, E. V. (1994). Crop response and management of salt affected soils/ Pessarakle M. (ed.) Handbook of plant and crop stress – New York, USA

Hayward, H.E. (1954). Saline and alkali soils -- Their diagnosis and improvement. Soil Conservation. 20:75-81. U.S. Salinity Laboratory-United States Department of Agriculture, Publication ID number 188. https://www.ussl.ars.usda.gov/pubinfo.aspx?id=188

Hopkins, B. G., Horneck, D. A., Stevens, R. G. and Ellsworth, J. W. (2007). Irrigation water quality in the Pacific Northwest, PNW 597-E Pacific Northwest Extension, Oregon State University, University of Idaho, Washington State University. http://extension.oregonstate.edu /catalog/pdf/pnw/pnw597-e.pdf

Horneck, D.S., Ellsworth, J.W., Hopkins, B.G., Sullivan, D.M. and Stevens, R.G. (2007). Managing Salt-Affected Soils for Crop Production. PNW 601-E. Oregon State University, University of Idaho, Washington State University.

Hulugalle, N.R., Finlay, L.A., (2003). EC1:5/exchangeable Na, a sodicity index for cotton farming systems in irrigated and rainfed Vertosols. Australian Journal of Soil Research 41, 761-769.

Lin, Z.Q and Bañuelos G.S. (2015) Soil Salinization Indicators. In: Armon R., Hänninen O. (eds) Environmental Indicators, Springer, Dordrecht. https://doi.org/10.1007/978-94-017-9499-2_20.

McKenzie, N.J., Jacquier, D.J., Isbell, R.F and Brown, K. L (2004) *Australian Soils and Landscapes An Illustrated Compendium*. CSIRO Publishing: Collingwood, Victoria.

Miller, R.W, Gardiner, D. T. (2007). Soils in our environment. 9th edition, Pp. 452, Prentice Hall-Inc., Upper. Sddle River, New Jersey 07458.

Munns, R. and Tester, M. (2008). Mechanisms of salinity tolerance. Annual Review of Plant Biology **59**, 651–681. doi:10.1146/annurev.arplant.59.032607.092911

National Population Commission of Nigeria [NPC] (2010). Population Distribution by Sex, State, LGA and Senatorial Districts, Pp 34. NPC website: www.population.gov.ng (Accessed on 14th May, 2017)

North East Arid Zone Development Programme [NEAZDP], (2015). Meteorological Data of Nine Local Government Areas in Northern Yobe State, 1992 – 2014. NEAZDP Hydromet station, Garin Alkali

Odeh, I.O.A. and Onus, A. (2008). Environmental Management, Springer-Verlag, 42: 265. https://doi.org/10.1007/s00267-008-9100-z

Parikh, S. J. and James, B. R. (2012). Soil: The Foundation of Agriculture. *Nature Education Knowledge* 3(10):2

R Core Team (2017). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Ryan, J; George, E and Abdul, R (2001) Soil and Plant Analysis Laboratory Manual.2nd ed., International Centre for Agricultural Research in the Dry Areas (ICARDA) and National Agricultural Research Centre (NARC), Aleppo, Syria.Pp172.

United State Environmental Protection Agency [USEPA](1999). Total Dissolved Solids (TDS): EPA Method 160.1 (Gravimetric, Dried at 180 deg. C)". *Washington, D.C.: U.S. Environmental Protection Agency (EPA). 1999-11-16.*

Vijayvargiya, S. and Kumar, A. (2011). Influence of Salinity Stress on Plant Growth and Productivity: Salinity stress influences on plant growth. Germany. Lap Lambert Academic Publishers.170 pp.

Author Information

Ibraheem Alhassan
Federal University Gashua
Yobe State, Nigeria
Contact e-mail: *ialhassand@email.com*

Sunday Dogo
Federal University Gashua
Yobe State, Nigeria

Auwalu Garba Gashua
Federal University Gashua
Yobe State, Nigeria