Research Article Open Access

Assessment of Microalgae Diversity and Water Salinity of a Salt Mine, Nasarawa State, Nigeria

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Received
24 November, 2016

Accepted
20 March, 2017

Published Online
31 March, 2017

Abstract: This study was carried out to assess the diversity of microalgae of a salt mine in Nasarawa State, Nigeria as influenced by salinity with a view to investigating and documenting the microalgae that are tolerant to salinity in this area. Water samples were collected randomly from three different locations on the salt mining site at about 5 cm below the water surface. The chemical properties (including the organic carbon, Nitrogen, Phosphorus, pH, Na, Ca, Mg) of the water samples were determined using standard methods. Microalgae types were identified by microscopic examination. Eight different species of microalgae belonging to four families were identified in all the three sampling locations. Bacillariophyceae has the highest percentage proportion. All the salt mining sites have high total dissolved solid, Organic Carbon, Nitrogen and available Phosphorus. The pH of the site ranges between 7.12 – 7.88. It was concluded that the water of Awe salt mining site has high level of salinity because of high electrical conductivity ranging between 10240 – 3950 µS/CM with low nutrient composition. The abundance of Bacillariophyceae particularly *Pleurosigma spp* at all the sample locations is an indication that the microalgae observed are tolerant to salinity despite the low nutrient.

Keywords: Anthropogenic pollution; Awe salt mining; Bacillariophyceae; Bio-indicator; Hydrology; Nasarawa State; Microalgae; Nutrient toxicity; Salinity.

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Cite this article as: Akomolafe, G.F. and K.C. Onwusiri. 2017. **Assessment of microalgae diversity and water salinity of a salt mine, Nasarawa State, Nigeria.** Journal of Environmental and Agricultural Sciences. 10: 78-83.

1 Introduction

Microalgae species have been sources of food and habitat for various kinds of animals in many coastal waters (Duarte and Cebrian, 1996; Cebrian et al., 2009). Ability of microalgae to show predictable and strong response both in terms of density of species and as well as their biochemical composition, productivity and growth rate under a wide range of aquatic conditions (Renaud et al., 2002; Henley et al., 2002; Parida and Das, 2005; Coltelli et al., 2014) make them a valuable ecosystem indicator (Burger, 2006; Parmar et al., 2016).

Short lifespan (6 to 8 weeks), generation times (few hours to few days) and nutrient requirements make them the very first biological organism to alter their composition and diversity in response to changing water quality (Cloern et al., 2013; De'ath and Fabricius, 2010). Any disturbances at first trophic level can magnify at upper trophic levels (Bartell, 2006; Cebrian et al., 2009; Coltelli et al., 2014).

The high accumulation of nutrients in many estuaries and enclosed bays may encourage the rapid and persistent growth of microalgae species thereby resulting in the development of blooms which are destructive to marine ecosystem and consequently have serious environmental and health implications (SEQHWP, 2010; Masmoudi et al., 2015). Among the vital abiotic stressors which influence an ecosystem salinization is most important (Nam et al., 2017). Salinization of water bodies, including streams and rivers, is of great ecological concerns, which is further intensified by changing climatic conditions and anthropogenic activities (Cañedo-Argüelles et al., 2013; Cañedo-Argüelles et al., 2016; Kefford et al., 2016).

Algal bloom followed by their death and subsequent decomposition of enormous quantity of organic cause depletion of available oxygen in water, leaving other organism to die under oxygen deficient conditions (Burkepile and Hay, 2006). Water analysis to determine density and diversity of algal species serves as early warning signal of deteriorating aquatic environment (Singh et al., 2013).

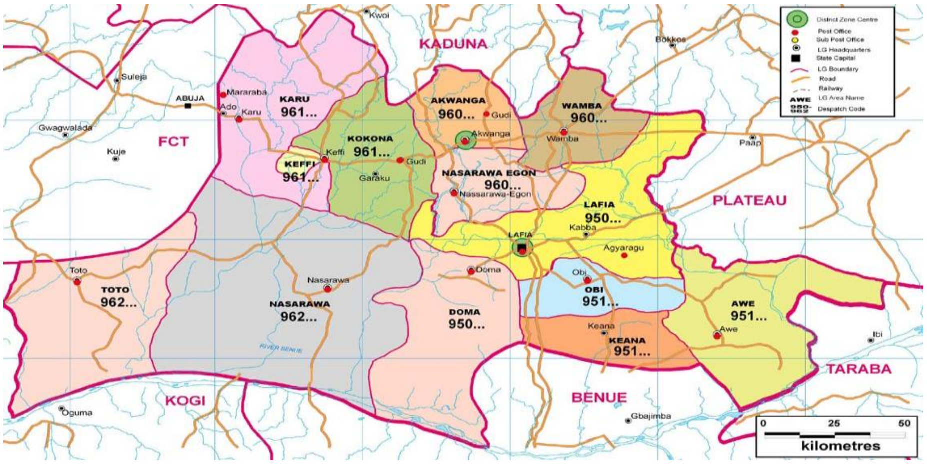

Fig 1: the map of Nasarawa State showing Awe town (Source: www.google.com)

Diatoms have been described as the major photosynthetic micro-algae that mostly dominate every aquatic environment. They are grouped in the class Bacillariophyceae and two orders centrales and pennales. They are also the principal contributors in phytoplankton communities in some parts of the world (Tomas, 1997; Raghavan et al., 2008).

Algal attributes exhibited strong physicochemical gradient along the water quality gradient and subsequently species abundance potentially decreased or increased with the variations in water quality (Andrei et al., 2015; Fabricius et al., 2005). A number of researches have reported ecological factors including light, nutrients, temperatures, pH and salinity as mostly influencing the biochemical composition, productivity and growth rate of microalgae (Renaud et al., 2002; Henley et al., 2002; Parida and Das, 2005). However, many microalgae species have been documented as tolerant to great degrees of salinity (Fabregas et al., 1984; Garcia et al., 2012; Ganguly et al., 2013; Jiang et al., 2011; Pal et al., 2011). Such species showed overrepresentation of gene families regulating biosynthetic process, nutrient utilization and biomass under stressful environment (Radakovits et al., 2012).

A study of phytoplankton in Saminaka reservoir, Northern Nigeria was carried out by Tanimu et al., (2011). Their observation showed that Bacillariophyceae had the highest occurrence while Euglenophyceae had the lowest occurrence and these had significant relationship with the physico-chemical characteristics of the water in the reservoirs.

This salt mine is located in Awe town which belongs to Awe local government area in Nasarawa State (home of solid minerals), North-Central Nigeria. This town is production site of salt both from soil and water bodies (Aderoju and Akomolafe, 2013). The town has an area of 2,557 km² with population of about 0.112 million. Some of the data from previous work done on this site only focused on the salinity of the soil and diversity of terrestrial higher plants (Aderoju and Akomolafe, 2013). There is paucity of information on the water chemical properties and diversity of microalgae of this mining site as influenced by salinity, hence this study aimed at investigating this. This paper also reveals the microalgae that are tolerant to higher degree of salinity.

2 Materials and Methods

2.1 Study location

The study site is located between longitudes 9°08'09, 50'' E and latitudes 8°09'29, 06'' N (Fig 1).

2.2 Sample Collection

The water samples were collected randomly using vendor water sampler from three different locations from the salt mining site of Awe, Nasarawa State, North-Central Nigeria at a depth of about 5 cm from the water surface. The three different locations are labeled A, B and C respectively. The three collection points were chosen at random on the salt mining site. The collection was done towards end of the rainy season.

2.3 Assessment of the Microalgae diversity

Microalgae types were observed through the digital compound microscope. The type, morphology and percentage occurrence of these plants were determined at each collection points. The relative abundance of the identified phytoplankton from each collection point was determined following the methods described by Bongers et al (1988) and Kayode (1999).

Table 1: Relative abundance of microalgae identified at all the sample locations

Name of identified Species	Location (s) found	Family name	Type of Plant	Overall Relative abundance
Eunophora spp	A	Bacillariophyceae	A diatom	Occasional
Pleurosigma spp	A, B and C	Bacillariophyceae	Pennate diatom	Very abundant
Rhizosolenia spp	A, B and C	Bacillariophyceae	Pennate diatom	Very abundant
Odontella aurita	A, B and C	Bacillariophyceae	Centric diatom	Very abundant
Anabaena spp	A and B	Cyanophyceae	Blue-green algae	Frequent
Spirogyra spp	A	Chlorophyceae	Green algae	Very abundant
Euglena spp	A, B and C	Euglenophyceae	Euglenoid	Abundant
Volvox aureus	A, B and C	Chlorophyceae	Green algae	Frequent

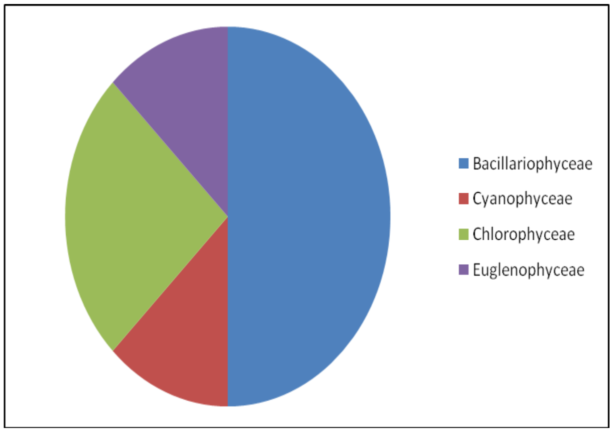

Fig 2: Proportion (%) of families of microalgae observed at the salt mining site

2.4 Chemical Analysis

The pH (Crockford and Norwell, 1956), electrical conductivity (EC) (Rayment and Higgison, 1992), organic carbon (OC) (Walkley and Black, 1934), nitrogen (N) (Jackson, 1958) and available phosphorus (P) (Bray and Kurtz, 1945) of the water were determined. Leaching method was used to determine Potassium (K), Sodium (Na), Calcium (Ca) and Magnesium (Mg). Exchangeable sodium percentage (ESP) of water was calculated as described by Mohsen et al., (2009):

$$ESP = \frac{Exchangeable\ Sodium}{Water\ CEC} X\ 100$$

Where: Exchangeable cations (CEC) = Na + Ca + K + Mg.

$$SAR\ (Sodium\ adsorption\ ratio) = \frac{[Na^{+}]}{½\{[Ca^{2+}] + [Mg^{2+}]\}}$$

2.5 Statistical analysis

All quantitative data were subjected to non-parametric test (Chi-Square analysis) for significance difference at $\alpha \leq 0.05$ using SPSS software version 17.

Table 2: Total dissolved solid (TDS), organic carbon (OC), nitrogen (TN) and available phosphorus (AP) in the water

Sample location	TDS	OC (%)	N (%)	AP (ppm)
A	2630	0.399	0.07	2.32
B	7520	0.40	0.07	2.14
C	6810	0.30	0.14	2.08

The values of TDS, OC, TN, AP are significantly different ($\alpha \leq 0.05$) across the three locations

3. Results

Eight different species of microalgae belonging to four families were identified in all the three sampling locations (Table 1). Bacillariophyceae has the highest percentage proportion across the three locations while Euglenophyceae and Cyanophyceae have the lowest and equal percentage proportions (Fig. 2).

The results of the total dissolved solid (TDS), organic carbon (OC), percentage N and available P (AP) is shown in Table 2 below. The highest TDS and OC values were observed at location B while location C had the lowest. Location C has the AP was observed at location A. Invariably, all the salt mining sites have high TDS, OC, N and AP. Also, the highest exchangeable cation (CEC) was observed in location A while location B had the lowest (Table 3).

The values of the pH, electrical conductivity (EC), ESP and SAR are displayed in Table 4. For the water pH, the location A had the lowest pH (7.12) whereas location B had the highest pH (7.88) which is slightly alkaline.

Table 3: The exchangeable cations in water samples

Sample location	K^{+} (ppm)	Na^{+} (ppm)	Ca^{2+} (ppm)	Mg^{2+} (ppm)
A	0.00	224.00	12.93	14.15
B	0.00	86.00	21.01	23.31
C	0.00	196.00	13.43	25.22

The values of Na, Ca, Mg are significantly different ($\alpha \leq 0.05$) across the three locations.

Table 4: The conductivity of the water samples

Sample location	pH (H_2O)	EC (µS/CM)	ESP	SAR
A	7.12	3950	89.21	16.54
B	7.88	11300	65.99	3.88
C	7.31	10240	83.54	10.14

The values of pH, EC, ESP, SAR are significantly different ($\alpha \leq 0.05$) across the three locations

The lowest EC (3950) is observed at location A while location B had the highest (11300). Furthermore, the highest ESP and SAR were observed in location A while location B had the lowest. The values of pH, EC, ESP and SAR in all the sampling locations were all significantly different.

4. Discussion

As reported by Aderoju and Akomolafe (2013) that the soil at this mining site had reduced OC, N and P as a result of the salinity of the site, similarly, the OC, N and AP of water in all the locations are also low. Moreover, high values of EC, ESP and SAR can be attributed to the high levels of CEC observed at the salt mining locations. The electrical conductivity which is refer to as ability of water to conduct electric current is a function of the total amount of salt (ions) dissolved in the water (Boyd and Frobish, 1998). Therefore, the higher EC observed at all the locations in the salt mining site may be attributed to high level of salinity in this area.

According to Abubakar and Abdullahi (2015), the nature of sediment always affects the concentration of nutrient (a function of Nitrate) in water body. From this work, the nitrate concentrations of all the locations are lower than the WHO and FEPA recommended level of 45 ppm. This could explain the reductions in the number and diversities of microalgae observed in all the study locations. However, the abundance of some members of Bacillariophyceae in all the salt mining locations could be attributed to their tolerance for high level of salinity of the areas. Also, the presence of *Eunophora spp* and *Spirogyra spp* in location A only could be as a result of the lower salinity in this location compared with the other locations which are far higher in salinity. This suggests that the two species of microalgae are not tolerant to higher salinity range. Similarly, the abundance of Cyanophyceae, Chlorophyceae and Euglenophyceae in an aquatic environment has been regarded to be an indication of the high level of organic pollution and deterioration in such water bodies (Odhiambo and Gichuki 1998; Tanimu et al. 2011; Mohammad and Saminu 2012) which is contrary to this report. However, this work agrees with Potapova, (2003) who reported that some species of microalgae are more likely tolerant to higher salinities while others grow maximally at lower conductivities. Masmoudi et al., (2015) also reported halotolerance in species of Chlorophyceae and Cyanophyceae in the saltiest ponds of Sfax saltern (Tunisia). They further proposed secondary influence of N and P ions on dynamics and distribution of phytoplanktons.

5. Conclusion

Conclusively, the water of Awe salt mining site has high level of salinity with low nutrient composition. The abundance of these different microalgae, *Pleurosigma spp, Rhizosolenia spp, Odontella aurita, Volvox aureus* and *Euglena spp* at all the sample locations is an indication that they are tolerant to salinity despite the low nutrient.

Acknowledgements: The authors hereby acknowledge the contribution of Mr. Zagu of Faculty of Agriculture, Nasarawa State University, Shabu-Lafia campus who assisted in the chemical analysis of water samples.

Competing Interests: The authors declare that there is no potential conflict of interest.

References

Abubakar, A. and B. A. Abdullahi. 2015. Flora composition of phytoplankton as bioindicators of water quality in Jakara Dam, Kano State, Nigeria. Bayero J. Pure Appl. Sci. 8(2):145 – 155.

Aderoju D. O. and G. F. Akomolafe. 2013. Influence of salinity on soil chemical properties and surrounding vegetation of Awe salt mining site, Nasarawa State, Nigeria. African J. Environ. Sci. and Tech. 7(12):1070-1075.

Andrei, A.-S., M.S. Robeson, A. Baricz, C. Coman, V. Muntean, A. Ionescu, G. Etiope, M. Alexe, C.I. Sicora, M. Podar and H.L. Banciu. 2015. Contrasting taxonomic stratification of microbial communities in two hypersaline meromictic lakes. ISME J. 9(12): 2642-2656.

Bartell, S.M. 2006. Biomarkers, bioindicators, and ecological risk assessment—a brief review and evaluation. Environ. Bioindicators. 1(1): 60-73.

Bongers, F., J. Popma, J. Meave del Castillo and J. Carabias. 1988. Structure and floristic composition of the lowland rainforest of Los Tuxtlos, Mexico. Vegetatio 74:55-80.

Boyd, C. E and L. Y. Frobish. 1998: Water Quality for Ponds Aquaculture. Birmingham Publishing Co., Birminghsm, UK. 5:90.

Bray, R. H. and L. T. Kurtz. 1945. Determination of total, organic, and available forms of phosphorus in soils. Soil Sci. 59:39-45.

Burger, J. 2006. Bioindicators: Types, development, and use in ecological assessment and research. Environ. Bioindicators. 1(1): 22-39.

Burkepile, D.E. and M.E. Hay. 2006. Herbivores vs. nutrient control of marine primary producers: Contect-dependent effects. Ecology. 87(12):3128-3139.

Cañedo-Argüelles, M., B.J. Kefford, C. Piscart, N. Prat, R.B. Schäfer and C.-J. Schulz. 2013. Salinisation of rivers: An urgent ecological issue. Environ. Pollut. 173: 157-167.

Cañedo-Argüelles, M., C.P. Hawkins, B.J. Kefford, R.B. Schäfer, B.J. Dyack, S. Brucet, D. Buchwalter, J. Dunlop, O. Frör, J. Lazorchak, E. Coring, H.R. Fernandez, W. Goodfellow, A.L.G. Achem, S. Hatfield-Dodds, B.K. Karimov, P. Mensah, J.R. Olson, C. Piscart, N. Prat, S. Ponsá, C.-J. Schulz and A.J. Timpano. 2016. Saving freshwater from salts. Science. 351(6276): 914-916.

Cebrian, J., J.B. Shurin, E.T. Borer, B.J. Cardinale, J.T. Ngai, M.D. Smith, et al. 2009. Producer nutritional quality controls ecosystem trophic structure. PLoS ONE 4(3): e4929. doi:10.1371/journal.pone.0004929.

Cloern, J.E., S.Q. Foster and A.E. Kleckner. 2013. Review: phytoplankton primary production in the world's estuarine-costal ecosystems. Biogeosci. Discuss. 10: 17725-17783.

Coltelli, P., L. Barsanti, V. Evangelista, A.M. Frassanito and P. Gualtieri. 2014. Water monitoring: automated and real time identification and classification of algae using digital microscopy. Environ. Sci. Processes Impact. 16:2656.

De'ath, G. and K. Fabricius. 2010. Water quality as a regional driver of coral biodiversity and macroalgae on the Great Barrier Reef. Ecol. Appl. 20(3): 840-850.

Duarte, C.M. and J. Cebrian. 1996. The fate of marine autotrophic production. Limonol. Oceanograph. 41(8):1758-1766.

Fabregas, J., J. Abalde, C. Herrero, B. Cabezas and M. Veiga. 1984. Growth of the marine microalga Tetraselmis suecica in batch cultures with different salinities and nutrient concentrations. Aquaculture. 42(3): 207-215.

Fabricius, K., G. De'ath, L. McCook, E. Turak and D.M. Williams. 2005. Changes in algal, coral and fish assemblages along water quality gradients on the inshore Great Barrier Reef. Mar. Pollut. Bull. 51(1–4): 384-398.

Ganguly, D., R.S. Robin, K.V. Vardhan, P.R. Muduli, K.R. Abhilash, S. Patra and B.R. Subramanian. 2013. Variable response of two tropical phytoplankton species at different salinity and nutrient condition. J. Exp. Marine Biol. Ecol. 440:244-249.

Garcia, N., A. José, López-Elías, M. Anselmo, M. Marcel, H. Nolberta and G. Antonio. 2012. Effect of salinity on growth and chemical composition of the diatom *Thalassiosira weissflogii* at three culture phases. Departamento de Investigaciones Científicas y Tecnológicas, Universidad de Sonora 435. Lat. Am. J. Aquat. Res. 40(2):435-440.

Henley, J.W., M. K. Major and L. J. Hironaka. 2002. Response to salinity and heat stress in two halotolerant Chlorophyte algae. J. Phycol. 38:757766.

Jackson, M. L. 1958. *Soil Chemical Analysis*. Prentice-Hall, Inc. Englewood Cliffs, N.J. p. 216.

Jiang, L., S. Luo, X. Fan, Z. Yang, R. Guo. 2011. Biomass and lipid production of marine microalgae using municipal wastewater and high concentration of CO_2. Appl. Energy. 88(10): 3336-3341.

Kayode, J. 1999. Phytosociological investigation of compositae weeds In abandoned farmlands in Ekiti State, Nigeria. Compositae Newsletter 34:62-68.

Kefford, B.J., D. Buchwalter, M. Cañedo-Argüelles, J. Davis, R.P. Duncan, A. Hoffmann and R. Thompson. 2016. Salinized rivers: degraded systems or new habitats for salt-tolerant faunas? Biol. Lett. 12(3).

Masmoudi, S., E. Tastard, W. Guermazi, A. Caruso, A. Morant-Manceau and H. Ayadi. 2015. Salinity gradient and nutrients as major structuring factors of the phytoplankton communities in salt marshes. Aquat. Ecol. 49(1): 1-19.

Mohammad, M. A. and M. Y. Saminu. 2012. A Water Quality and Phytoplankton of Salanta River Kano, Nigeria. J. Bio. Sci. and Bioconserv. 4:2277-0143.

Mohsen, S., R. Majid and G. K. Borzoo. 2009. Prediction of soil exchangeable sodium percentage based on soil sodium adsorption ratio. American- Eurasian J. Agric. Environ. Sci. 5 (1):01-04.

Nam, K.-H., Y.-J. Kim, Y.S. Moon, I.-S. Pack and C.-G. Kim. 2017. Salinity affects metabolomic profiles of different trophic levels in a food chain. Sci. Total Environ. 599–600: 198-206.

Odhiambo, W. and J. Gichuki. 1998. Seasonal Dynamics of the Phytoplankton Community in Relation to Environment in Lake Baringo, Kenya. African J. Trop. Hydrobio. and Fisheries, 8:36-40.

Pal, D., I. Khozin-Goldberg, Z. Cohen and S. Boussiba. 2011. The effect of light, salinity, and nitrogen availability on lipid production by Nannochloropsis sp. Appl. Microbiol. Biotechnol. 90(4): 1429-1441.

Parida, A. K. and A. Das. 2005. Salt tolerance and salinity effects on plants: a review. Ecotox. Environ. Safe. 60:324-349.

Parmar, T.K., D. Rawtani and Y.K. Agrawal. 2016. Bioindicators: the natural indicators of environmental pollution. Front. Life Sci. 9(2):110-118.

Potapova, M. and D. Charles. 2003. Distribution of benthic diatoms in U.S. rivers in relation to conductivity and ionic composition. Freshwater Bio. 48:1311-1328.

Radakovits, R., R.E. Jinkerson, S.I. Fuerstenberg, H. Tae, R.E. Settlage, J.L. Boore, M.C. Posewitz. 2012. Draft genome sequence and genetic transformation of the oleaginous alga Nannochloropsis gaditana. Nat. Comm. 3: 686.

Raghavan,G., C.K. Haridevi and C.P. Gopinathan. 2008. Growth and proximate composition of the Chaetoceros calcitrans f. pumilus under different temperature, salinity and carbon dioxide levels. Aquacult. Res. 39: 1053–1058.

Rayment, G. E and F. R. Higgison. 1992. Australian Laboratory Handbook of Soil and Water Chemical Methods. Melbourne, Inkata Press (Australian Soil and Land Survey Handbooks vol. 3).

Renaud, S. M., L. V. Thinh, G. Lambridis and D. L. Parry. 2002. Effect of temperature on growth, chemical composition and fatty acid composition of tropical Australian microalgae grown in batch cultures. Aquacult. 211:195-214.

Singh, U.B., A.S. Ahluwalia, C. Sharma, R. Jindal and RK. Thakur. 2013. Planktonic indicators: A promosing tool for monitoring water quality (early-warning signals). Ecol. Environ. Conserv. 19(3):793-800.

South East Queensland Healthy Waterways Partnership. 2010. *Coastal Algal Blooms of South East Queensland A FIELD GUIDE*. Department of Environment and Resource Management

Tanimu, Y., S. P. Bako, J. A. Adakole and J. Tamimu. 2011. Phytoplankton as Bioindicator of Water Quality in Saminaka Reservoir. Proceedings of 2011 International Symposiumon Environmemtal Science and Technology,Dongguan, Guangdong province, China, Science press USA.318-322.

Tomas, C. R. 1997. Identifying Marine Diatoms and Dinoflagellates. Academic Press, San Diego; 1 - 384.

Walkley, A. and I. A. Black. 1934. An Examination of Degtajar off method for Determining Soil Organic Acid Filtration Method. Soil Sci. 37:29-38.