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IMPACTS OF LAND USE ON INFILTRATION

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ABSTRACT

Land use can affect natural ecological processes such as infiltration. There are many land uses applied at Ikeduru L.G.A. in Imo State, Nigeria, thus, the area is selected as a case study. The objective of study is to determine the effects of land use on infiltration by three different land use types; 34 of them are in farmlands, 34 in Bamboo field and 32 in forestlands. Within each land use type, multiple regression are used to determine degree of association between the rates of infiltration, moisture content, porosity, bulk density and particle sizes. Non-parametric Kruskal-Wallis analysis of variance is used to determine whether significant differences in infiltration rates existed between different land uses. The mean steady state infiltration rate of farmlands, bamboo fields and forestland are 1.98 cm/h, 2.44cm/h and 2.43cm/h respectively. The regression model shows that infiltration rate decreases with increase in moisture content and bulk density but increases with the increase of soil particle sizes and porosity. The most important multiple regression variables is % porosity. The differences in infiltration rates between different land uses are not significant at the 95% confidence level.

KEYWORDS: Land use, infiltration, regression, effect.

1.0 INTRODUCTION

Water can be the limiting resource for plant growth and consequently reproduction, and infiltration into the soil is unquestionably a key process that replenishes the root-zone soil moisture. However, human-induced disturbance equally has significant effect on soil infiltration through its impact on soil and vegetation. Burning reduced infiltration rates in soils of Missouri Ozark forests (Arend, 194l). Justin (1997) detected no significant difference between cut and burnt juniper sites. But few studies are available dealing with soil infiltration changes associated with land use. Thus, the target of this research was to study the effect of land use on infiltration.

2.0 MATERIALS AND METHOD

2.1 Study Area

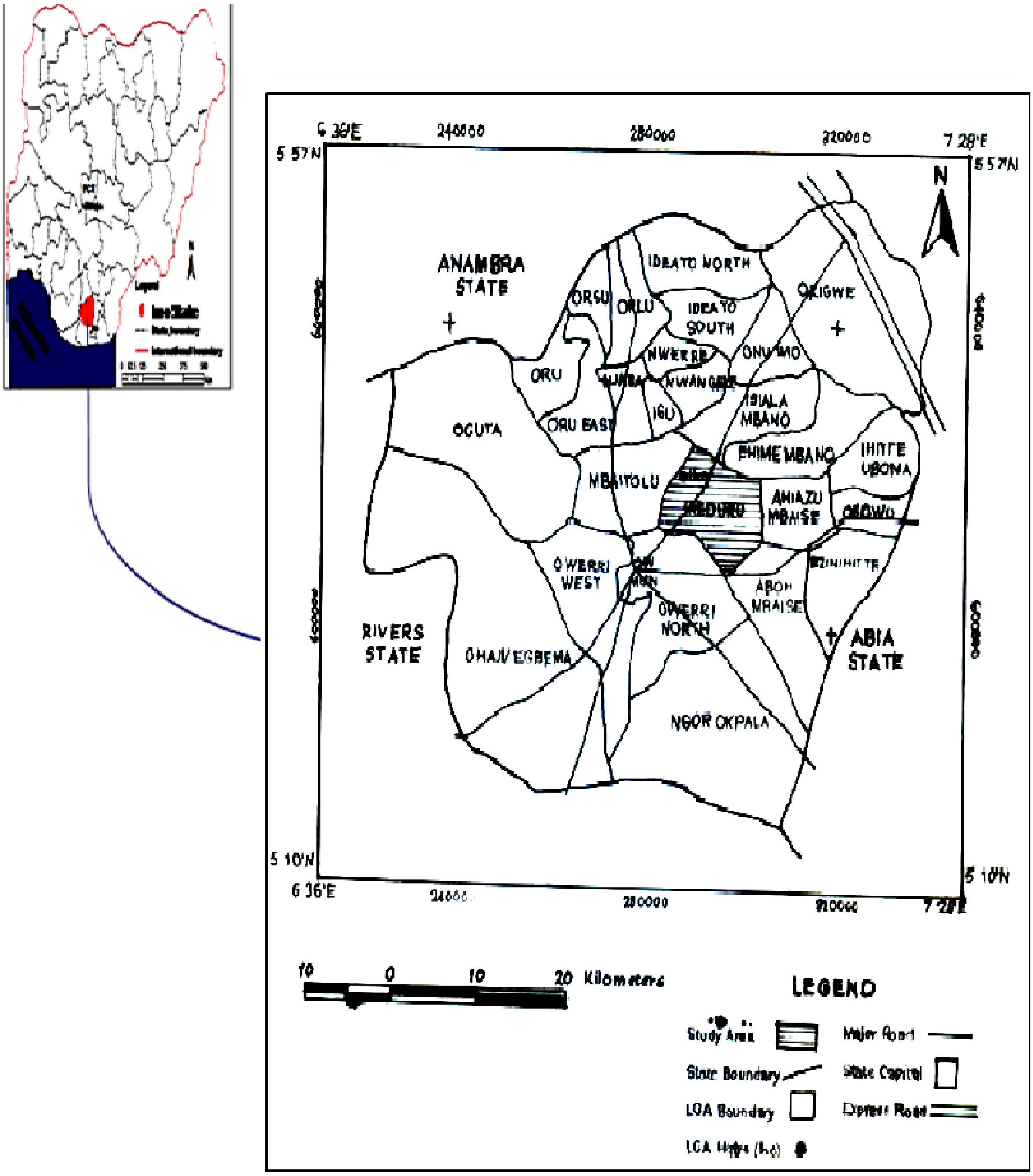


Figure 1: Locations of Ikeduru L.G.A. of Imo state, Nigeria.

Ikeduru (Lat 5 ^{0}27 ^{0} N) and Long 7 ^{0} 07 ^{0}E) is one of the twenty seven Local Government Areas (L.G.A.) of Imo State in Nigeria. The LGA is made of 17 communities namely: Avuvu, Atta, Eziama, Amakohia, Ngugo, Ikembara, Akabo, Abazu, uzoagba, Amaimo, Inyishi, Iho,Okwu, Umudim, Ugiri, and Eziama. The average daily temperature is 27^{0}C and average annual rainfall is 1750-2000mm while relative humidity lies between 71.6 -6.6%. The soil type according to the USDA soil classification scheme is ultisol derived from the coastal plain sands (Uzoho et al., 2007 in Chukwuocha et al. 2014). Rainfall distribution is uneven because topography (relief is about 240m), and mainly concentrates in the raining season.

2.2 Measurement of Infiltration

In each type of land use, three 60 × 60 m plots were subdivided into 2 × 2 m subplots. For each large plot, four subplots were selected at random to perform infiltration measurements, giving a total of 108 infiltration sites, 36 for each land use. Each infiltration measurement required an undisturbed site 20 cm in diameter. Soil moisture content on the profile within 20cm was determined by the gravimetric method (Gardner 1965). After that, infiltration rate was determined. The percentage ground covered by farmland, bamboo field and forestland were determined by ocular estimates on each runoff plot from a gridded sampling quadrant.

2.3 Soil Sampling and Analysis

Soil samples were collected from top soils (0-20 cm) using steel cylinders at 108 different sampling points from three land use types: farmlands, bamboo fields and forestlands, with percentage ground cover of 18.70%, 8.08% and 73.22% of the total areas respectively. In farmlands, cassava has been grown without soil conservation measures. Soil samples were taken from three different land use types, three elevations (150-350 m, 350-550 m and > 550 m) and two aspects (major aspects of the study area were east and west). There were 36 sampling points in farmlands, 36 in bamboo field and 36 in forests; 52 of them on east, 52 of them on west aspects.

2.4 Laboratory Measurements

Following the infiltration measurements, the contact sand was removed and 5 cm diameter, 30 cm deep soil cores were taken from within the 20 cm diameter infiltration ring. The cores were separated into two components by depth: 0–10 cm and 10–20cm. Soil bulk density was determined on the 0–10 cm cores by the core method (Black, 1965). Sand, silt, and clay fractions of the sampled soils were determined gravimetrically by the pipette method (Gee and Or, 2002).

2.4 Data Analysis

Data normality was determined by tests for skewness and kurtosis (Snedecor and Cochran, 1971). Values for infiltration were highly skewed. Infiltration rates were log transformed prior to this analysis. Between different land use sites, non-parametric Kruskal-Wallis analysis of variance (Gibbons, 1985; Hollander and Wolfe, 1999) was used to determine whether significant differences in infiltration rates existed between different land uses. Within each land use type, multiple regression were used to determine degree of association and to identify the most important factors determining infiltration rates (Draper and Smith, 1981).

3.0 RESULTS AND DISCUSSION

Figures 2 and 3 present the means and standard deviations of all the variables under study. The mean value of moisture content is least in the farmlands and highest in the forestlands. The canopy of vegetation found in the forestlands tends to reduce evaporation due to direct sun heat hence, more soil moisture unlike where the absence of dense vegetation facilitated rapid evaporation in the farmlands. Loose soil due to tillage guaranteed more pores, hence mean values of percentage porosity and infiltration rate recorded highest values in farmlands than any other land use type. Frequent tramping of the soil due to absence of vegetative undergrowths (shrubs) ensured high mean value of soil bulk density in bamboo field unlike the farmlands where the soil profile is not compacted. Also roots of bamboo plants offered bonding of soil particles thus increasing the bulk density. The variation of standard deviation of soil particle sizes in the different land uses is due to the varying properties of the parent geologic formations. Mean infiltration rate was greater in the bamboo field with value of 2.44cm/h (0.534cm/h); standard deviation is shown in brackets; than in forestland [2.43cm/h (2.34cm/h)]. The farmland had lower mean infiltration rate of 1.98 cm/h (0.247cm/h).

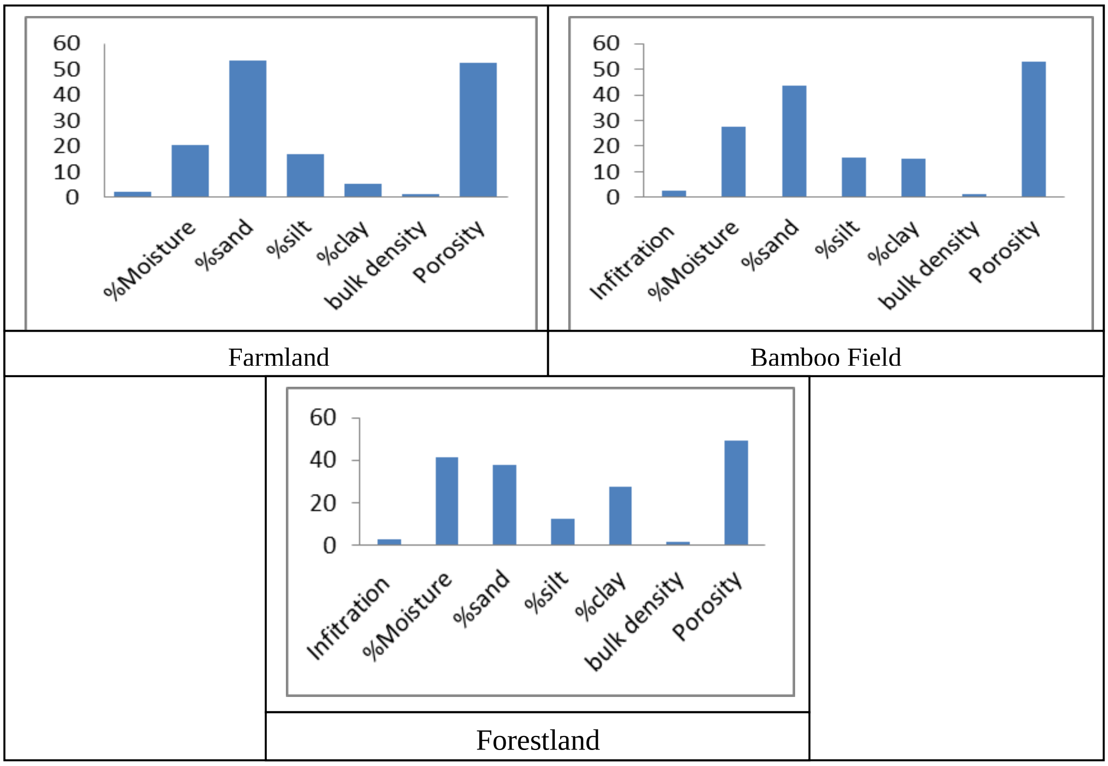


Figure 2: Mean values of variables of different Land Uses.

Table 2 shows very low coefficient of determination (5.9% in farmlands, 2.9% in bamboo fields and 3.4% in forestlands. None of the regression models is significant (at 95% confidence level) in representing the association between soil properties and rate of infiltration.

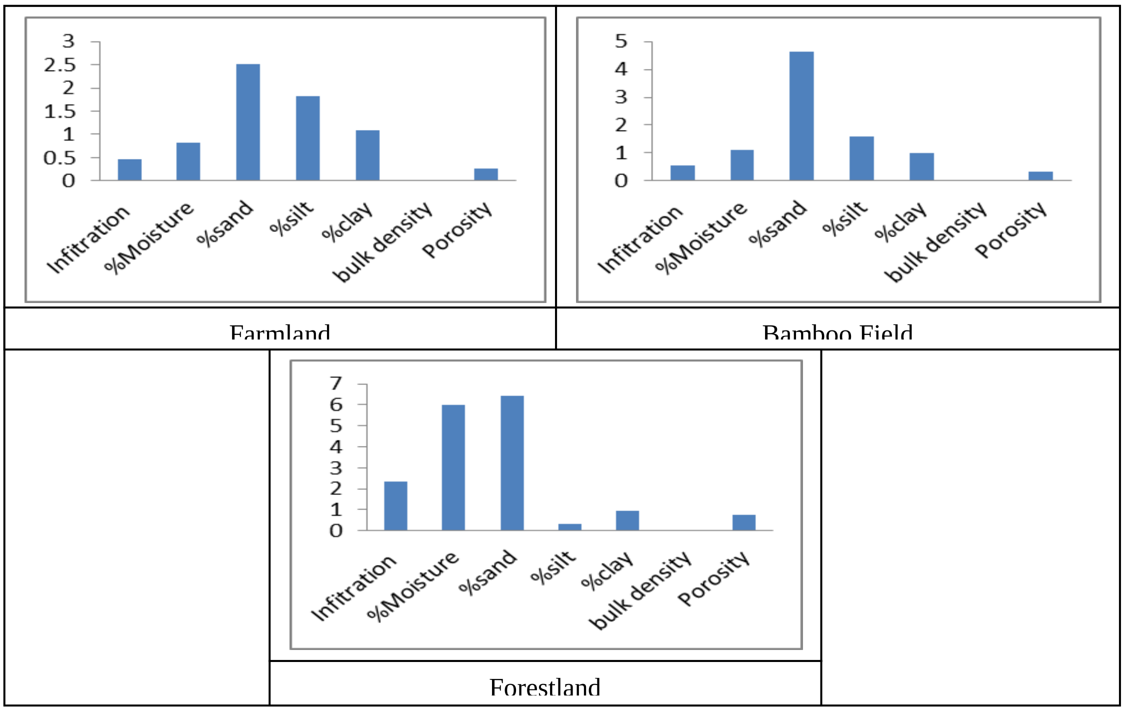
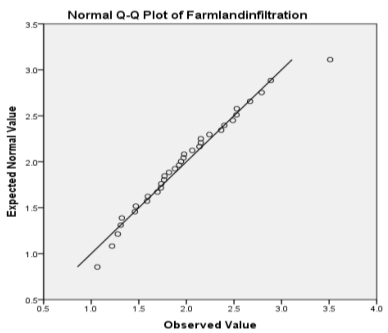


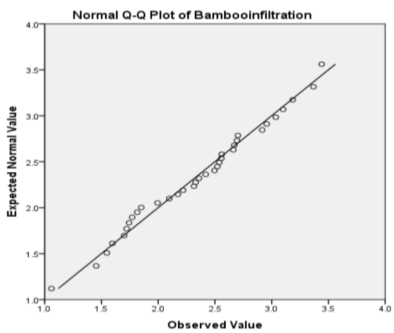
Figure 3: Standard deviation of variables of Different Land uses.

Figure 4 shows the normality plot of infiltration data obtained from three land use sites. Most of the points follow approximately along the diagonal lines which show that the data is normally distributed. The p-value of Levene statistic was 0.00 meaning that the data lacked equal variances, thus failing one of the assumptions of parametric one-way ANOVA. Thus, the non-parametric Krustal-Wallis ANOVA was used to investigate the effect of land use on infiltration.

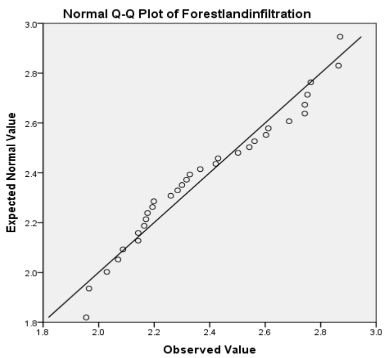
Table 3 shows the result of the ANOVA. It can be concluded that the differences in infiltration rates between different land uses were not significant at the 95% confidence level as assessed by non-parametric Kruskal-Wallis analysis of variance.



Farmland



Bamboo Field



Forestland

Figure 4: Normality Plot of Infiltration Rates for Each Land Use Site.

Table 1: Location and description of Land use Types.

Sample Locations	**Atta**	**Amamba Inyishi**	**Iho**
Land use Type	Farmland	Bamboo Field	Forestland
Description	cassava plants in strips with average heights of 1m and presence of weeds	Tall bamboo trees in clusters. Absence of weeds. Presences of structuraldevelopment	densely vegetated, has been left fallow for over 15years)

Table 2: Infiltration/Soil Properties Model for different Land uses.

Land use Type	Regression Model	R %	Error Estimate	P-value
Farmland	In = 20.9-0.04Mc+0.022%s-0.007%si-0.0025%cl-1.71bd-0.325p	5.9	0.5	0.45
Bamboo Field	In = 10.7-0.02MC-0.016%s+0.025%si-0.0506%cl-0.82bd-0.12P	2.9	0.6	0.84
Forestland	In = 2.59+0.002MC+0.00007%s-0.003%si-0.0542%cl-0.03bd+0.0267p	3.4	0.3	0.77

In = infiltration (cm/h), Mc= moisture content, %s=% sand, %si= % silt, %cl= % clay, bd= bulk density (kg/m^3) and %p = % porosity

Table 3: Kruskal-Wallis Test on Effect of Land Use on Infiltration Rates.

Land use	Number of Observations	Median	Average Rank	Z
Farmlands	34	1.930	35.9	-3.61
Bamboo Fields	34	2.390	56.1	1.39
Forestlands	32	2.35	60.0	2.25
Overall	100		50.5	

H= 13.32 DF =2 P-value =0.001

4.0 CONCLUSION

Based on the results in this study, following conclusions can be reached. On bamboo fields, soil infiltration rate was higher as the aeration conditions were better. With the increase of vegetation cover, soil infiltration was lowered in forestlands. Infiltration rates on farmlands were lowered than that on forestlands. Existence of surface vegetation protected the soil from direct splash of raindrop and the resulting organic matter decreased soil infiltration rates. Variables influencing infiltration rates include soil particle size, % porosity, moisture content, bulk density. The most important multiple regression variables was % porosity.

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