Impact of Slash and Burn Agricultural Practice on Selected Towns of Owerri West Local Government Area, Imo State, Nigeria

Dr. R.F. Njoku, Dr. C.C. Ejiogu*, and Duru, C.C.

Department of Environmental Management Technology, Federal University of Technology Owerri, P.M.B, Owerri Nigeria.
**Corresponding author*

***Abstract*: The objective of the study was to determine the effects of slash and burn farming practices on cultivated soils in a few communities in the Owerri West Local Government Area of Imo State, Nigeria. Stratified random sampling technique was adopted. Farmerland were selected at random from Owerri West Local Government Area. Soil sample were collected at a depth of 0-15cm from six different point before and after slash and burn using soil auger, bagged and labelled for laboratory analysis. The soil samples were then analyses: bulk density (BD), moisture content, total porosity, particles distribution, pH, exchangeable magnesium and calcium, total nitrogen, exchangeable acidity, exchangeable bases and acidity, effective cation exchange capacity and percentage base saturation. pH, Organic Carbon (OC), Organic Matter (OM), and Nitrogen contents in soil of the various research locations ranged from 3.38-6.66 (4.030.25), 1.18-6.66 (2.530.28), 2.04-6.16 (4.050.27), and 0.11-0.38 (0.250.02) percent, respectively. Available Phosphorus (Av.P) varied from 3.55-7.28 (5.550.36) mg/g, Ca ions varied from 0.05-2.64 (0.480.17) mg/g, and Mg ion concentrations varied from 0.15-0.63 (0.280.04) Cmol/kg. Base Saturation (BS) varied from 10.18-94.33 (30.717.21) percent. Acidity and Al ions, as well as K and Na ions, ranged from 0.06-0.77 (0.130.04), 0.53-0.88 (0.660.03), 0.40-4.83 (3.520.29), and 0.00-2.62 (1.700.20) Cmol/kg. Cation Exchange Capacity (CEC) was 2.57-11.00 (8.000.55) Cmol/kg, while Mn ions were 1.10-19.20 (5.391.25) mg/g. Fe ions ranged from 70.60 to 233.00 mg/g (113.598.02), Cu ions from 0.50 to 1.10 mg/g (0.750.04), and Zn ions from 3.33-6.70 mg/g (5.750.17). Chemical parameter concentrations differed between the burned and unburned sampling areas. The mean (SE) concentrations of pH, KCl, OC, OM, and Available P at the burnt areas were 4.0 (0.34), 3.21 (0.17), 2.95 (0.48), 4.42 (0.22), and 5.82 (0.58) mg/g, respectively.. At the burnt areas, mean concentrations of BS, Fe, Zn, CEC, and Mn ions were 31.53 (11.40) percent, 109.12 (7.52) mg/g, 5.41 (0.27) mg/g, 8.58 (0.73) Cmol/kg, and 5.11 (1.80) mg/g, respectively, and 29.89 (9.54) percent, 118.06 (14.56) mg/g, 6.10 (0.14) mg/g, 7.41 (Cu, Acidity, and Al ion concentrations were 0.800 (0.06) mg/g, 3.91 (0.43) Cmol/kg, and 1.75 (0.32) Cmol/kg, respectively, in burnt locations. Only the mean Zn concentration differed substantially (Sig. Fvalue=0.036) between the burnt and unburnt areas at the p0.05 level using ANOVA. There were also correlation coefficients between the chemical parameters of burned and non-burned soils. Soil sample from Obinze and Ihiagwa after slash burn was slightly acidic whereas that of Eziobodo was within a preferable range for plants. Soil samples from Obinze and Ihiagwa has a low percentage of organic matter and nitrogen and could be conducive for some acid-sensitive crops. However, future research work should investigate the Effects of soil temperature on some soil properties and plant growth.**

I. INTRODUCTION

The Nigerian economy revolves round farming. More than 30 percent of gross domestic product (GDP) generated in this country comes from agriculture, employs approximately 68 percent of the workforce and it is also responsible for more than 70% exports that are not related to oil, and equally provides food more than 80% of the food consumed in Nigeria (Anderson, 2017). With Nigeria's growing population and the resulting demand for expanded agricultural production (food and fiber crops, as well as livestock), better management of the country's agricultural resources is critical (Christian, 2020). Agriculture plays a significant role in these processes and is a major contributor to biodiversity loss (Radoslava, 2016) changes in evapotranspiration, runoff and local climate. One of the oldest farming practices in tropical countries is slash-and-burn Agriculture, when forest vegetation is cut and burned on the spot (Thomaz & Staffan, 2020). It is further referred to as shifting cultivation and swidden agriculture, both of which are major sources of deforestation in the tropics. Deforestation and slash-burn, on the other hand, typically result to considerable losses of CO_2 and Greenhouse gases (GHGs) from soil and vegetation, as well as changes in runoff and local climate (Bennett, 2017). It has been reported that bush burning contributes to global warming by emitting NO_2, SO_2, SO_3, NO, CO, and CO_2 gases, all of which have a significant impact on the ozone layer. Marc, (2018), argued that bush burning changes the microclimate at the soil–atmosphere interface. According to Cho (2018), atmospheric carbon dioxide continues to rise due to absence of green plants to absorb it and setting of trees on fire in order to remove forest debris during forest cleanup, both of which have released additional carbon dioxide into the atmosphere. Human activities are responsible for the rise in levels of carbon dioxide and other gases in the environment due to bush burning which are currently thought to be the cause of global warming (Sulaiman and Abdul-Rahim, 2018). Slash and burn allows farming to be conducted because it makes removal of forest debris very easy because less human effort is needed. Apart from that, it improves the fertility of the soil. It provides farmers with a good source of income and food during period of uncertainty especially when forest are set on fire hunting wildlife species becomes easy.

Slash-and-burn agriculture, despite its many advantages, is acknowledged to have a negative impact on the environment and some of the impact are deforestation resulting to loss of biodiversity. It also brings about depletion in the water table and it may causes soil erosion (Jara-Rojas, *et al*., 2020).

Agriculture, while providing a source of income for many people in the tropics, has resulted in the loss of vegetative cover due to slash and burn practices. Similarly, fire has a depressing effect on soil fungus, animal populations, moisture content, micro and macro organisms, organic matter as well as facilitating erosion. Agriculture dominates all other variables identified in their study as impeding afforestation and restoration programs, hastening deforestation and ultimately loss of tree species (Jara-Rojas, *et al*., 2020).

Carbon emissions from slash and burn have been estimated globally over the last three decades, resulting in CO_2 released to the atmosphere (Abeydeera, *et al*., 2019). Forest fires is associated with accumulation of greenhouse gases resulting to global warming, principally carbon dioxide. However, approximately two-thirds of the carbon dioxide generated by man are product of burning of fossil fuels, whereas one-third comes from burning of forest biomass for example crops cultivated on the farm, grasses, and forest trees.

The majority of slash-and-burn studies show that burning increases soil nutrient availability (Gay-des-Combes, *et al*., 2017). In practically all tropical forest types where slash-and-burn has been studied, increases in soil fertility have been attributed to nutrient-rich ash (Reed, *et al*., 2017). Slash-and-burn farming, on the other hand, has been linked to low crop yields and quick soil degradation in several studies (Zhang, *et al*., 2016). When soil is burned, its nutrients are eliminated, and the soil is drained. Furthermore, when grass is burned, carbon dioxide is released into the atmosphere, contributing to the ozone layer loss and climate change (Gay-des-Combes, *et al*., 2017). They concluded that slash-and-burn farming practices are harmful to both local agriculture and the environment and recommended that Durban conference must provide alternatives for small scale farmers.

Splash and burn agriculture has been linked to the deterioration of soil qualities, according to certain studies. Despite the fact that slash and burn farming is unsustainable and has already harmed the soils, it is nevertheless practiced in rural areas (Gay-des-Combes, *et al*., 2017). Slash and burn land clearing is an important aspect of the traditional farming system in the southern portion of Nigeria, where it is commonly utilized to prepare land for tillage (Edem, *et al.*, 2013). Clearing forest lands for agriculture is a major threat to Imo State's forest estate (Kalu, *et al*., 2014).

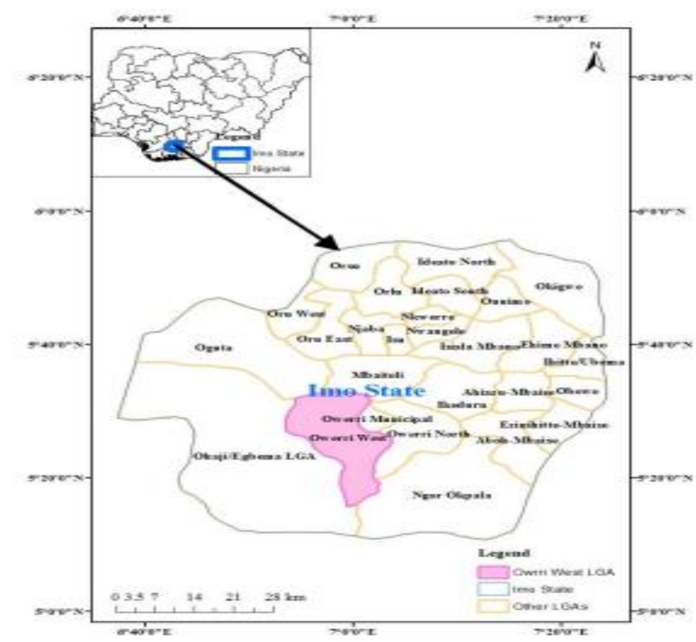
Burning has been the easiest and most practical way of clearing and preparing land for planting in the humid tropics for food production as more land is cleared and prepared each year (Edem, *et al*., 2012). Slash fires have among of the greatest rates of nutrient loss of any fires (Gay-des-Combes, *et al*., 2017), and maintaining site fertility requires a thorough understanding of the nutrient fluxes and losses that come with them. Rapidly growing human population with corresponding increase in agriculture to produce food for the teaming population has resulted to increase in slash and burn agricultural practice. However, there is lack of information on the impact on slash and burn agricultural practice in Owerri West Local Government Area. Similarly, Owerri Local Government Area is one of the Local government in Imo State that the population is growing rapidly, due to proximity to the State capital and presence of higher institutions. The purpose of this research is to determine the influence of slash and burn agricultural land use techniques on cultivated soils in the Imo State towns of Ihiagwa, Obinze, and Eziobodo.

II. MATERIALS AND METHODS

Study Area

Sample site (farms) are in Owerri West Local Government Area (Obinze, Ihiagwa and Eziobodo), located in the south eastern part of Nigeria, within latitude 5° 29" N and 20° 612"N and longitude 7° 1"E and 3.317"E and occupies a land area of about 295 square kilometers and population of about 99,265 at the 2006 census. It lies within the humid tropical climate with annual rainfall and temperature of over 2000 mm and 20 ºC respectively (Akagha, *et al*., 2020).

Fig. 1: Map of the Study Area



(Source: Adeyemi, *et al*., 2015)

Sample Collection

Primary Data were collected from survey collected which involves collecting soil sample before and after slash and burn. The collected soil samples were analysed in the laboratories. Stratified Random sampling technique was adopted and soil samples were collected from Ihiagwa, Obinze and Eziobodo without segregation.

Permission was solicited from the farm owners. Before slashing (cutting of the trees) in the farmland, soil sample were collected at burnt and unburnt locations. Soil sample were collected using soil auger, bagged in large cellophane bag, Soil samples were collected, using simple random sampling. In each of the selected plots in the study area, soil samples was collected at a depth of 0-15cm from six different point at surface level before burning (unburned forest soil), store in a black polyethene bag and labelled. The collected samples were taken to the laboratory to determine the impact of slash and burn on the soil and two weeks after burning (burned forest soil). Black polyethene bag was used to store the samples so that the soil does not loss it quality. A GPS instrument was used to obtain the co-ordinates of the sample sites, so as to obtain the map of the area. The samples were air dried, sieved to pass through 2mm diameter mesh for removing all the stones and plant debris and root.

The soil samples were taken to the FUTO soil science laboratory and were oven dried and were weighed, before and after oven-drying. The soil samples were then subjected to the following routine analyses: bulk density (BD), moisture content**,** total porosity, particles distribution, pH, exchangeable magnesium and calcium, total nitrogen, exchangeable acidity, exchangeable bases and acidity, effective cation exchange capacity and percentage base saturation.

Bulk Density

The bulk density (BD) was calculated using the core method, as recommended by Van-Bruggen and Semenov (2000). The formula P=m/v was used to compute bulk density from oven-dry weight of soil from a known volume of measured soil.

Where P = bulk density (g cm^{-3}), M = oven-dry soil mass (g), and V = volume of soil (cm^{-3}) equivalent to cylinder volume, v = nr 2.

Soil Moisture Content Determination

The moisture content of the soil samples was determined using the oven dry method.

For a period of 24 hours, the weighed sample was baked in an oven set to 105 $+2^{oC}$. After that, the soil samples were taken out of the oven and allowed to cool in desiccators containing silica gel before being weighed again. The samples were returned to the oven for another 30 minutes of drying before being placed in the desiccators to cool. The oven drying and cooling process was repeated until the weight was consistent. The moisture content of the core sample was calculated by calculating the difference between the wet core soil and the dry core soil. The formula was used to calculate:

$$MC = \frac{(Mn - Mo)}{Mn} \times 100$$

Where: MC=Moisture Content,

Mn=Weight of soil with moisture (Weight),

Mo=Weight of soil with moisture (wet weight),

Mo=Weight of soil without moisture (oven dry weight).

Total Porosity

Total porosity was calculated using the formula:

$$n = 100 \frac{(1 - B_d)}{P_d}$$

Where n stands for total porosity,

Bd for bulk density,

Pd for particle density, which is 2.65g/clm^3.

Particle Size Distribution

Using water and sodium hexametaphosphate (calgon) as a dispersant, the particle size distribution was measured using the hydrometer method.

Laboratory Analysis of Burnt and Unburnt Soil Chemical Properties

In a 1:2.5 soil/liquid suspension, the pH of the soil was measured in water and 0.1 using a pH meter.

The wet oxidation method was used to determine organic carbon. The value of soil organic carbon was multiplied by 1.724 to calculate organic matter.

The bray 2 solution method was used to determine the amount of available phosphorus.

The amount of exchangeable potassium and sodium was evaluated using a flame photometer and 1 neutral ammonium acetate ($NH_{40}OAC$).

A atomic Absorption Spectrometer was used to quantify the amount of exchangeable magnesium and calcium.

Using concentrated H_2SO_4 and a sodium copper sulphate catalyst mixture, total nitrogen was measured using the Kjehdahl digestion method.

The titration method was used to determine the exchangeable acidity.

The total of all exchangeable bases and acidity was used to calculate the Effective Cation Exchange Capacity (ECEC). Percentage base saturation (percent BS) was calculated in percent using the formula:

%BS = Total exchangeable base x 100)/(ECEC).

Method Of Data Analysis:

Mean, minimum value, maximum value and standard error were calculated using descriptive statistics. To investigate various variations in soil parameters before and after slash and burn, the data was subjected to analysis of variance (ANOVA) at a 5% probability level using the Genstat statistical program. The association between soil characteristics and organic matter at the burnt and unburned locations of the research regions was determined using correlation analysis.

III. RESULTS AND DISCUSSIONS

Results

The concentrations of the seventeen chemical parameters measured in soil of the various study locations are shown in Table 1. pH, Organic Carbon (OC), Organic Matter (OM) and Nitrogen varied from 3.38-6.66 (4.03±0.25), 1.18-6.66 (2.53±0.28) %, 2.04-6.16 (4.05±0.27) % and 0.11-0.38 (0.25±0.02) % respectively (Table 1). Base Saturation (BS), varied from 10.18-94.33 (30.71±7.21) (%), Available Phosphorus (Av.P) varied from 3.55-7.28 (5.55±0.36) mg/g, Ca ions varied from 0.05-2.64 (0.48±0.17) mg/g and Mg ion concentrations varied from 0.15-0.63 (0.28±0.04) Cmol/kg. K and Na ions, as well as Acidity and Al ions varied from 0.06-0.77 (0.13±0.04), 0.53-0.88 (0.66±0.03), 0.40-4.83 (3.52±0.29) and 0.00-2.62 (1.70±0.20) Cmol/kg respectively (Table 1). Cation Exchange Capacity (CEC) varied from 2.57-11.00 (8.00±0.55) Cmol/kg, Mn ions varied from 1.10-19.20 (5.39±1.25) mg/g, Fe ions varied from 70.60-233.00 (113.59±8.02) mg/g, Cu ions varied from 0.50-1.10 (0.75±0.04) mg/g and Zn ions varied from 3.33-6.70 (5.75±0.17) mg/g. Table 2 shows the descriptive statistic of Chemical properties of soil in Owerri West Local Government Area.

Table 1: Soil Chemical Properties among Different Locations

Locatio n Unburn t	Soil depth	PH(1:1) H_2O	PH(1: 1) KCL	%Oc	%OM	%N	%BS	(mg/ g) Avp	(Cm ol/kg) Ca	(Cm ol/kg) Mg	(Cm oi/kg)k	(Cmol/kg) Na	(Cmol/kg)Al	(Cm ol/kg)ECE C	(mg/g) Mn	(mg/g) Fe	(mg/g) Cu	(mg/ g)Cu	(mg/ g)Zn
Ihiagw a	(0.15c m)	3.65	2.99	2.76 5	4.767	0.287	12.4 12	7.16	0.06 3	0.16 4	0.11 2	0.705	4.41	2.02	8.411	3.4	126	1	5.8
Obinze	(0.15c m)	3.44	2.78	2.06 5	3.56	0.214	10.1 95	3.56 8	0.22 9	0.16 4	0.09 7	0.631	4.82	2.61	10.996	1.2	119	0.6	5.4
Eziobo do	(0.15c m)	4.36 3.81 666	3.86	2.87 2.56 666	4.948	0.298 0.266	85.6 76 36.0 9433	7.28 2 6.00 3	2.63 5 0.97 5	0.55 9 0.29 566	0.11 4 0.10 766	0.526 0.62 066	0.83 3.35 333	0 1.54 33	4.475 7.96 066		70.6 105.	0.8	6 5.73 333
Mean burnt	(0.15c m)	667	3.21	7	4.425	333	3	333	667	7	7	7	3	3	7		2	0.8	3
Ihiagw a	(0.15c m)	3.39	2.9	2.27 5	3.922	0.236	13.3	5.15 1	0.07 8	0.21 4	00.1 06	0.874	4.06	2.22	9.559		106.3	0.6	5.7
Obinze	(0.15c m)	3.46	2.85	1.19	2.0516	0.123	12.2 2	3.75 1	0.16 7	0.18 3	0.07 7	0.574	3.23	2.03	8.109		108.1	0.7	6.6
Eziobo do	(0.15c m)	5.15 3.99 666	4.87	3.57 2.34	6.155 4.042	0.37	80.6 1 35.3 766	6.91 7	0.95 3 0.39 9	0.50 2 0.29 633	0.08 4 0.08	0.535 0.66	0.4 2.56 333	0 1.41 666	2.573 6.74		86.3 100. 233	1 0.76 666	6
Mean	(0.15c m)	667	3.54	5	867	0.243	7	5.27 3	333	3	9	1	3	7	7	7	3	7	6(.1

(Source: Field Data, 2021)

Table 2: Descriptive statistics of the Chemical properties of soil in Owerri

Parameters	Minimum	Maximum	Mean	SE
pH	3.38	6.66	4.03	0.25
OC (%)	1.18	6.66	2.53	0.28
OM (%)	2.04	6.16	4.05	0.27
N (%)	0.11	0.38	0.25	0.02
BS (%)	10.18	94.33	30.71	7.21
Av.P (mg/g)	3.55	7.28	5.55	0.36
Ca (Cmol/kg)	0.05	2.64	0.48	0.17
Mg (Cmol/kg)	0.15	0.63	0.28	0.04
K (Cmol/kg)	0.06	0.77	0.13	0.04
Na (Cmol/kg)	0.53	0.88	0.66	0.03
Acidity (Cmol/kg)	0.40	4.83	3.52	0.29
Al (Cmol/Kg)	0.00	2.62	1.70	0.20
CEC (Cmol/kg)	2.57	11.00	8.00	0.55
Mn (mg/g)	1.10	19.20	5.39	1.25
Fe (mg/g)	70.60	233.00	113.59	8.02
Cu (mg/g)	0.50	1.10	0.75	0.04
Zn (mg/g)	3.33	6.70	5.75	0.17

(Source: Field Data, 2021)

SE=standard error of mean, OC=organic carbon, OM=organic matter, BS=base saturation, Av.P=available phosphorus, CEC=cation exchange capacity

The concentrations of the chemical parameters measured also varied between the burnt and unburnt sampling locations. At the burnt locations, mean (±SE) concentrations of pH, KCl, OC, OM and Available P were 4.0 (±0.34), 3.21 (±0.17), 2.95 (±0.48) %, 4.42 (±0.22) % and 5.82 (±0.58) mg/g respectively (Fig. 2).

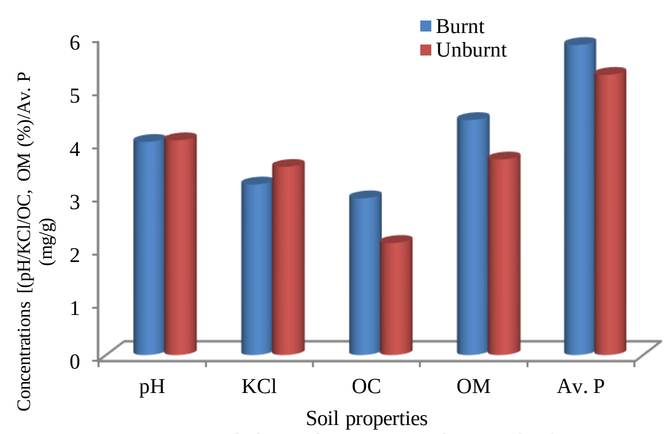


Fig. 2. Mean soil chemical properties in burnt and unburnt locations in Owerri

(Source: Field Data, 2021)

However, at the unburnt locations, mean (±SE) of the parameters were 4.04 (±0.38), 3.54 (±0.33), 2.11 (±0.27) %, 3.68 (±0.48) % and 5.27 (±0.46) mg/g respectively.

At the burnt locations, mean (±SE) concentrations of N, Ca, Mg, K and Na ions were 0.25 (±0.01) %, 0.70 (±0.31) Cmol/kg, 0.26 (±0.06) Cmol/kg, 0.18 (±0.07) Cmol/kg and 0.65 (±0.03) Cmol/kg respectively. At the unburnt locations, their respective mean concentrations were 0.24 (±0.04) %, 0.27 (±0.10) Cmol/kg, 0.29 (±0.05) Cmol/kg, 0.08 (±0.01) Cmol/kg and 0.68 (±0.05) Cmol/kg (Fig. 3).

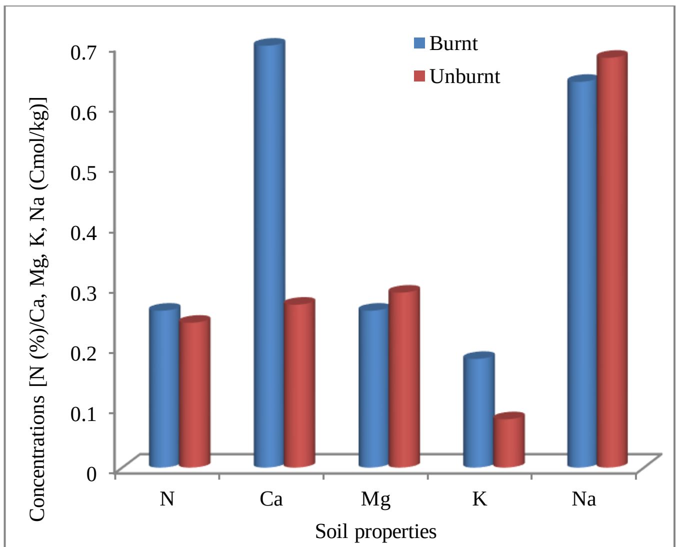


Fig. 3. Mean soil chemical properties in burnt and unburnt locations in Owerri

(Source: Field Data, 2021)

Mean concentrations of BS, Fe, Zn, CEC and Mn ions were 31.53 (±11.40) %, 109.12 (±7.52) mg/g, 5.41 (±0.27) mg/g, 8.58 (±0.73) Cmol/kg and 5.11 (±1.80) mg/g respectively at the burnt locations, and 29.89 (±9.54) %, 118.06 (±14.56) mg/g, 6.10 (±0.14) mg/g, 7.41 (±0.82) Cmol/kg, and 5.66 (±1.83) mg/g respectively at the unburnt location (Fig. 4).

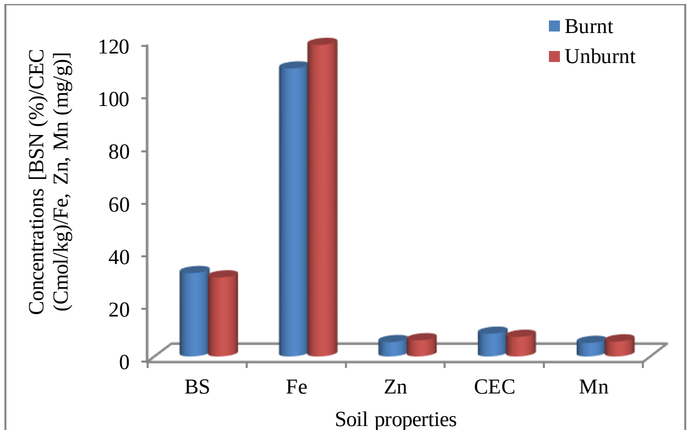


Fig. 4. Mean soil chemical properties in burnt and unburnt locations in Owerri

(Source: Field Data, 2021)

At the burnt locations, mean (±SE) concentrations of Cu, Acidity and Al ion were 0.800 (±0.06), mg/g, 3.91 (±0.43) Cmol/kg and 1.75 (±0.32) Cmol/kg respectively; and at the unburnt locations, they were 0.70 (±0.05) mg/g, 3.13 (±0.38) Cmol/kg and 1.65 (±0.27) Cmol/kg respectively (Fig. 5). The One-Way Analysis of Variance (ANOVA) test reveals that only the mean concentration of Zn differed significantly (Sig. F_{value}=0.036) between the burnt and unburnt locations at $p<0.05$ level.

Relationships between the chemical properties of Burnt and Unburnt soil

There was correlation coefficients between the chemical properties of burnt and unburnt soils from the sampling locations. At $p<0.05$, pH correlated with N (r=0.564), CEC (r=-0.548), and Mn (r=0.472); KCl correlated with Ca (r=0.470); and OC correlated with N (r=0.496), available P (r=0.483) and Mg (r=0.585). Organic Matter (OM) correlated with BS (r=0.554), Mg (r=0.478), Acidity (r=-0.569), CEC (r=-0.533) and Cu ions (r=0.536); N correlated with CEC (r=-0.578); BS correlated with available P (r=0.529) and K (r=0.514); Available P correlated with Mg ions (r=0.508); Ca correlated with CEC (r=-0.549); and Na correlated with Acidity (r=0.504).

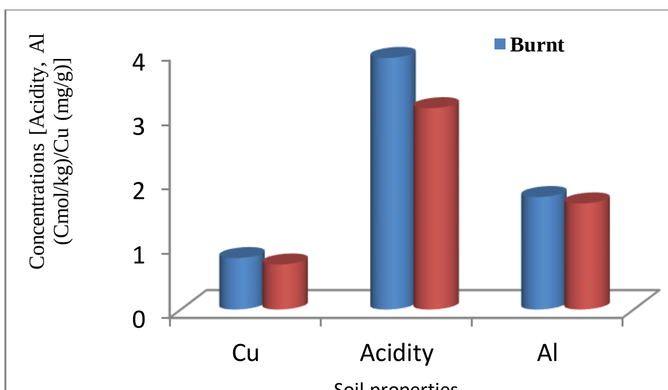


Fig. 5. Mean soil chemical properties in burnt and unburnt locations in Owerri

(Source: Field Data, 2021)

However, at $p<0.01$, pH correlated with KCl (r=0.727), OC (r=0.692), BS (r=0.880), Mg (r=0.901), K (r=0.607) and Al (r=0.790). KCl correlated with OM (r=0.612), N (r=0.804), BS (r=0.790), Available P (r=0.634), Mg (r=0.801), Acidity (r=-0.688), Al (r-0.808), CEC (r=-0.831) and Mn (r=0.740); while OC correlated with OM (r=0.673), BS (r=0.685), K (r=0.876), Al (r=0.599) and Zn (r=0.858). Organic Matter (OM) correlated with N (r=0.875), Available P (r=0.826) and Mn (r=0.663); N correlated with BS (r=0.597), Available P (r=0.833), Mg (r=0.608), Al (r=0.596) and Mn (r=0.614); while BS correlated with Ca ions (r=0.695), Mg ions (r=0.977), Acidity (r=-0.724), Al (r=-0.963), CEC (r=-0.757) and Mn (r=0.800). Available P correlated with Al (r-0.625), CEC (r=-0.636), Mn (r=0.614) and Cu (r=0.626); Ca ions correlated with Mg ions (r=0.635), Acidity (r=-0.670), Al (r=-0.705) and Mn ions (r=0.765); and Mg ions correlated with Acidity (r=-0.680), Al ions (r=-0.929), CEC (r=-0.708) and Mn ions (r=0.746). K ions correlated with Zn (r=-0.863); Acidity correlated with Al (r=0.847), CEC (r=0.917) and Mn ions (r=-0.917); Al ions correlated with CEC (r=0.887) and Mn ions (r=-0.885); and CEC correlated with Mn ions (r=-0.874).

A pair-wise comparison in levels of the chemical parameters measured in burnt and unburnt soil samples collected from the locations, of the parameters measured, Organic Matter (OM) contents of the soil (Sig. t_{value}=0.039), Acidity levels (Sig.t_{value}=0.006) and Mn ion concentrations (Sig.t_{value}=0.012) differed significantly at the 95% confidence interval between the burnt (1) and unburnt (2) locations.

Discussions

The pH of burnt soil at Eziobodo was within the range that plants prefer, whereas the pH of the other soils was slightly acidic. Fire can directly alter soil parameters through heating and combustion processes, as well as indirectly through changes in vegetation cover and greater redistribution of soil through rapid post-fire erosion. This findings was in consonance with the research work of Ngole-Jeme, (2019). All areas treated to slash and burn experienced an increase in base saturation. Soil fertility is measured using base saturation. The more fertile the soil is, the higher the base saturation. A low base saturation implies that, the soil is acidic (Eriksson, *et. al*., 2005). From all indication, before the areas were subjected to slash and burn, the soil pH was slightly acidic. In the study areas only Eziobodo has a pH of 5.15 in burnt soil. Some tropical soils have a high base saturation, which may explain why some acid-sensitive crops may be cultivated on acid tropical soils and why liming has little effect on their yield.

When farmland are subjected to fire additional material are added to the soil in form of ashes, a particulate post-fire residue which is made up of mineral elements and burned organic components (Santin, *et al*., 2016). While some ash comes directly from charred topsoil, the majority of it comes from above-ground biomass that has been burned alive or dead (Santin, *et al*., 2016; Santin, *et al*., 2016). All the soils samples analyzed from burnt areas have a low percentage of organic matter and nitrogen except soils samples from Eziobodo. The levels of calcium, magnesium and copper increases in burnt areas, whereas potassium levels decreased in burnt areas. However, in most burnt areas, exchangeable acidity (Al^{+++}) was very low and did not contribute to soil acidity of the burnt areas. The majority of iron in the soils was probably tightly bound in complexes, making sodium-acetate extraction impossible.

Chemical qualities change at high temperatures due to the combustion of soil organic matter and organic compounds, as well as an increase in soil pH, and physical properties vary due to changes in soil ability to repel water and aggregate stability. When high temperatures are attained, even soil minerals can undergo changes. This is also responsible for low potassium levels in all the locations. Manganese levels fluctuate between rises and declines. In ECEC, there were both increase and decrease in burnt areas. This findings is in agreement with the research work of Rahul, (2021).

There was loss of organic matter in burnt areas compared to unburnt areas. This research finding is in agreement with Ngole-Jeme (2019). Fire has a major impact on soil parameters because organic matter (OM) that are on the surfaces or close to the surfaces are rapidly combusted. This is also responsible for increase in pH of the soil because variations in OM have an impact on the underlying soil's chemical, physical, and microbiological properties. Although some nutrients were lost due to volatilization, the majority of nutrients are made more accessible in the burnt areas. This is also in consonance with the research findings of Santin and Doerr, (2016).

Soils have facilitated the establishment of human agro-ecosystems and, as a result of human population increase, there is also an increase in slash and burn practices (Pyne, 2016). Soils are one of the most important non-renewable resources (Santin and Doerr, 2016). Subjecting it to slash and burn could be harmful to soil inhabitants such as micro-organisms and macro-organisms. This organisms are one of the active agents of soil formation. The soil plays a vital role in the ecosystem such as water storage and filters, as well as being the greatest terrestrial organic carbon resource and carbon storage (Martin, 2016).

There is a good interaction between soil and fire. Fire, in addition to time, organisms, parent material, environment, terrain, and man, is now considered the seventh factors of soil formation and it is capable of influencing the quantity and quality of soil form (Deng, 2017). From the research findings fire has ability to add or delete mineral element from the soil. Using fire as a vegetation-management or land-clearing tool could be beneficial and detrimental to the soil this is in agreement with the research work of Pyne, (2016); Martin, (2016); Swetnam, *et al*. (2016); Scott, *et al*. (2016).

Slash and burn agricultural practices also increases the soil temperature (Wietinga, *et al*., 2017). However, soils are poor conductors of heat (Santin, *et al*., 2016), even when intense fire that is capable of consuming most of the available ground and above-ground fuel only limited amount of heat penetrates the soil. Organic matter content, moisture content, mineral composition, and thermal properties are changed this is in agreement with the research findings of Santin, *et al*., (2016) and Wang, *et al*., (2016). Apart from that, biological properties such as microbial biomass, seed bank and fine roots) were destroyed by slash and burn agricultural practices in the study areas and it is in consonance with the research findings of Santin and Doerr, (2016). Some of the most prevalent direct changes to the soil are caused by heat transfer from biomass and necromass combustion above the soil and combustion of live and dead organic materials in the soil itself. These are mostly determined by the temperature at which the soil reaches, as well as the resulting effects on the soil's biological, chemical, and physical qualities.

Slash and burn stimulated erosion and thinning of soils depending on the topography of the soil (Santin, *et al*., 2016). Vegetation and litter, as well as a loss in soil structure and, in some cases, an increase in water repellency, which results in more rainfall directly impacting the soil surface, resulting in increased surface runoff and erosion.

Slash and burn practices may result to significant losses of surface soil, if the soil is subject to fire annually (Fonseca, *et al*., 2017). In the long run, only material deposited in marine sediment can be protected from fire (Hou, *et al*., 2020; Razali, *et a*l., 2021). Slash and burn agricultural practices improves soil fertility, which is one of the reasons for burning crops and pastures (Thomaz and Staffan, 2020). Considerable research has focused on the potential for fire to boost soil fertility. Fire can improve soil formation by speeding up the decomposition of live and dead organic matter above the soil and its input (mostly in charred forms) into the soil which may increase the pH of the soil (Santin, *et al*., 2016).

IV. CONCLUSION AND RECOMMENDATIONS

Conclusion

Comparing the soil sample from the study shows that the pH of burnt soil at from Obinze and Ihiagwa after slash burn was slightly acidic except that of Eziobodo which was within the range that plants prefer. However, from the research findings Obinze and Ihiagwa could be conducive for some acid-sensitive crops this could be as a result of additional material added to the soil in form of ashes. These ashes are made up of mineral elements and burned organic components. Low percentage of organic matter and nitrogen where recorded except in Eziobodo. There was an increase in levels of calcium, magnesium and copper in burnt areas but with decrease in potassium levels. High temperatures were responsible for changes in potassium and Manganese levels in all the locations of which the ECEC was not an exception. Fire has a major impact on soil parameters because organic matter (OM) that are on the surfaces or close to the surfaces are rapidly combusted. Fire can directly alter soil parameters through heating and combustion processes, as well as indirectly through changes in vegetation cover and greater redistribution of soil through rapid post-fire erosion. Subjecting soils to slash and burn could be harmful to soil inhabitants such as micro-organisms and macro-organisms. Apart from that, microbial biomass, seed bank and fine roots) were destroyed by slash and burn agricultural practices. Fire has ability to add or delete mineral element from the soil which could be beneficial and detrimental to soil management.

Recommendations

Due to composite connections involving fire and soils, slash and burn agricultural practices have significant direct impacts on soils, resulting in significant changes in soil vegetation cover, increased soil fertility, organic carbon and organic matter contents, weathering, and, ultimately, soil formation. Slash and burn agricultural practice has both positive and negative benefits. However, future research work should investigate the Effects of soil temperature on some soil properties and plant growth and Slash-and-burn cultivation practice and agricultural input demand and output supply.

REFERENCES

[1] Abeydeera, L. H. U.W., Mesthrige, J.W. and Samarasinghalage, T.I. (2019). Global Research on Carbon Emissions: A Scientometric Review Sustainability, 11(3972) 1-24; doi:10.3390/su11143972.

[2] Adeyemi, A.A., Ohwo, O.A. and Ekeada, I.S (2015).Status And Distribution Patterns Of Selected Medicinal And Food Tree Species In Owerri West Local Government Area Of Imo State, Nigeria, Journal of Agriculture, Forestry and the Social Sciences (JOAFSS), Vol. 13(1):44- 62.

[3] Akagha, N.U., Onyebule, U.O., Nnadi, C.C. (2020). Effect of Rainfall Variation on Cassava (Manihot Esculenta) Yield in Owerri West Local Government Area of Imo State, Nigeria, Journal of Scientific and Engineering Research, 2020, 7(11):30-35

[4] Aleš Kučera, Pavel Samec, Aleš Bajer, Keith Ronald Skene, Tomáš Vichta, Valerie Vranová, Ram Swaroop Meena and Rahul Datta (2020). Forest Soil Water in Landscape Context, Soil Moisture Importance, Ram Swaroop Meena and Rahul Datta, IntechOpen, DOI: 10.5772/intechopen.93003. Available from: https://www.intechopen.com/books/soil-moisture importance/forest-soil-water-in-landscape-context.

[5] Ambe, B. A., Eja, l. E. and Agbor, C. E. (2015). Assessment of the Impacts and People'S Perception of Bush Burning on the Grasslands and Montane Ecosystems of the Obanliku Hills/Plateau, Cross River State, Nigeria. Journal of Natural SciencesResearch, 5, (6): 12-20.

[6] Anderson, J., Marita, C., Musiime, D. and Thiam, M. (2017). National Survey and Segmentation of Smallholder Households in Nigeria: Understanding Their Demand for Financial, Agricultural, and Digital Solutions WORKING PAPER, Page 1-88.

[7] Antoneli, V.; Mosele, A.C.; Bednarz, J.A.; Pulido-Fernandez, M.; Lozzano-Parra, J.; Keesstra, S.D.; Rodrigo- Comino, J. (2019). Effects of applying liquid swine manure on soil quality and yield production in tropical soybean crops (Parana, Brazil). Sustainability, 11, 3898.

[8] Bang-Andreasen, T., Nielsen, J. T., Voriskova, J., Heise, J., Rønn, R., Kjøller, R., Hansen, H., & Jacobsen, C. S. (2017). Wood Ash Induced pH Changes Strongly Affect Soil Bacterial Numbers and Community Composition. Frontiers in microbiology, 8, 1400. https://doi.org/10.3389/fmicb.2017.01400.

[9] Bennett, L. (2017). Deforestation and Climate Change Publication of Climate Institute, Page 1-16. http://climate.org/wpcontent/uploads/2017/04/deforestation-final_r1.pdf Accessed 25th March, 2021.

[10] Chijioke A. N. and Ozurumba O. P. (2019). Prevalence and Antibiogram of Staphylococcus Aureus Isolated from Herd of Goat, Cow and Ram at Obinze, Imo State, Nigeria. Microbiology and Infectious Disease, 3(2): 1 – 5.

[11] Cho, R. (2018). Can Removing Carbon From the Atmosphere Save Us From Climate Catastrophe?

https://blogs.ei.columbia.edu/2018/11/27/carbon-dioxide-removal-climate-change/ Accessed 25th March, 2021.
[12] Christian, L. (2020). Impact Of Selected Agricultural Policies And Intervention Programs In Nigeria – 1960 Till Date, https://www.irglobal.com/article/impact-of-selected-agricultural-policies- and-intervention-programs-in-nigeria-1960-till-date/ Accessed 25th March, 2021.
[13] Chu, E. W., and Karr, J. R. (2017). Environmental Impact: Concept, Consequences, Measurement. Reference Module in Life Sciences, B978-0-12-809633-8.02380-3. https://doi.org/10.1016/B978-0-12-809633- 8.023803.
[14] Deng, Q.; Hui, D.; Chu, G.; Han, X.; Zhang, Q. (2017). Rain-induced changes in soil CO_2 flux and microbial community composition in a tropical forest of China. Scientific Reports 7: 5539.
[15] Edem, I. D. and Alphonsus, D. U. (2013). soil properties dynamics induced by passage of fire during agricultural burning. International of Advance Agricultural Research, 5(1): 43 – 52.
[16] Edem, I. D. Uduak, C., Udo, I. and Ifiok, R. I. (2012). Erodibility of Slash-and-Burn Soils along a Toposequence in Relation to Four Determinant Soil Characteristics. Journal of Biology,Agriculture and Healthcare (2)5:93-102.
[17] FAO (2017). Soil Organic Carbon: the hidden potential.Food and Agriculture http://www.fao.org/3/I6937EN/i6937en.pdf Accessed 26th March, 2021.
[18] Fonseca, F., Figueiredo, T., Nogueira, C., Queirós, A. (2017). Effect of prescribedfire on soil properties and soil erosion in aMediterranean mountain area Geoderma 307:172–180.
[19] Gay-des-Combes, J. M., Sanz Carrillo, C., Robroek, B., Jassey, V., Mills, R., Arif, M. S., Falquet, L., Frossard, E., and Buttler, A. (2017). Tropical soils degraded by slash-and-burn cultivation can be recultivated when amended with ashes and compost. Ecology and evolution, 7(14), 5378–5388. https://doi.org/10.1002/ece3.3104.
[20] Gerhardus, P.S. and Ben du T. (2016) Potential use of wood ash inSouth African forestry: a review, Southern Forests: a Journal of Forest Science, 78:4, 255-266, DOI: 10.2989/20702620.2016.1230716.
[21] Gowlett J.A.J. (2016). The discovery of fire by humans: a long and convoluted process. Phil. Trans. R. Soc. B 371, 20150164 (10.1098/rstb.2015.0164).
[22] Holly D. D. and Shaun A.W. (2020). Effects of Non-Industrial Wood Ash (NIWA) Applications on Soil Chemistry and Sugar Maple (Acer saccharum, Marsh.) Seedling Growth in an Acidic Sugar Bush in Central Ontario, Forests 11(693): 1-21, doi:10.3390/f11060693.
[23] Hou, X., Shao,J., Chen, X., Li, J. and Lu, J. (2020) Changes in the soil erosion status in the middle and lower reaches of the Yangtze River basin from 2001 to 2014 and the impacts of erosion on the water quality of lakes and reservoirs. International Journal of Remote Sensing 41:8, pages 3175-3196.
[24] Hyde, K.D., Xu, J., Rapior, S. (2019). The amazing potential of fungi: 50 ways we can exploit fungi industrially. Fungal Diversity 97, 1–136. https://doi.org/10.1007/s13225-019-00430-9.
[25] Jara-Rojas, R., Russy, S., Roco, L., Fleming-Muñoz, D. and Engler A. (2020). Factors A_ecting the Adoption of Agroforestry Practices: Insights from Silvopastoral Systems of Colombia Forests, 11 (648), 1-15; doi:10.3390/f11060648.
[26] Kalu, C., Edet, D. I. and Chukwuenye, C. E. (2014). Assessment of Afforestation and Reforestation Efforts by Forestry Department, Ministry of Environment, Imo State. Journal of Research in Forestry, Wildlife and Environmental, 6 (2) 54 – 65.
[27] Kim J. M., Roh A.-S., Choi S.-C., Kim E.-J., Choi M.-T., Ahn B.-K. (2016). Soil pH and electrical conductivity are key edaphic factors shaping bacterial communities of greenhouse soils in Korea. J. Microbiol. 54 838–845. 10.1007/s12275-016-6526-5.
[28] Marc, L. (2018). What Is the Greenhouse Effect? https://www.livescience.com/37743-greenhouse-effect.html Accessed 25th March, 2021.
[29] Martin, D.A. (2016). At the nexus of fire, water and society. Phil. Trans. R. Soc. B, 371, 20150172 (doi:10.1098.rstb.2015.0172).
[30] Merino A., Omil B., Fonturbel M. T., Vega J. A., Balboa M. A. (2016). Reclamation of intensively managed soils in temperate regions by addition of wood bottom ash containing charcoal: SOM composition and microbial functional diversity. Appl. Soil Ecol. 100 195–206.
[31] Mkomwa, S.; Lugandu, S.; Kuria, P.; Mutai, W. (2017). Empowering smallholder farmers with profitable and sustainable farming using conservation agriculture: The case of East Africa. In Conservation Agriculture for Africa. Building Resilient Farming Systems in a Changing Climate; Kassam, A.H., Mkomwa, S., Friedrich, T., Eds.; CABI: Wallingford, UK; Boston, MA, USA; Chapter 4; p. 58. ISBN 9781780645681.
[32] Ngole-Jeme, V.M. (2019). Fire-Induced Changes in Soil and Implications on Soil Sorption Capacity and Remediation Methods Appl. Sci., 9, 3447: 1-24; doi:10.3390/app9173447.
[33] Noyce G. L., Fulthorpe R., Gorgolewski A., Hazlett P., Tran H., Basiliko N. (2016). Soil microbial responses to wood ash addition and forest fire in managed Ontario forests. Appl. Soil Ecol. 107 368–380. 10.1016/j.apsoil.2016.07.006. .
[34] Peruzzi, A.; Martelloni, L.; Frasconi, M.; Fontanelli, M.; Pirchio, M.; Rafaelli, M. (2021). Machines for Non-Chemical Intra-Row Weed Control in Narrow and Wide-Row Crops: A Review. J. Agric. Eng., 48. Available online: https://www.agroengineering.org/index.php/jae/article/view/583/629 accessed on 25 March, 2021.
[35] Pyne, S.J. (2016). Fire in the mind: changing understandings of fire in Western civilization. Phil. Trans. R. Soc. B, 371, 20150166 (10.1098/rstb.2015.0166).
[36] Radoslava, K. (2016). Agriculture and Its Impact on Land-Use, Environment, and Ecosystem Services, Landscape
[37] Ecology - The Influences of Land Use and Anthropogenic Impacts of Landscape Creation, Amjad
[38] Almusaed, Intech Open, DOI: 10.5772/63719.
[39] Rahul D. (2021). To extinguish or not to extinguish: The role of forest fire in nature and soil resilience, Journal of King Saud University - Science, Volume 33(6):1-11. https://doi.org/10.1016/j.jksus.2021.101539.
[40] Razali, A., Ismail, S.N.S., Awang,S., Praveena,S.M., Abidin, E.Z. (2021) Distribution and source analysis of bioavailable metals in highland river sediment. Environmental Forensics 22:1-2, pages 205-218.
[41] Reed, E. Y., Chadwick, D. R., Hill, P. W., and Jones, D. L. (2017). Critical comparison of the impact of biochar and wood ash on soil organic matter cycling and grassland productivity. Soil Biology and Biochemistry, 110, 134– 142. https://doi.org/10.1016/j.soilbio.2017.03.012.
[42] Santín, C., and Doerr, S. H. (2016). Fire effects on soils: the human dimension. Philosophical transactions of the Royal Society of London. Series B, Biological sciences, 371(1696), 20150171. https://doi.org/10.1098/rstb.2015.0171.
[43] Santín, C., Doerr, S.H., Kane, E.S., Masiello, C.A., Ohlson, M., de la Rosa, J.M., Preston, C.M. and Dittmar, T. (2016). Towards a global assessment of pyrogenic carbon from vegetation fires. Glob. Chang. Biol., 22: 76-91. (10.1111/gcb.12985).
[44] Scott, A.C., Chaloner, W.G., Belcher, C.M. and Roos, C.I. (2016). The interaction of fire and mankind. Phil. Trans. R. Soc., B 371: 20160149 (10.1098/rstb.2016.0149).
[45] Sorina-Simona M., Antoaneta E. and Alina B. (2020). Physical and Hydro-Physical Characteristics of Soil in the Context of Climate Change. A Case Study in Danube River Basin, SE Romania Sustainability, 12(9174):1-26.
[46] Sousa Junior, J.G.A.; Cherubin, M.R.; Oliveira, B.G.; Cerri, C.E.P.; Cerri, C.C.; Feigl, B.J. 2018. Three-year soil carbon and nitrogen responses to sugarcane straw management. BioEnergy Research 11: 249-261.
[47] Sparling, G.; Chibnall, E.; Pronger, J.; Rutledge, S.; Wall, A.; Campbell, D.; Schipper, L. 2016. Estimates of annual leaching losses of dissolved organic carbon from pastures on Allophanic soils grazed by dairy cattle, Waikato, New Zealand. New Zealand Journal of Agricultural Research 59: 32–49.
[48] Sulaiman, C. and Abdul-Rahim, A. S. (2018). Population Growth and CO2 Emission in Nigeria: A Recursive ARDL Approach, SAGE Open: 1 –14, DOI: 10.1177/2158244018765916.

[49] Swetnam, T.W., Farella, J., Roos, C.I., Liebmann, M.J., Falk, D.A. and Allen, C.D. (2016). Multi-scale perspectives of fire, climate and humans in western North America and the Jemez Mountains, USA. Phil. Trans. R. Soc. B, 371, 20150168 (doi:10.1098.rstb.2015.0168

[50] Thomaz, E. and Staffan, R. (2020) Slash-and-burn agriculture in southern Brazil: characteristics, food production and prospects, Scottish Geographical Journal, 136:1-4, 176-194, DOI: 10.1080/14702541.2020.1776893.

[51] Ubuoh, E. A., Ejekwolu, C. C. and Onuigbo, I. V. (2017). The Effect of Burnt and Un-burnt Land on Soil Physicochemical Characteristics inEkeya-Okobo Local Government Area, Akwa Ibom State, Nigeria. Journal of Applied Science Environmental Management, 21 (5): 923 – 929.

[52] van Bruggen, A.H.C., and Semenov, A.M. (2000). In: search of biological indicators for soil health and disease suppression. Appl. Soil Ecol. 15, 13–24. doi:10.1016/ S0929-1393(00)00068-8

[53] Wang, X.; Li, C.; Luo, Y.; Hua, K.; Chou, M. (2016). The impact of nitrogen amendment and crop growth on dissolved organic carbon in soil solution. Journal of Mountain Science 13: 95–103.

[54] Wietinga, C., Ebelb, B.A, and Singha, K. (2017). Quantifying the effects of wildfire on changes in soil properties by surface burning of soils from the Boulder Creek Critical Zone Observatory, Journal of Hydrology: Regional Studies 13 (2017) 43–5.

[55] Win, K.H., Khaing, T. and Moe, T.T (2020). Investigation on Chemical Constituents in Soil Samples from Selected Areas Journal of Computer Applications and Research, 1(1): 249- 253.

[56] Yadav PK, Kapoor M, Sarma K (2012) Impact of Slash-And-Burn Agriculture on Forest Ecosystem in Garo Hills Landscape of Meghalaya, NorthEast India. J Biodivers Manage Forestry 1:1.

[57] Zhang, Y., Li, C, Wang, Y, Hu, Y, Christie, P, Zhang, J, and Li, X. (2016). Maize yield and soil fertility with combined use of compost and inorganic fertilizers on a calcareous soil on the North China Plain. Soil and Tillage Research, 155, 85–94. https://doi.org/10.1016/j.still.2015.08.006.