Original Research

Volume 3, Issue 2, pp 86-94, December 2021

ACHIEVERS JOURNAL OF SCIENTIFIC RESEARCH

Opecn Access Publications of Achievers University, Owo

Available Online at www.achieversjournalofscience.org

Effects of Heat Treatment on Some Cations in the Soil

T.E. Anaun[1] and O.D. Ogundele[1*]

[1]Department of Chemical Sciences, Achievers University, Owo, Ondo State, Nigeria

*E-mail: olusoladavidogundele@gmail.com

Submitted: October 18, 2021 Revised: December 1, 2021 Accepted: December 4, 2021 Published: December 13, 2021

ABSTRACT

This study aims to determine the effects of heat treatment on some cations in the soil. Soil samples were taken from Nigeria Institute for Oil Palm Research (NIFOR), Benin, Edo state Nigeria. The soil samples were heated at 50–60 ^{o}C for 2 hours using a muffle furnace. Magnesium (Mg) and calcium (Ca) were determined using titrimetric method and potassium (K) by flame photometry. From the results obtained, the mean value of calcium and magnesium for unheated soil sample are 2.9973 and 1.4040 respectively which were observed to be higher than the mean value of calcium and magnesium for the heated soil sample (2.1173 and 0.9493). In comparison, the t-value (4.523) obtained for both heated and unheated calcium with a p-value of 0.00 differ from the t-value obtained for heated and unheated magnesium (3.177) with a p-value of 0.004. This shows that there is a significant difference between the heated and the unheated calcium and magnesium respectively. This could be attributed to the increase in temperature which affects the amount of exchangeable magnesium and calcium in the soil. The mean value for unheated potassium was 0.2416 with a t-value of 1.145 and p-value 0.266. This shows that there are no significant differences as heat do not affect the exchangeable potassium (K) in the soil. Heating the soil results in significant effects on physical and chemical properties of the soil. It specifically changes elemental contents in the soil compound as the temperature increases, exchangeable calcium and magnesium decreases.

KEYWORDS: Heat Treatment, Cations, Soil

1. Introduction

Bush bushing is a common practice among farmers and crop planters generally during annual preparation of land for cultivation in order to eliminate soil pathogens and weeds. It is one of the cheapest means of weeding among farmers (Stephens *et al.*, 2014). However, burning of bushes and residues may have effect on both soil surface and mineral content of the soil. During the process of bush burning, the temperature of soil surface may get raised up to 500°C (Thomaz, Antoneli, and Doerr, 2014). The high temperature has great effects on the biological, physicochemical, and mineralogical properties of the soils. Stoof *et al.* (2010) concluded in a research that temperature of 300°C causes an increase in clay, silt contents, and bulk density, but decreased sand contents and organic matter (Ulery *et al.*, 2017).

Raising the soil temperature to 300°C will result in a decrease in sand, clay, organic matter, and cation exchange capacity (CEC) while an increase in

$CaCO_3$ and salinity content (Inbar *et a.,* 2014). Reduction of biomass and activity of microorganisms in the soil and an increase in microorganism diversity in fire affected soils were also reported by Fontúrbel *et al.* (2012). Although pollution is mostly reported as a global problem facing the world at large (Thompson *et al.,* 2019), however the ill treatment of the soil surface causes more harm than good in terms of soil fertility and productivity (Ulery *et al.,* 2017). Potassium (K), Calcium (Ca) and Magnesium (Mg) are important macronutrient for plants growth which are available as exchangeable, non- exchangeable, soluble, and structural forms. Soluble and exchangeable forms are easily available to plants, whereas non- exchangeable are slowly available (Ulery *et al.,* 2017).

Availability of these nutrients makes the soil fertile and increase its productivity. Accordingly, farmers in these regions use little or no K fertilizers for crop production. Nowadays, due to the intensive cultivation and little application of K fertilizers, the content of available K has decreased (Ulery *et al.,* 2017). Heating of soils as a result of bush burning may affect the availability of potassium (K), calcium (Ca) and magnesium (Mg) in the soil. Therefore, the main objectives of this research is to study the effects of heat on some cations in the soil.

2 Materials and Methods

2.1 Study Area

The study area for this work was in the Nigeria institute for oil palm and research (NIFOR). In ovia north east local government area of Edo-State. The area falls under the rain forest vegetation of Nigeria. The area surrounded by smaller village and the occupation of the people are mainly farming and trading.

2.2 Sample Description

Soil samples were collected from an agricultural Soils in the Nigerian Institute for Oil Palm Research NIFOR in a randomized sampling manner from five different fields with the use of a soil auger at depth of 15cm and georeferenced with a high sensitivity Garmin (200-2007) GPS instrument. The soil samples were collected stored in a polythene bag and transported to the laboratory for air drying (ambient) and heating before analysis. Parameters analyzed were moisture content, exchangeable potassium, calcium and magnesium for both ambient and heated soil samples at 50 to 60^{0}C**.** Table 1 shows description of soil sampling locations

Table 1: Description of Soil Sampling Locations.

S/N	Sample Identity	Depth(cm)	Elevation(cm)	Co-ordinate	Remarks
1	Field 18 SS_1	0-15cm	155m	$N06^{0}{}_{31}{}^{1}{}_{57.7}{}^{11}$ $E005^{0}37^{1}19.9^{11}$	Flat land, grass land cultivated to raphia palm
2	Field 18 SS_2	0-15cm	150m	$N06^{0}{}_{3157.7}{}^{11}{}_{E005}{}^{0}{}_{37}{}^{1}{}_{19.3}{}^{11}$	Flat land, grass land cultivated to raphia palm
3	Field 18 SS_3	0-15cm	149m	$N06^{0}{}_{031}{}^{1}{}_{58.4,}{}^{11}$ $_{E005}{}^{0}{}_{37.19.3}{}^{11}$	Flat land, grass land cultivated to raphia palm
4	Field 18 SS_4	0-15cm	149m	$N06^{0}{}_{31}{}^{1}{}_{59.2}{}^{11}$ $_{E005}{}^{0}{}_{37}{}^{1}{}_{17.2}{}^{11}$	Flat land, grass land cultivated to raphia palm

5	Field 18 SS_5	0-15cm	147m	N06^{0} 3159.2^{11} E005^{0} 37^{1}18.8^{11}	Flat land, grass land cultivated to raphia palm
6	Field18 SS_6	0-15cm	156m	N06^{0}31^{1}57.7 E005^{0}37.18.4^{11}	Flat grass land with covered grass (peurorial) cultivated close to cassava farm
7	Afeyo SS_7	0-15cm	155m	N06^{0}32^{1}31.3^{11} E005^{0}37^{1}28.4^{11}	Flat farm land with plantain plantation.
8	Afeyo SS_8	0-15cm	157m	N06^{0} 32^{1}31.9^{11} E005^{0}37^{1}28.3^{11}	Covered grass and sticky sample.
9	Afeyo SS_9	0-15cm	156m	N06^{0}32^{1} 31.9^{11} E005^{0}37^{1}27.8^{11}	Farm land with plantain plantation intercropped with pineapple with covered grass.
10	Afeyo SS_{10}	0-15cm	155m	N06^{0} 32^{1}32.1^{11} E005^{0}37^{1}27.1^{11}	Plantain plantation with little forest tree
11	Afeyo SS_{11}	0-15cm	148m	N06^{0} 32^{1}32.3^{11} E005^{0}37^{1}26.5^{11}	Forest land with rich grown bush .
12	Afeyo SS_{12}	0-15cm	157m	N06^{0} 32^{1}40.7^{11} E005^{0}37^{1}23.7	Open grass land ,grown tall elephant grass near cassava farmland.
13	Field SS_{13}	0-15cm	149m	N06^{0}32^{1}41.4^{11} E005^{0}37^{1}21.9^{11}	Land cultivated with oil palm with grass recently cut
14	Field SS_{14}	0-15cm	150m	N06^{0} 32^{1}42.2^{11} E005^{0}37^{1}21.3^{11}	Land cultivated with oil palm with grass recently cut
15	Field SS_{15}	0-15cm	152m	N06^{0} 32^{1}42.8^{11} E005^{0}37^{1}22.1^{11}	Farm grass growing around.
16	Field SS_{16}	0-15cm	152m	N06^{0} 32^{1}43.4^{11} E005^{0}37^{1}22.4^{11}	Farm grass growing around.
17	Field SS_{17}	0-15cm	163m	NO6^{0}32^{1}44.4^{11} E005^{0}37^{1}22.6^{11}	Farm grass growing around.
18	Field SS_{18}	0-15cm	155m	N06^{0}32^{1}44.8^{11} E005^{0}37^{1}21.5^{11}	Farm grass growing around.
19	Field 16 SS_{19}	0-15cm	155m	N06^{0}32^{1}41.0^{11} E005^{0}37^{1}19.8^{11}	Land cultivated to oil palm with elephant and peurorial grass.
20	Field16 SS_{20}	0-15cm	155m	N06^{0} 32^{1}39.7^{11} E005^{0}37^{1}18.7^{11}	Land cultivated to oil palm and farm grass grow around.
21	Field16 SS_{21}	0-15cm	153m	N06^{0} 32^{1}38.8^{11} E005^{0}37^{1}18.3^{11}	Land cultivated to oil palm and farm grass grow around.
22	Field16 SS_{22}	0-15cm	150m	N06^{0}32^{1}39.3^{11} E005^{0}37^{1}17.5^{11}	Land cultivated to oil palm and farm grass grow around.
23	Field16 SS_{23}	0-15cm	150m	NO6^{0}32^{1}37.3^{11} E005^{0}37^{1}17.5^{11}	Land cultivated to oil palm and farm grass grow around.
24	Field16 SS_{24}	0-15cm	144m	N06^{0} 32^{1}35.4^{11} E005^{0}37^{1}17.5^{11}	Land cultivated to oil palm and farm grass grow around.

25	Field11 SS_{25}	0-15cm	108m	N06^{0}33^{1}51.7^{11} E005^{0}37^{1}20.1^{11}	Secondary forest with shrub and elephant grass
26	Field11 SS_{26}	0-15cm	110m	N06^{0}33^{1}51.6^{11} E005^{0}37^{1}20.0^{11}	Secondary forest with shrub and elephant grass
27	Field11 SS_{27}	0-15cm	111m	N06^{0} 33^{1}51.4^{11} E005^{0}37^{1}20.0^{11}	Secondary forest with shrub and elephant grass
28	Field 11 SS_{28}	0-15cm	118m	N06^{0}33^{1}50.0^{11} E005^{0}37^{1}20.1^{11}	Secondary forest with shrub and elephant grass
29	Field11 SS_{29}	0-15cm	118m	N06^{0}33^{1}49.8^{11} E0050 E005^{0}37^{1}19.8^{11}	Secondary forest with shrub and elephant grass
30	Field11SS_{30}	0-15cm	119m	N06^{0}33^{1}50.0^{11}E005^{0}37^{1}19.9^{11}	Secondary forest with shrub and elephant grass

2.3 Moisture Content

An empty crucible with its cover was dried in the oven at 105 ^{0}C and weighed (W_1). Exactly 5 g of the sample was then added to the already weighed crucible, dried for 3 h in an oven at 105 ^{0}C, cooled in a desiccator and weighed (Emmanuel *et al.*, 2020). The crucible and its content were returned to the oven for 1h and the cooling was repeated and weighing was done (Anaun and Ogundele, 2021). This process was repeated successively until a constant weight was obtained (W_2) (Ogundeleolusola *et al.*, 2019). Moisture content was determined using equation 3.1:

$$\text{Moisture content (\%)} = \frac{W_1 - W_2}{W_1} \times 100\ \% \quad \text{......... 2.1}$$

2.4 Determination of Some Exchangeable Cations

2.4.1 Determination of Potassium in Heated Soil

0.1g of processed soil Sample was weighed into a crucible. The samples were heated in a muffle furnace for 2 hours at 50-60 ^{0}C and later removed from the muffle furnace and allowed to cool. 50 mL of HNO_3 was added, the mixture was filtered using the whatzman filter paper and the filtrate was taken for analysis using flame photometer.

2.4.2 Determination of Potassium (K) in Unheated Soil

0.1g of processed soil Sample was weighed into a crucible, 50ml of dilute HNO_3 was added and the mixture was filtered using the whatzman filter paper. The filtrate was taken for analysis using flame photometer.

2.4.3 Determination of Calcium (Ca) and Magnesium (Mg) in Unheated Soil

5g of air dried soil was weighed into a plastic bottle. Exactly 100 mL of 1N neutral ammonium acetate(NH_4OAC) was added into the sample and corked, then agitated for 30 minutes and filtered using whatzman filter paper. Sample extract was made up to the mark with the ammonium acetate. The cation (Ca and Mg) from the extract was determined using complexometric titration method (Nearly *et al.*, 2005).

2.4.4 Determination of Calcium (Ca) and Magnesium (Mg) in Heated Soil

5g of processed soil Sample was weighed into a crucible. The samples were heated in a muffle furnace for 2 hours at 50-60^{0}c and later removed from the muffle furnace and allowed to cool. 5g of air dried soil was weighed into a plastic bottle. 100 mL of 1N neutral ammonium acetate (NH_4OAC) was added into the sample and corked, then agitated for 30 minutes and filtered using whatzman filter paper. Sample extract was made up to the mark with the ammonium acetate. The cation (Ca and Mg) from the extract was determined using complexometric titration method (Nearly *et al.*, 2005).

2.3 Statistical Analysis

T-test was used to determine if there were significant difference between some non-heated and heated cations while analysis of variance(ANOVA) enables us to determine if there were significant difference in each of the elements at the different locations. The least significant differences at 5% level of probability level was used to separate the means

3. Results and Discussions

The tables 1, 2 and 3 shows analysis of result obtained for some exchangeable cations with moisture content of ambient dried soil samples, mean value of the results obtained for some exchangeable cations and mean values of the moisture content from the ambient dried soil samples respectively.

Table 1: Laboratory Analysis Results of Some Exchangeable Cations in the Soil

S/N	Soil Samples Identity	Normal Air Dried Soil (cmol/kg K)	Normal Air Dried Soil (cmol/kgCa)	Normal Air Dried Soil (cmol/kgMg)	% Moisture Content	Heated to 50-60^{0}Cfor 2hours (cmol/kg K)	Heated to 50-60^{0}Cfor 2hours (cmol/kgCa)	Heated to 50-60^{0}Cfor 2hours (cmol/kgMg)
1	Field 18 (0-15cm)	0.203	3.28	2.32	24.65	0.190	1.68	0.80
2		0.155	2.32	0.32	10.78	0.250	2.32	1.60
3		0.143	5.68	0.72	9.97	0.167	1.68	1.12
4		0.203	2.48	1.28	12.10	0.215	2.48	0.32
5		0.155	2.72	0.88	10.65	0.179	3.28	0.24
6		0.155	3.76	2.32	12.81	0.155	2.08	0.16
7	Afeyo (0-15cm)	0.680	3.84	2.56	17.48	0.739	2.72	2.24
8		0.477	5.44	1.04	18.47	0.560	2.80	1.04
9		0.262	4.24	0.72	11.06	0.190	1.44	1.04
10		0.334	4.08	1.20	16.89	0.393	1.76	1.20
11		0.262	2.88	2.00	4.27	0.215	1.84	1.28
12		0.465	3.44	2.16	13.03	0.298	2.00	1.28
13	Field 3 (0-15cm)	0.167	2.48	1.28	8.54	0.143	1.60	0.56
14		0.131	1.84	0.56	10.47	0.179	1.76	0.56
15		0.119	3.60	2.88	12.59	0.143	2.40	1.44
16		0.167	2.96	1.76	11.23	0.155	1.68	1.36
17		0.131	2.48	1.68	11.59	0.155	2.40	1.52
18		0.131	3.12	1.76	11.90	0.131	2.40	0.88
19	Field 16 (0-15cm)	0.167	2.32	1.52	11.73	0.155	2.00	1.52
20		0.203	3.12	1.36	11.32	0.167	1.36	0.72
21		0.155	2.16	0.96	12.78	0.155	1.84	0.56
22		0.179	2.96	1.20	10.76	0.250	2.24	0.72
23		0.167	2.08	1.28	11.06	0.190	1.84	0.56
24		0.238	2.48	1.52	10.06	0.227	1.68	0.24
25	Field 11 (0-15cm)	0.382	2.08	1.52	11.19	0.346	2.08	1.04
26		0.215	3.12	1.60	11.44	0.227	2.32	1.20
27		0.215	2.48	0.20	11.01	0.274	2.88	1.84
28		0.190	1.76	0.96	9.83	0.334	2.08	1.20
29		0.238	2.48	1.52	10.05	0.262	2.40	0.16

30	0.203	2.24	1.04	10.47	0.203	2.48	0.08

Table 2: The Mean Difference of Some Exchangeable Cation Between Non-Heated and Heated Soil Samples

Variables	Mean	T-value	P-value	Remarks
Non Heated k	0.2297			
Heated K	0.2416	1.145	0.266	No significant difference
Non Heated Ca	2.9973			
Heated Ca	2.1173	4.523	0.000	Highly Significant
Non Heated Mg	1.4040			
Heated Mg	0.9493	3.177	0.004	Highly Significant

Tables 3: For the Moisture Means of the Various Field.

Sample Identification	Mean
Field 18	13.31
Afeyo	13.53
Field 3	11.05
Field 16	11.29
Field 11	10.66
Grand mean	11.97
L.S.D	4.055

3.2 Discussion

Table 2 shows the mean values of Ca, Mg i.e. (2.9973), (1.4040) for unheated soil samples was higher than the mean value of Ca and Mg i.e. (2.1173), (0.9493) of the heated soil samples. In comparism, the t –value for heated and non-heated Calcium (Ca) gave (4.523) with a p value of (0.000) also the t-value for heated and unheated Mg gave (3.177) with a p value (0.0004). This shows that there is a significant difference between the heated and unheated Ca and Mg respectively.

The decrease in exchangeable Ca could be attributed to effect of temperature on exchangeable Ca with a steady decrease in the soils with rising temperature as reported by (Giovannini *et al.*, 1990). Exchangeable Mg also showed similar pattern with exchangeable Ca with the temperature. The reasons could be that the soil samples did not form soluble MgO and that small ions such as Mg was forced into octahedral structure of clay minerals during dehydration (Sertsu and Sanchez, 1978). Exchangeable K showed an increase with a mean value of 0.2297 to 0.2416 with non-heated and heated soils respectively although not significant at p-value of 0.266 This may be due to fusion in the soils as the temperature rose (Giovannini *et al.,* 1990; Marcos *et al.,* 2007). The net effect of heating on K is relatively small (Table 2), perhaps because of interactions between physical processes that enrich and deplete surface nutrient stocks. (Harden *et al.*, 2004). Soil colour was observed to darken with increasing temperature.

In Table 3, the mean moisture content value of non-heated soil samples ranged from 13.53-10.67 within the location of study; field 18 gave the highest moisture content at 13.53 mean values and field 11 gave lowest mean value of 10.67 which could be attributed to the topography and vegetative covering.

There is significant difference among some cation of both heated and non-heated parameters with respects to moisture content in the different fields of study. Moreover, it also shows the various means for some heated and non-heated cations with respect to the locations. Afeyo gave the highest mean value of 3.39 while field 11 gave the lowest mean value of 2.36 for both non-heated Ca in the fields which is highly significant. This decrease in the solubility of Ca in field 11 could have been a result of precipitation. Phosphate concentration in solution will increase if the Ca^2+ activity is depressed (Knight *et al.*, 1992).
Field 11 gave the highest mean value of 2.37 while field 16 gave the lowest mean value of 1.83 for heated Ca which is not significant. For the non-heated Mg Field 3 gave the highest mean value of 1.65 while field 11 gave the lowest mean value of 1.14 which is not significant. The decrease in soil Mg concentration observed with rising soil moisture and pH levels may be due to Mg immobilization as a result of the increase in pH with soil moisture. Chan *et al.* (1979) showed that Mg becomes much less exchangeable in soils above pH 6.5. Afeyo gave the highest mean value of 1.347 and Field 18 gave the lowest mean value of 0.71 for the heated Mg which is also not significant. Non heated K, Afeyo gave the highest mean value of 0.413 which could be attributed to increased soil moisture and decomposition of crop residues releasing K to the soil (Ebelhar and Varsa, 1996) while Field 3 gave the lowest mean value of 0.14 which is highly significant statistically and this could be attributed to crop uptake of K and possible K fixation because of drier soil conditions (Ebelhar and Varsa, 1996). Heated K, Afeyo also gave the highest mean value of 0.399 while Field 3 gave the lowest mean value of 0.151 which is also highly significant.

4. Conclusions

Statistically, important differences were observed with heating for some chemical property of the soils, such as exchangeable Ca (p=0.000), Mg (p=0.004), K (p=0.266). Exchangeable K, shows no significant increase with temperature in this present studies. Heating soils results in significant effects on physical and chemical properties of the soils. It specifically changes elemental contents in the soil compounds as the temperature increased, exchangeable calcium and magnesium in the soils decreased.

References

Anaun, T. E., & Ogundele, O. D. (2021). Physicochemical Analysis and Functional Properties of Sponge Gourd (Luffa cylindrica Linn.) Seed Oil Obtained from Owo, Ondo State Nigeria. *Achievers Journal of Scientific Research*, *3*(1), 97-104.

Ebelhar, S. A., & Varsa, E. C. (1999). Tillage and potassium placement effects on potassium use efficiency in a corn-soybean rotation. In *1999 Illinois Fertilizer Conference Proceedings. University of Illinois* (Vol. 19, pp. 161-180).

Emmanuel, A. T., David, O. O., & Oyeniyi, A. T. (2020). Effects of Processing Temperature on the Proximate and Mineral Composition of Oreochromis niloticus. *International Journal of*

Recent Innovation in Food Science & Nutrition, *3*(1).

Fontúrbel, M. T., Barreiro, A., Vega, J. A., Martín, A., Jiménez, E., Carballas, T., ... & Díaz-Raviña, M. (2012). Effects of an experimental fire and post-fire stabilization treatments on soil microbial communities. *Geoderma*, *191*, 51-60.

Giovannini, C., Lucchesi, S., & Giachetti, M. (1990). Effects of heating on some chemical parameters related to soil fertility and plant growth. *Soil Science*, *149*(6), 344-350.

Harden, J. W., Neff, J. C., Sandberg, D. V., Turetsky, M. V., Ottmar, R., Gleixner, G., ... & Manies, K. L. (2004). Chemistry of burning the forest floor during the FROSTFIRE experimental burn, interior Alaska, 1999. *Global Biogeochemical Cycles*, *18*(3).

Inbar, A., Lado, M., Sternberg, M., Tenau, H., & Ben-Hur, M. (2014). Forest fire effects on soil chemical and physicochemical properties, infiltration, runoff, and erosion in a semiarid Mediterranean region. *Geoderma*, *221*, 131-138.

Knight, W. G., Dudley, L. M., & Jurinak, J. J. (1992). Oxalate effects on solution phosphorus in a calcareous soil. *Arid Land Research and Management*, *6*(1), 11-20.

Marcos, E., Tárrega, R., & Luis, E. (2007). Changes in a Humic Cambisol heated (100–500 C) under laboratory conditions: the significance of heating time. *Geoderma*, *138*(3-4), 237-243.

Neary, D. G., Ryan, K. C., & DeBano, L. F. (2005). Wildland fire in ecosystems: effects of fire on soils and water. *Gen. Tech. Rep. RMRS-GTR-42-vol. 4. Ogden, UT: US Department of Agriculture, Forest Service, Rocky Mountain Research Station. 250 p.*, *42*.

Ogundeleolusola, D., Thompson, S. O., Lawalsonsimisola, K., & Demehin, B. F. (2019). Effects of drying temperature on proximate composition and functional properties of (Colocasiaesculenta) cocoyam flour. *International Journal of Recent Innovation in Food Science & Nutrition*, *2*(1), 25-33.

Sertsu, S. M., & Sánchez, P. A. (1978). Effects of heating on some changes in soil properties in relation to an Ethiopian land management practice. *Soil Science Society of America Journal*, *42*(6), 940-944.

Stephens, S. L., Burrows, N., Buyantuyev, A., Gray, R. W., Keane, R. E., Kubian, R., ... & Van Wagtendonk, J. W. (2014). Temperate and boreal forest mega-fires: Characteristics and challenges. *Frontiers in Ecology and the Environment*, *12*(2), 115-122.

Stoof, C. R., Wesseling, J. G., & Ritsema, C. J. (2010). Effects of fire and ash on soil water retention. *Geoderma*, *159*(3-4), 276-285.

Thomaz, E. L., Antoneli, V., & Doerr, S. H. (2014). Effects of fire on the physicochemical properties of soil in a slash-and-burn agriculture. *Catena*, *122*, 209-215.

Thompson, S. O., Ogundele, O. D., Abata, E. O., & Ajayi, O. M. (2019). Heavy metals distribution and pollution indices of scrapyards soils. *International Journal of Current Research in Applied Chemistry & Chemical Engineering*, *3*(1), 9-19.

Ulery, A. L., Graham, R. C., Goforth, B. R., & Hubbert, K. R. (2017). Fire effects on cation exchange capacity of California forest and woodland soils. *Geoderma*, *286*, 125-130.