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Assessment of the Effect of Burning on Soil Properties in the Guinea Savannah Zone of Ghana

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Abstract — **Bush burning has been adopted by most farmers in northern Ghana for clearing land for cultivation annually, because of its ease and convenience. This exposes the surface soil layer to destruction. In this study, the effects of burning on some selected soil physical and chemical properties in the Guinea Savannah Zone of Ghana were studied. Three samples each from six randomly selected sites were taken from 0–10cm layer on burnt and un-burnt sites. These were used to determine the moisture content (MC), bulk density (BD), pH, electrical conductivity (EC) and soil texture. The double ring infiltration rates (IR) were also measured on sites. The T-test was used to determine differences existing between the burnt and un-burnt soil properties. The results of the analysis showed that the bulk density, EC, soil texture and infiltration rates are not significantly different (p<0.05) on both the burnt and un-burnt sites. However, the moisture content and pH were significantly different (p<0.05). The soil moisture content, pH and EC under burnt sites were 8.7%, 6.7 and 80.4 uS while they were 14.1 %, 6.0 and 59.9 uS under un-burnt sites respectively. Higher infiltration rates were measured on burnt soils as compared to un-burnt soils. Therefore burning has some effects on soil physical and chemical properties.**

Keywords — **Bush Burning, Electrical Conductivity, Ghana, Guinea Savannah, Soil Properties.**

I. Introduction

Burning of grass cover is a major cultural practice in the farming system in Sub-Saharan Africa especially in northern Ghana. As land is being cleared and prepared for cultivation annually, burning has become the easiest and most convenient method most often employed [1]. This practice invariably results in heating and drying of the top soil [2] and exposes the surface soil layer to destruction [3], [4], [5]. In many farming areas in northern Ghana, this practice has changed to that of total burning of crop residue and this becomes a major cause of depletion of soil nutrient status and low fertility. The reasons for the annual burning of lands in northern Ghana include: for cropping, hunting, migration and land settlement [6], removing unpalatable grasses from previous growing season, stimulating the re-growth of fresh herbage [3], [7] and getting rid of parasitic insects [8].

The environmental suitability of bush burning has been called into question by many authors [9], [10]. All fires, regardless of whether they are natural or human-caused, alter the cycling of soil nutrients and the biotic, physical, moisture, and temperature characteristics of the soil [8]. According to a study cited by [1], relatively loss of soil nutrients and an alteration of soil physical and chemical conditions occur after burning the soil. The numbers and distribution of micro organisms present in the soils are also often influenced resulting in a decline in soil fertility [11]. Therefore, the main objective of this work was to study the effect of bush burning on selected soil properties in the Guinea Savannah zone of Ghana.

II. Materials and Methods

A. The study area

This study was conducted in six (6) communities (Bayunsa, Chansa, Zamisa, Zaring, Gaadema and Kpikpaluk) at Kadema in the Builsa District of the Upper East Region of Ghana (Figure 1). The rainfall distribution pattern is irregular and varies from year to year with a long-term mean annual rainfall of 990 mm. The average temperature is about 29°C. Relative humidity is highest (65%) during the rainy season and drops to a value of less than 10% during the harmattan period [12]. It is in the Guinea savannah agro-ecological zone, characterised by few and scattered trees such as the baobab, locust bean, acacias and sheanut [13]. Soils in the catchment consist of lithic leptosols, fluvisols, gleyic lixisols and haplic arenosols [12], [14].

B. Reconnaissance survey

A reconnaissance survey was carried out to select appropriate sites for the study. Information collected during the survey included land sizes, cropping type and history, and method and history of land clearance.

C. Soil sampling and analysis

Following the reconnaissance survey, some plots of land were selected at different locations within the study area. Twelve (12) locations were selected based on history and method of land clearance. Three (3) disturbed and undisturbed soil samples were collected from 0 – 10 cm on burnt and un-burnt plots of land in each of the six communities (Bayunsa, Chansa, Zamisa, Zaring, Gaadema and Kpikpaluk). In all, thirty-six (36) disturbed and undisturbed samples were collected.

All disturbed soil samples were air dried for a number of days, gently crushed and sieved with 2 mm, 0.5 mm and 0.2 mm mesh. These were analyzed for particle size distribution, pH and electrical conductivity (EC). The undisturbed soil samples were dried at 105 °C for 24 hours in an oven and analyzed for moisture content and bulk density. Bulk density was determined by the core method [15] using a 5.0 cm long by 5.0 cm diameter cylindrical metal core. The pH was determined by suspending the soil in distilled water, using a 1:3 soil to water ratio on two-way calibration with buffer solution at pH 4.00 and 7.00. The pH was taken using a multi-parameter analyzer and a combined glass electrode [16]. The temperature was calibrated before the pH was taken. Electrical conductivity of the saturated paste extract of 1:3 soil to water ratio was also determined using a multi-parameter analyzer at 25°C [17].

D. Data analysis

Results from the laboratory analyses and field measurements were subjected to statistical analyses using Statistical Package for Social Science (SPSS) v16.0 whereby the mean, standard error and coefficient of variation of each soil property under burnt sites (BS) and un-burnt sites (UBS) were determined. The T-test was used to infer whether there were significant differences in the soil properties between the BS and UBS.

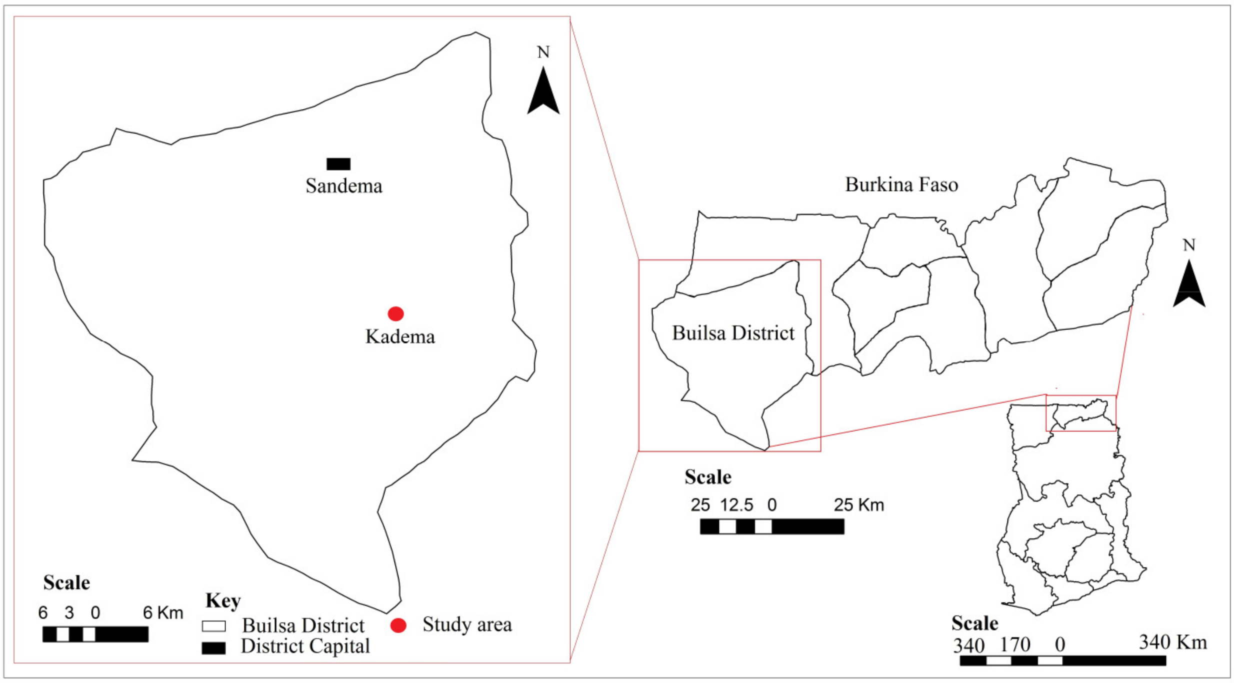

Fig.1. Location map of the study area

III. Results and Discussions

Table 1 shows the mean, standard error (SE) and coefficient of variation (CV) for selected soil physical and chemical properties. The statistical analysis for mean difference comparison of soil properties of burnt sites (BS) and un-burnt sites (UBS) is also shown in Table 1.

The results of the analysis showed that the mean moisture content was significantly higher ($p<0.05$) in the un-burnt sites than in the burnt sites. Moisture content is a spatially highly varied parameter. Its coefficient of variation in BS and UBS were 54.7% and 33.7%, respectively. The lower moisture content in the BS as compared with the UBS may be due to increased population density of soil living organisms and reduction in soil organic matter [18] which improves the aeration of the soil. Also, the dead leaves from plants and trees on the un-burnt plots could serve as mulch and therefore increase the soil moisture content through minimizing soil surface evaporation [19].

The bulk density values in the BS were generally lower than that of the UBS. The mean bulk densities of soils were 1.6 g cm^{-3}and 1.7 g cm^{-3} respectively for the BS and UBS. The CV in BS and UBS were 6.6% and 5.2%, respectively. Similar results have been reported by [20], [21] [22]. However, there was no significant difference in the average bulk density values at 5% confidence level.

The mean soil pH was higher in the BS than that of the UBS. The mean soil pH values in the BS and UBS were 6.7 and 6.1, respectively. The CVs were 8.3% and 5.5% respectively for the BS and UBS. Therefore, it can be inferred from the results that the soils in BS had a slight increase in soil pH compared with that of UBS that have not been subjected to burning. This may be as a result of the ash that is generated during the burning of plant biomass which raised the pH of the soil [8], [23], [24], [25]. Similar results were observed by [8], [23], [24], [26], [27], [28] and [29]. Also, there was significant difference in the mean values of soil pH of both sites under consideration at 5% confidence level.

The mean soil EC was lower in the UBS than in the BS. The mean EC values were 84 µS and 59.9 µS for BS and UBS respectively. The CV for the BS and UBS were 69.2% and 48.6%, respectively. The higher values of EC of the BS compared with the UBS may be due to the resulting ash material from burning that is known to be a rich source of exchangeable cations [30]. Similar results were reported by [8]. However, there was no significant difference in the mean values of EC of both burnt and un-burnt plots ($p<0.05$).

The mean double ring infiltration rates were generally higher in the BS as compared with the UBS. The mean IR values were 130 mm h^{-1} and 95 mm h^{-1} respectively for the BS and UBS. The CV in the BS and UBS were 117.7% and 129.6%, respectively. The higher infiltration rate values observed on the BS as compared with the UBS could be due to a decrease in organic matter and an increase in soil macro fauna density resulting in improved [9], [31]). Similar results were observed by [24]. There was no significant difference in the mean values of infiltration rates of the two sites at 5% confidence level.

The results of the analysis also showed that the sand and silt fractions of soils in both BS and UBS were similar (Table 1). The mean values for the sand and clay fractions were slightly higher in the BS compared with the UBS. However, the silt fraction in the BS was slightly lower compared with the UBS. The similarity in the values may probably be due to the formation of the soil from the same parent [23]. The mean differences in the sand and silt fractions of the soil were not significantly different ($p<0.05$) in both the BS and UBS as reported [24]. However, the clay content of the soil in both BS and UBS was significantly different at 5% confidence level. Similar results were observed by [8].

Table 1: Statistics for selected soil properties on BS and UBS in Kadema

Soil Parameters	Mean		SE		CV (%)		Student's T-test	
	BS	UBS	BS	UBS	BS	UBS	t-statistic	M_d
Moisture Content (%)	8.7	14.1	1.1	1.1	54.7	33.7	-3.38	*
Bulk Density (cm^{-3})	1.6	1.7	0.0	0.0	6.6	5.2	0.17	NS
pH	6.7	6.1	0.1	0.1	8.3	5.5	4.37	*
EC(µS)	84.0	59.9	13.7	6.9	69.2	48.6	1.58	NS
IR(mm h^{-1})	130.0	95.3	44.2	35.7	117.7	129.6	0.60	NS
Sand (%)	48.4	42.8	5.0	3.3	43.9	32.7	0.94	NS
Silt (%)	19.2	23.1	2.9	1.6	63.9	28.9	-1.20	NS
Clay (%)	32.4	23.1	4.2	1.6	54.5	28.9	2.10	*

*EC: Electrical Conductivity, IR: Infiltration Rate, BS: Burnt Sites, UBS: Un-burnt Sites, SE: Standard Error, CV: Coefficient of Variation, NS: Not Significant, *: Significant under 5% Confidence Level, M_d: Mean Difference*

. IV. Conclusions

The study investigated the effects of bush burning on selected soil physical and chemical properties in the Guinea Savannah zone of Ghana. Most of the soil properties were affected by bush burning. It can be concluded from the study that bush burning significantly affected moisture content and soil pH ($p<0.05$). That is, burning increases the soil pH and reduces soil moisture content. However, although burning affected the bulk density, electrical conductivity and infiltration rates, these differences were observed not to be statistically significant ($p<0.05$).

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