Variability of Soil Physical Conditions Along a Slope as Influenced by Bush Burning in Acid Sands.

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Abstract The experiment was conducted at University of Uyo Teaching and Research Farm to evaluate slash and burn method of land clearing which is an integral part of the traditional farming system and is widely used as a mean of land clearing to pave way to minimum or zero tillage. A plot of land measuring 720 m^2 on a slope of 7 % was used, divided into six plots, each measuring 40 x $3m^2$ in the burnt and unburnt plots, with a landscape position described as the upper slope, middle slope and valley bottom. Progressively, fire was set into three out of the six plots. And soil samples collected in the respective burnt and un-burnt plots at two depths of 0.15 m and 0.30 m for soil physical properties analysis in the upper slope, middle slope and valley bottom. Descriptive statistics within the plots showed that variability was high in the three landscape positions in the burnt plot, while in the unburnt plots variability was moderate. In paired samples correlation analysis, the relationship between the baseline and weight of soil parameters after burning were not statistically significant, except silt contents (r = 0.999) ($p<0.05$) with almost a perfect correlation, unlike the other measured or determined parameters where changes were not consistent.

Index Terms: Slash-and-burn, slope, modification, soil properties, changes, soil productivity, infiltration,

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1. INTRODUCTION

Soil structural behavior varies with soil management practices and landscape position. The physical properties of soils are important components in determining their potential uses, sustainability and productivity [5]. As soil properties influence productivity, spatial variability of soil properties within fields offer various conditions for the diverse development of crops as well as many pests [1]. In a report [25], among three landscape positions (upper slope, middle slope and valley bottom) the valley bottom had better soil physical properties than upper and middle slope. Simultaneously, reforested land improves soil physical properties more obviously when compared to farmland and wasteland. In hilly landscapes, tillage, burning and water erosion combine to induce large variation in soil productivity at the field scale. Burning is one of the ways of clearing vegetation and reducing debris on site to be cultivated [14]. To carry out successful slash and burn, vegetable matter must be dry, under calm weather fire line, and full precautions taken to keep the fire under control. The benefits of burning in improving soil by immediate release of occluded mineral nutrients for crop use seem to be short- lived due to its degenerative effects on soil physical properties [26],[31]. Suffice it to say that burning among other soil degrading factors results in environmental damage in intensive arable lands.

Despite the merits of slash and burn, major setbacks in this method of cultivation includes destruction of soil structure thereby creating variability in soil physical conditions, and the risk of fire getting out of control or flaring up from smoldering debris, loss of organic matter and nitrogen from soil, exposure of soil surface to erosion especially at high fire intensity, and reduction in soil fauna population [12]. Although, approaches to manage this variability have been proposed, acquisition of the small-scale variability of soil properties from a burned plot of known quantity of biomass provides multiple possibilities to optimize site specific crop protection [31] This suggests that, one of the ways to study the effects of fire on soil ecosystem carefully is through measuring the various soil parameters before and after performance of experimental fire on vegetation. This will help to ascertain the sudden modifications of soil physical properties induced by the fire and its implication on soil productivity. Field studies on the effect of heating soil are rare; hence this study is aimed at measuring the variability of the soil physical condition along a slope as influenced by bush burning.

The specific objectives of this study are:-

(i) to evaluate the immediate modification of soil physical properties as a result of passage of fire.

(ii) to determine the variability of soil properties down the slope after burning.

2. MATERIALS AND METHODS

2.1 Site Description

The study was conducted at University of Uyo Teaching and Research Farm, Use Offot, Uyo. Uyo and its environs, located between latitudes 40^0 30^1 and 5^0 3^1N and longitudes 7^0 31^1 and 8^0 20^1 E [18]. The state has an estimated area of 8, 412 km^3. It is characterized by two seasons, a wet season that last for nine (9) months (April – October) and dry season (November-March). The annual rainfall ranges from 2000-3000 mm, while annual temperature varies between 26^oc and 28^oc. Relative humidity is high varying from 75-95 % with the highest and lowest values in July and January respectively.

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2. 2. Site Location and Land Preparation

Reconnaissance survey was carried out at University of Uyo Teaching and research farm, Use Offot and a plot size of 40 × 18 m^2 on 7 % slope was chosen for the study. A total of six plots each measuring 40x3 m^2 with a landscape position described as the upper slope, middle slope and valley bottom were cleared and pegged. Progressively, fire was set into three out of the six plots.

2.3. Soil Sampling, Field and Laboratory Analyses

A total of six plots were used for the study and soil samples were collected both in the burnt and in the control (unburnt) plot. Bulk samples were collected at the depth of 15 cm and 30 cm for particle size analysis in the upper slope, middle slope and valley bottom [6]. Undisturbed core samples were taken with cylindrical core samplers measuring. 6.4 cm length and 5.4 cm in diameter. And one end of the core sample was covered with a piece of cheese cloth fastened with a rubber band and properly labeled. The bulk samples were collected and secured in polythene bags and properly labeled. The cores were saturated with water overnight and thereafter weighed at saturation for moisture retention ([19].

2.3.1 Saturated Hydraulic Conductivity [21]

(Ks) was estimated using the relations

$$Ks = \frac{qs}{[H/(C_1 d + C_2 r)] + \{1/[\alpha(C1d + C_2 r]\} + 1}$$

Where;

K_S is the field saturated hydraulic conductivity (cms^{-1}),
qs is the steady state infiltration (cm s^{-1}),
H represents water ponding depth (cm),
α is the microscopic capillary length put at 0.12 cm^{-1})

2.3.2 Bulk Density was estimated by dividing the oven-dry mass of the soil by the volume of the soil [11]

2.3.3 Total Porosity was estimated from bulk density, assuming particle density of 2.65g/cm^3 [6]

$$f = [1 - (BD/Ps)] \times 100$$

Where; f = total porosity (%)
BD = Bulk density (gcm^{-3})
Ps = particle density (gcm^{-3})

2.3.4 Infiltration Test:

As described by [13], infiltration test was conducted on the three landscape positions (Upper, Middle and Valley bottom) before and after burning the vegetation using a double ring infiltrometer method. Double ring infiltrometer consist of two ring cylinders (the outer and the inner ring) the inner cylinder from which the infiltration measurement was taken was 30 cm in diameter the outer cylinder was 50 cm in diameter. The cylinders were 25 cm in height and are formed from 2 mm rolled steel. These cylinders were driven concentrically into the ground to a depth of 10 cm using a driving plate and mallet. The soil surface within these rings covered with dry leaves to prevent puddling and sealing of soil pores during pouring in of water to the rings. Infiltration experiment started by adding sediment free water into the outer ring and allowed to infiltrate. This acted as a buffer to discourage lateral flow and encourage one dimensional vertical downward flow. Immediately afterward, water was added to the depth of 15 cm in the inner ring. Water levels in the inner ring and the buffer pond were kept approximately the same throughout the experiment. Infiltration runs lasted for 3 hours using a calibrated float held vertically by a hole in a wooden bridge, in each of the locations. A stop watch was used to record the rate of water intake in cm. Infiltration data were fitted into Philips (1957), vertical flow equation; ($I = St^{-\frac{1}{2}} + At$) [20]. From this equation, estimate of sorptivity and transmisivity were possible.

2.3.5 Determination of Soil-Moisture Constants

After the conduction of saturated hydraulic conductivity, the weight of those core samples were taken in grams, then after 3 days the weights (g) were taken again to determine moisture content at field capacity, then on the 10th day the weights were also recorded to determine the permanent wilting coefficient. However, field experiment was also conducted to confirm laboratory procedure on available water at field capacity (FC) and permanent wilting point (PWP). Field measurements at FC and PWP were made by ponding a dyke of 7 m^2 with water up to 0.20 m. Free drainage of water was allowed while evaporation was prevented using polythene. Soil samples were taken 2 days after saturation; when the drainage rate became negligible for FC determination [24]. PWP was determined after the moisture content is negligible and the soil can no longer transfer water towards the roots of the plant seedlings on it [2] Available water content was calculated by subtracting permanent wilting point from the water at field capacity by using the formulae:

$$AWC = FC - PWP$$

Where;
FC = Field capacity (g)
PWP = Permanent wilting coefficient (g).
AWC = available water content (m^3m^{-3})

2.3.6 Aggregate Size Distribution

As cited by [13], aggregate size distribution was determined by wet sieving method of Toddler 1936. 100g of soil sample was weighed into a moisture can (w1) and was then transferred into a nest of sieves which were separated into various sizes by sieving the sample under a basin of water. These sieves were 4 mm, 2 mm, 1 mm, 0.5 mm and 0.25 mm. The samples were placed in the upper sieve (4 mm). The set of sieves containing the soil samples were then lowered into and out of water 20 times. The samples in the sieve were then transferred to moisture cans and oven dried at 105^O c and the soil samples in the moisture cans were all weighed and recorded as (W2). Progressively, 20 ml of sodium hexametaphosphate (calgon) was added and 30 ml of water was also added in a stirring cup containing the oven dried sample and was stirred for 5 minute each using a mechanical stirrer. The samples in the stirring cup were then transferred into a 210 micro meter sieve and were washed into the respective moisture cans by using wash bottle, and finally oven dried to a constant weight at 105^oC; then weights were accurately taken and recorded as (W3) and then their percentages determined as.

$$\%WSA = \frac{W_2 - W_3}{W_1 - W_3} \times 100$$

Where

WSA = Percent water stable aggregates

W_1 = mass of the initial soil (g)

W_2 = mass of resistance aggregates plus sand fraction (g)

W_3 = mass of sand fraction alone (g)

2.4 Distribution of Soil Particles

Soil particle size distribution was determined using the modified Day's hydrometer technique based on logarithmic density-depth relationship [13]. The soil particles after dispersing with sodium hexametaphosphate was stirred in a mechanical stirrer and were separated into coarse sand using 210 um sieve, fine sand using 100 um sieve and very fine sand using 50 um sieve sizes. The textural classes of the various soil samples were determined using the textural triangle.

2.5 Organic Carbon:

The contents of organic carbon of the soil were determined using Walkey Black 1934 wet oxidation method. The contents of organic matter were obtained by multiplying the values of organic carbon by 1.729. And that of total Nitrogen was obtained by multiplying the values of organic matter by 0.025 [29].

2.6 Experiment Layout and Statistical Analyses

The experiment consists of two treatments of burnt and unburnt plots replicated three times within each block (slope) in Randomized complete block design (RCBD). Analysis of variance was performed to assess the effect of heat on soil properties using GLM procedure (SPSS soft ware, Version 17).The means were compared using Fisher's least significant difference (LSD) test. Pearson correlation and regression coefficients were calculated to determine relationship between soil properties in a given treatment among the geomorphic surfaces. All tests of significance were made with probability value of 0.05.

3. RESULTS AND DISCUSSION

3.1 Soil Physical Properties

Results of the analyses from the three landscape positions before and after burning showed no variation in the textural classes of soils. The textural class of 15 and 30cm depths of the three landscape positions before and after burning was the same- loamy sand. This could due its intrinsic or fundamental attribute which cannot easily alter by management practices [11]. Changes in soil physical properties before and after vegetation burning along the slope at surface and sub-surface soils (Table 1) showed that sand fraction dominates the particle size distribution of the three landscape positions (the upper, middle, and bottom slopes) before and after burning. At the soil surface (0-15 cm), Coarse sand (CS) in the upper slope (US) has a mean weight of 408.57 g/kg before burning and 277.5 g/kg after burning with a moderate variability among the sampling units, but in the middle slope (MS) it has a mean weight of 147.6 g/kg before burning and 365.8 g/kg after burning, whereas in the bottom valley (BV), coarse sand has a mean weight of 274.4 g/kg before burning and 288.4 g/kg after burning. Coarse sand increased in middle and valley bottom locations after burning but reduces in upper slope. Burning had been identified as one of the degrading practices that result in soil structural degradation (Giovanni et al, 1988). Fine sand increased after burning and this may be due to ash deposit. This made the soil finer than before burning, a reduction in larger pores concomitantly increase finer particles [16]. Specifically, 25.2 % increase in fine particles were noticed after burning in the upper slope and 2.98 % in the valley bottom, but the reverse was true for the middle geosurface position (30.74 %). It therefore appears that a soil with greater percentage of finer particles has its structural quality improved after burning [22] Clay in the upper slope has a mean weight of 127 g/kg before burning and 140.3 g/kg after burning but in the middle slope, clay has a mean value of 133 g/kg before burning and 127 g/kg after burning and in the valley bottom slope, clay has a mean value of 40.3 g/kg before burning and 153.6 g/kg after burning. The increase in clay fractions of soils in the upper and valley bottom slope after burning suggest that some coagulation or breakdown of larger particles into smaller silt size particles occurred. While reduction of clay particles in the middle slope after burning suggest that some aggregations of finer particles (clay) into larger silt size particles perhaps increased the silt fractions following burning [17], [12], [11] Organic matter in the upper slope has a mean value of 31.1 g/kg before burning and 6.16 g/kg after burning, in the middle slope, Organic matter has a mean value of 23.8 g/kg before burning and 25.3 g/kg after burning and in the valley bottom, organic matter has a mean value of 30.3 g/kg before burning and 23.7 g/kg after burning. Organic matter in the upper slope at the depth of 30 cm has a mean value of 20.4 g/kg before burning and 22.1 g/kg after burning. In the middle slope, it increased from 20.3g/kg before burning and 27.1g/kg after burning and in the valley bottom. The role of soil organic matter in improving aggregate stability has been reported [4]. Organic matter at this depth increased in the three landscape positions following burning. This shows that when both vegetation and litter are burnt, it is not the organic matter, rather the interparticle bonding [30]. Soil organic C stock may be additional nutrient that increased the value of organic matter content of the soil when the bonds between carbons are weaken following burning. This immediate mineralized nutrient is short-live, and cultivation will put at risk the soil's ability to hold cations.

3.2 Bulk Density

As shown in Table 1, bulk density varied irregularly with each landscape position. The samples were collected and analyzed before and after burning. Bulk density (BD) has a mean value of 1.55 mgm^{-3} before burning and 1.35 mgm^{-3} after burning. In the middle slope, bulk density has a mean value of 1.65 mgm^{-3} before burning but reduced to 1.49 mg/m^3 after burning. But, in the bottom slope bulk density has a mean value of 1.57 mgm^3 before burning and 1.53 mgm^3 after burning. Generally, it was observed that vegetation burning reduces bulk density of the soil hence leading to unstable or less stable structure.

3.3 Saturated Hydraulic Conductivity (KS)

Saturated hydraulic conductivity (Ks) varied widely among the three landscape positions before and after burning. In the upper slope, Ks have a mean value of 22.1 cmh^{-1} before burning and 16.4 cm/hr after burning, but in the middle slope, Ks has a mean value of 13.4 cmh^{-1} before burning and 17.9 cmh^{-1} after burning and in the valley bottom, Ks has a mean value of 19.1 cm/hr before burning and 20.1 cm/hr after burning. There was no significant change in Ks at middle and bottom slopes. The values of Ks were generally high but varied among the landscape position in magnitudes as follows; upper slope > bottom valley > middle slope. The high values of Ks following burning may be attributed to distribution of pores and the burning effect which introduced excessive heat (temperature not measured) to the soil, thereby causing the cementing agent e.g. organic matter to be broken down. As a result of this, pore spaces were created to allow water to pass freely through the soil column. Also, the variability can be as a result of differences in particle fractionation, pore size distribution and soil cracking.

3.4 Volumetric Moisture Content

Soil water characteristics as shown by volumetric moisture in Table 1, showed the observed difference in moisture retention before and after burning the field was that, the amount of moisture content from one landscape position to the other varied considerably with differences in particle distribution. Only a small increase in moisture content was observed from post-burnt soils. Moisture content in upper slope has a mean value of 0.54 m^{3}m^{-3} before burning and 0.6 m^{3}m^{-3} after burning. In the middle slope, moisture content has the mean value of 0.63 m^{3}m^{-3} before burning and 0.7 m^{3}m^{-3} after burning and in the bottom valley, moisture content has a mean value of 0.62 m^{3}m^{-3} before burning and 0.6 m^{3}m^{-3} after burning. Volume of water retained in the soil after burning was not significant.

3.5 Available Moisture Content (AWC)

Available moisture content in the upper slope has a mean value of 0.58 m3m-3 before burning and 0.83 m3m-3 after burning. In the middle slope, available water content has a mean value of 0.7 m^{3}m^{-3} before burning and 0.88 m^{3}m^{-3} after burning, and in the bottom slope, available moisture content has a mean value of 0.71 m^{3}m^{-3} before burning and 0.67m^{3}m^{-3} after burning. The soil tends to store relative more atmospheric moisture for plants use after burning the plots than in unburnt condition.

TABLE 1

CHANGES IN SOIL PHYSICAL PROPERTIES BEFORE AND AFTER VEGETATION BURNING ALONG THE SLOPE

n = 18 samples.

Parameters	**Upper slope**		CV	**Middle slope**		CV	**valley bottom**		CV
	Before	After	%	Before	After	%	Before	After	%
				0-0.15 m depth					
CS (gkg-^{1})	408.57	277.50	27.02	147.60	365.80	60.10	274.4	288.40	3.52
FS (gkg-^{1})	417.00	522.30	15.85	657.00	455.30	25.64	503.6	518.00	.1.99
VFS (gkg-^{1})	10.40	8.50	14.22	11.40	8.20	23.09	11.00	11..20	1.27
Silt (gkg-^{1})	37.00	51.30	22.90	50.30	43.60	10.09	70.3	30.30	56.23
Clay (gkg-^{1})	127.00	140.30	7.04	133.60	127.00	3.56	140.3	153.60	6.39
OM (gkg-^{1})	31.10	6.16	5.49	23.80	25.30	15.60	30.3	23.70	44.8
Texture	LS	LS	LS	LS	LS	LS	LS	LS	LS
BD (mgm^{3})	1.55	1.35	9.75	1.65	1.49	3.58	1.71	1.53	1.82
P (m^{3}m^{3})	0.42	0.42	0.00	0.41	0.44	7.20	278.60	0.43	3.37
Ks (cmhr–^{3})	22.10	16.40	20.94	13.40	17.90	4.99	514.30	20.10	3.6
MC (m^{3}m^{3})	0.54	0.60	7.44	0.63	0.70	20.33	16.20	0.60	2.32
AWC (m^{3}m^{3})	0.58	0.83	25.07	0.70	0.83	7.44	0.71	0.67	4.01
				0.15-0.30m depth					
CS (gkg-^{1})	222.3	283.3	17.06	520.3	283.3	12.01	278.6	280.3	0.43
FS (gkg-^{1})	591	504	11.24	290	625	41.71	514.3	523.6	1.27
VFS (gkg-^{1})	16	9.5	36.05	12.3	9.5	18.16	16..20	10.7	28.91
Silt (gkg-^{1})	23.6	43.6	42.09	17	4.36	62.08	57.00	24.6	56.15
Clay (gkg-^{1})	147	133.6	6.75	160.3	133.6	12.85	147.00	160.3	6.12
OM (gkg-^{1})	20.4	22.1	48.3	20.3	27.1	41.0	19.30	32.70	48.70
Texture	LS	LS		LS	LS		LS	LS	

* Mean of 3 replicates

CS = Coarse sand, FS = fine sand, VFS = very fine sand, BD = bulk density, P = porosity, Ks = saturated hydraulic conductivity, MC = moisture content, AWC = available moisture content, US upper slope, MS = middle slope, BV= Bottom valley (slope), CV = coefficient of variation, OM = Organic matter

3.6 Stability of Soil Aggregates to Water

As shown in Table 2, within each row in each landscape position indicates values significantly different ($p < 0.05$). In the upper slope the trend of aggregate size of 4 mm > 1.0 mm > 0.5 mm > 0.25 mm > 2.0 mm (26.30 g/g > 0.60 g/g > 0.54 g/g > 0.53 g/g 0.23 g/g before burning and after burning 4 mm > 0.25 mm > 0.5 mm > 1.0 mm > 2 mm (15.77 g/g > 0.99 g/g > 0.76 g/g > 0.40 g/g). In the middle slope, the trend of aggregate size of 4 mm > 1 > 0.25 > 0.5 > 2 mm (3.67 g/g > 1.37 g/g > 0.97 g/g > 0.76 g/g > 0.70 g/g) before burning and after burning (4 mm > 0.5 mm > 0.25 > 2 > 1 mm (3.67 g/g > 1.37 g/g > 1.33 g/g > 0.95 g/g > 0.68 g/g). And in the valley bottom , the trend of aggregate size of 4 mm > 1 mm > 0.25 mm > 0.5 mm > 2 mm. (16.76 g/g> 0.99 g/g > 0.88 g/g >0.69 g/g > 0.33 g/g before burning and 4 mm > 0.25 mm > 0.5 mm > 1 mm >2 mm (14. 05 g/g > 1.32 g/g > 0.67 g/g > 0.63 g/g > 0.35 g/g after burning. On the average more of 4 mm size aggregates were retrained in the three landscape positions regardless of the fire treatment. This suggests that if high fire intensity is induced, there may be significant change in the dominant 4 mm aggregate size observed in the experiment. Aggregates that are larger than 0.25 mm are responsible for stable soil structure. The percentage of aggregates > 0.05 mm has been used to characterize the state of aggregate of the soil. Therefore, in the upper slope more stable aggregates were observed before setting fire in the field and this confirmed the earlier work of Ussirri and Lal 2009. Generally, before application of fire in the field, stable aggregates were more in the upper slope, followed by bottom slope and the lest stable aggregates were noticed in the middle slope. The same holds after burning or setting fire in the plots. Averagely, there was significant reduction in stable aggregate to water after fire inducement in all the geosurface positions. The concentration of soil water-stable aggregates and mean weight diameter (MWD) of aggregates were significantly higher in the unburnt plots than the burnt plots. Reduced soil aggregation (< 4 mm) under burnt condition could be attributed to heating temperature and destruction of cementing agents during burning, which increase susceptibility to aggregate disruption [25]

TABLE 2

SUMMARY OF WATER STABLE AGGREGATES (WSA), BEFORE AND AFTER VEGETATION BURNING

Sieve (mm)	**Plot 1**		LSD 0.05	**Plot 2**		LSD 0.05	**Plot 1**		LSD 0.05
	Upper slope			Middle slope			Valley bottom		
	Before	After		Before	After		Before	After	
4.0	26.30	15.77	5.27*	9.57	3.67	2.95*	16.70	14.05	1.55
2.0	0.23	0.40	0.08*	0.70	0.95	0.13*	0.33	0.35	0.11
1.0	0.60	0.56	0.02*	1.42	0.68	0.37*	0.99	0.63	0.18*
0.5	0.54	0.76	0.11*	0.76	1.37	0.31*	0.69	0.67	0.10
0.25	0.53	0.99	0.23*	0.97	1.33	0.18	0.88	1.32	0.22*
$\bar{x}$	5.64	3.69		2.68	1.91		3.91	3.40	

Within each row in each landscape position, (*) indicates mean values are significantly different ($\alpha < 0.05$)
US = upper slope, MS = middle slope, BV = valley bottom.

Table 3 summarizes the value of cumulative infiltration rates (cm) at 1 minute and 3 hours, sorptivity (cm min$^{-1/2}$) and absorptivity (cm min$^{-1/2}$). The cumulative infiltration at 1 minute in the upper slope before burning was 2.4 cm and 1.7 cm after burning. In the middle slope, cumulative infiltration at 1 minute before burning was 3.4 cm and 3.3 cm after burning while cumulative infiltration at the bottom slope before burning was 4.5 cm and 5.0 cm after burning. It was also observed here that there was a decline in soil infiltrability after burning. The decrease in infiltration rates was in response to the reduction in saturated hydraulic conductivity and high moisture content in post-burn soil. It was however expected that initial infiltration will be affected by initial moisture content of the soil at the time of measurement [15]

3.7 Cumulative Infiltration

Cumulative infiltration at 3 hours (cm) at 3 hours, the cumulative infiltration in the upper slope before burning was 185.cm and 261.9 cm after burning. In the middle slope, cumulative infiltration at 3 hours was 245.7 cm before burning and 265.0 cm after burning. While the cumulative infiltration in the bottom slope at 3 hours before burning was 262.8 cm and 316.8 cm after burning. Generally, there was an increase in the cumulative infiltration at 3 hours in the three landscapes positions after burning. The increase is as a result of introduction of heat into the soil, which breakdown cementing agents like organic matter thereby creating more capillary pores and cracking for water to infiltrate.

3.8 Sorptivity

As shown in Table 3, there was an increased in sorptivity, in the three landscape positions following burning. The increase was also due to the addition of heat into the soil. Generally, the amount of water sorbed in the upper slope before burning was 3.63 cm min$^{-1/2}$ and 20.3 cm min$^{-1/2}$ after burning. In the middle slope the amount of water sorbed before burning were 0.85 cmmin$^{-1/2}$ and 2.00 cmmin$^{-1/2}$ after burning while in the bottom slope, the quantity of water sorbed before burning was 13.0 cmmin$^{-1/2}$ and 14.2 cmmin$^{-1/2}$ after burning.

3.9 Absorptivity:

The amount of water absorbed in the upper slope before burning was 0.89 cmmin$^{-1/2}$ and 0.69 cmmin$^{-1/2}$ after burning. In the middle slope, the amount of water absorbed by the soil before burning was 1.39 cm min$^{-1/2}$ and increased to

1.54 cm $min^{-1/2}$ after burning. Whereas at valley bottom location, it increased from 1.94 to 2.29 cm $min^{-1/2}$ after burning. It is observed here that vegetation burning increased the amount of water retained in the middle slope and valley bottom while decreases in the upper slope. This result is attributed to increase in soil depth from upper to valley bottoms and heat effect that shows more at shallower depths of upper slope more than middle and valley bottom.

TABLE 3
INFILTRATION CHARACTERISTICS OF THE UN-BURN AND BURNT PLOTS DOWN THE SLOPE.

Parameters	**Upper slope**		**Middle slope**		**Valley bottom**	
	Before	After	Before	After	Before	After
Cum. infiltration at 1 min (cm)	2.4	1.7	3.4	3.3	4.5	5.0
Cum. infiltration at 3hrs (cm)	185.10	261.90	245.70	265.00	262.80	316.80
(Sorptivity cm $min^{-½}$)	3.63	20.30	0.85	2.00	13.00	14.20
Absorptivity (cm $min^{-1/2}$)	0.89	0.69	1.39	1.54	1.94	2.29

3.10 Effects of Burning on Soil Properties

Paired differences analysis of the soil physical conditions showed no significant changes in most of the properties examined. On the contrary, 0.25 mm aggregate size was significantly higher in post burn system than pre burn condition. Average increase of 0.42g/kg aggregate noticed may be attributed to addition of ash resulting from burning. Therefore, it is pertinent to say that micro aggregate stability (MAS) of the soil increased after burning. Dominance of MAS in soil could imply high susceptibility to erosion by water In paired samples correlation analysis, the relationship between the baseline and weight of soil parameters after burning were not statistically significant, except silt contents. Silt increase mat reflect ash inputs. Silt content or fraction measurement was 0.999 ($p< 0.05$) almost a perfect correlation, unlike the other measured or determined parameters that changes in weight. Overall, there were changes in soil parameters in their weight after burning. For instance, clay fraction, moisture content, and aggregate stability to water, but several others did not change (porosity and texture), while varied increase in weight was noticed in primary particles distributions, saturated hydraulic conductivity and available water content. Across the sampling units, coarse sand increased to 33.73 g/kg soil on the average after burning plots. 2 mm aggregates 0.147 g/g, 0.5 mm aggregates 0.270 g/g, whereas fine sand dropped to 27.33 g/kg, VFS- 1.633 g/kg, silt-10.80 g/kg, bulk density 0.133 mg/ m^3.

4.0 CONCLUSION

Results of this study support these conclusions: Vegetation burning has immediate and direct effects on physical and hydrological conditions of the soils. There were slight changes in the particle size distribution of post burn soils. No significant changes were observed in bulk density, volumetric moisture content, saturated hydraulic conductivity and porosity. However, significant reduction in the values of structural stability was recorded. This deterioration in structural stability in the surface soil associated with the rapid decomposition of organic matter coupled with heavy rainfall will lead to the formation of surface cap and may reduce porosity. The reduced infiltration capacity and poor stability can lead to erosion. It is pertinent to say that, tropical soils generally have an extremely delicate nature and lack resilience once degraded by slash-and-burn method of land clearing. This point to the need for conservation method of land clearing for sustainable crop production.

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