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Infiltration characteristics of soils of some selected schools in Aba, Nigeria

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ABSTRACT

The infiltration characteristics of soils of some selected schools in Aba, Abia State Nigeria, were measured using double ring infiltrometer - falling head method. Infiltration rates were studied mainly under fallow lands with exception of one location (Girls Secondary School, Umungasi) studied under farmland use practice. The tests were conducted during the rainy (wet) season. Infiltration rates obtained ranged from 1.2cm/hr – 4.28cm/hr with average water intake of 3.2cm - 10cm for the fallow lands. It was observed that the infiltration rates for the farmland was quite higher than the others. It recorded 12.4m/hr with average water intake of 31.1cm within the same time interval of 150mins. The soils were found to belong to two textural class; sandy loam and clay loam. The initial moisture content was found to be quite high, ranging from 32.6% – 40.01%. This seems to have affected the infiltration rate negatively. Porosity of the soils ranged from 34% to 37%. The pH of the soils ranged from 5.3 – 6.8 indicating that they are acidic. The soils were generally found to be prone to ponding and surface run-off.

Keywords: Infiltration, soil, water intake, Aba, infiltrometer

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INTRODUCTION

Infiltration is the process by which water on the surface penetrates the soil. It refers to the vertical movement of water downwards form the soil surface to replenish the soil water and moisture deficiency, with the excess percolating down to build up the water table by gravitational flow [1]. It is related to overland flow and groundwater, determining the fraction of irrigation or rain water that enters the soil and thus, affecting the amount of runoff responsible for soil erosion [2]. It can be quantified by cumulative infiltration or infiltration capacity.

Infiltration capacity is determined by the matrix potential gradient at the soil surface. Water in excess of infiltration capacity of the soil will flow overland as surface runoff. Where infiltration is high, runoff is low therefore erodibility of the soil is low [3]. The rate at which infiltration occurs is limited by the water transmission characteristics of the soil profile. While swelling in clay soils and impervious soil layer reduces the rate [4], the presence of macro pores, high organic matter, good porosity and thick vegetative cover promotes infiltration. Infiltration measurement is an important parameter required in the design and evaluation of irrigation design and evaluation, in groundwater modeling and in the prediction of surface runoff. [5], [6].

LOCATION

Aba is located within latitude $7^{o}10'$E and longitude $5^{0}27^{o}$N. it is highly populated with and average population density of 3000 people per square kilometer [7]. It is a strategic commercial city in Abia state where a lot of economic activities that supports the local economy go on. Owing to this reason, it attracts a lot of people from both the rural areas of the state and beyond the shores of the state. As a result, the number of schools sited in this area has increased in order to serve the growing population. Unfortunately, most of the schools were built in areas prone to water logging and ponding after prolonged rainfall events. This disturbs the academic activities in these schools. There are two reason attributed to this, its either that the infiltration data of Aba does not exist or it was not considered before building these school; therefore it is the objective of this study to determine the infiltration

characteristics of these soils of these school and investigate into the physical properties of the soils that could have contributed to ponding and surface runoff in this area.

GEOLOGY

The geology of Aba is of the Benin formation, consisting of coarse sands, interrupted by clay lenses of quaternary age. It has good aquiferous potential. Depths to water table are shallow, ranging from 8m – 26m. [8] The thickness of the aquifer is about 1500m. Aba enjoys a lot of rainy days. The rainy season occurs between March and October. Its vegetation is characterized by tropical rain forest.

MATHEMATICAL THEORY - PHILIP'S EQUATION

Philip's theory of infiltration separates the process into two components: that caused by sorptivity factors and that influenced by gravity. Sorptivity is the rate at which water will be drawn into a soil in the absence of gravity; it comprises the combined effects of absorption at surfaces of soil particles and capillarity in soil pores. The gravity factor is due to the impact of pores on the flow of water through soil under the influence of gravity. The Philip`s model is given by the two-parameter equation

$$i = St^{1/2} + At \qquad (1)$$

The rate of infiltration is determined by differentiating Eq. 1:

$$dt/\,di = \tfrac{1}{2}\, st^{-1/2} + A \qquad (2)$$

The constants of *A* and S may be determined by plotting the graph of di/dt against $t^{-1/2}$.

Where

A (gravity factor) = intercept

S (sorptivity factor) = slope.

MATERIALS AND METHODS

A double ring infiltrometer cylinder of sizes 15/30cm was used to measure the infiltration rate of the soils at various sample points within the premises of each of the schools under study. In accordance with [9], [10], [11] method the inner ring was first driven into the ground. Then the outer ring was placed centrically around the inner ring. The two were driven into the ground to a depth of about 10cm. 2cm of sand layer was spread at the bottom of the inner ring to minimize soil surface disturbance when pouring water into the ring compartments. To ensure vertical flow in the inner ring, the outer ring was first filled with water so that the soil profile around the inner ring would be wet. Water intakes of the soils were read off with the help of the rule attached to the bridge.

Water levels of the two rings were maintained at the same level, and repeated readings of the water levels in the inner ring were taken at intervals of 5, 10, 15 and 30mins respectively. Each experiment lasted for 150mins. A ponding level of 5cm was maintained throughout the experiments. Soil samples were taken from each location using core samplers. These were bulked for determination of bulk densities and other physical characteristics of the soil. The pH of the soils were determined using a pH Meter.

RESULTS

Table 1: Average Cumm. Water Intake for the various schools in Aba

cumm. time (mins)	cumm. Intake (Girls' sec. Sch. Umungasi)	cumm. Intake (Eziama primary Sch.1)	cumm. Intake (Eziama Primary Sch. 2)	cumm. Intake (Eziama Primary Sch. 3	cumm. Intake (Abayi primary sch.)	cumm. Intake Rate (Zonal Board Sch.)	Cumm.Intake (Army Barrack's Pri. Sch. Faulks Road)
5	2.1	0.5	1	0.1	0.2	0.4	0.7
10	3.6	1	1.5	0.2	0.4	0.7	1
15	4.6	1.3	2	0.3	0.6	1	1.2
20	5.6	1.5	2.5	0.3	0.8	1.2	1.7
30	7.4	2.2	3.3	0.5	1	1.6	2
45	9.4	3.4	4.2	0.8	1.3	2.3	2.7
60	11.5	4.3	5.9	1	1.6	3	3
75	13.6	5.2	6.3	1.4	2	3.5	3.2
90	15.6	6	7.6	1.7	2.3	4	4
120	24.6	7.7	9.4	2.5	3	5	5.1
150	31.1	9.6	10	3.2	3.7	6.1	6.2

Table 2: Average Infiltration Rates for the various schools in Aba

cumm. Time (mins)	Infilt. Rate (Girls' Sec. Sch. Umungasi)	Infilt. Rate Eziama primary Sch.1)	Infilt. Rate (Eziama Primary Sch. 2)	Infilt. Rate Eziama Primary Sch. 3	Infilt. Rate (Abayi primary sch.)	infilt. rate (Zonal Board Pri. Sch.)	Infilt. Rate (Army Barrack's Pri. Sch.)
5	25.2	6	12	1.2	2.4	8.4	4.8
10	21.6	6	9	0.6	2.4	6	4.6
15	18.6	5.22	7.8	0.4	2.4	4.8	4
20	16.8	4.5	7.5	0.9	2.4	4.2	3.6
30	14.4	4.38	6.6	1	1.98	4.2	3.2
45	14.4	4.35	5.59	1.1	1.73	3.6	3.1
60	13.8	4.32	5.22	1.2	1.6	3	3.1
75	13.8	4.26	5.04	1.2	1.6	2.5	2.8
90	12.6	4.02	5.04	1.2	1.53	2.4	2.7
120	12.6	3.84	4.26	1.2	1.5	2.4	2.5
150	12.4	3.84	4.28	1.2	1.48	2.4	2.4

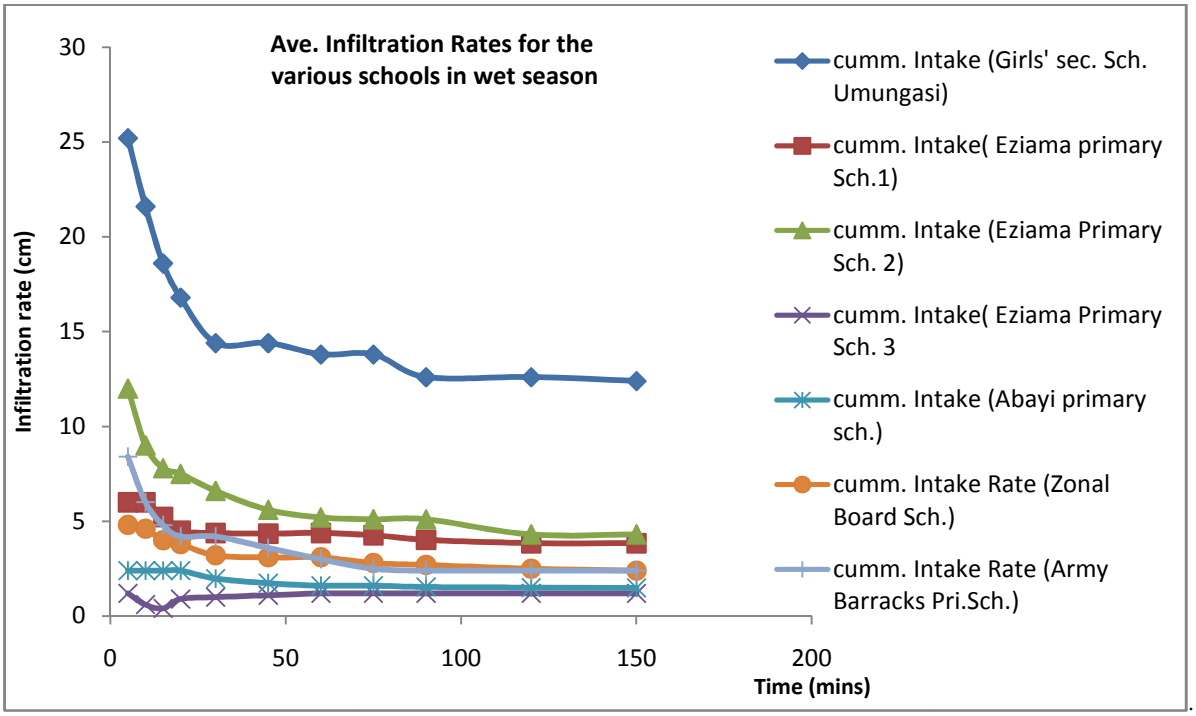

Fig 1: Ave. Infiltration Rates curves for the various schools in wet season

Table 3: Physical properties of the soils of the Schools

S/N	Location	Sand %	Silt %	Clay %	Text.	B. D (g/cm^3)	Org (%)	pH	CW. (%)	MC. (%)	Poro. (%)
1	Army Barracks Pri. Sch	58.0	24	18	Clay loam	1.5	1.69	6.3	5.7	32.6	36
2	Abayi Pri. Sch. Abayi	43.0	19	38	Clay loam	1.5	1.24	6.4	11.6	45.3	34
3	Zonal Board Pri. Sch.	42.0	18	39	Clay loam	1.8	1.50	6.5	18.3	40.0	34
4	Girls Sec. Sch. Umungasi	79.3	7	13.7	Sandy loam	1.6	2.00	5.5	13.4	39.1	37
5	Eziama Pri. Sch. I	78.0	18	4	Sandy loam	1.5	0.14	6.7	13.7	32.8	36
6	Eziama Pri. Sch. 2	82	10	8	Sandy loam	1.5	3.84	6.8	13.1	34.2	37
7	Eziama Pri. Sch. 3	76	18	6	Sandy loam	1.6	1.19	6.8	5.8	36.3	36

BD = Bulk density P.D = Particle Density Text = Texture Org = Organic matter Poro =Porosity MC = Moisture Content

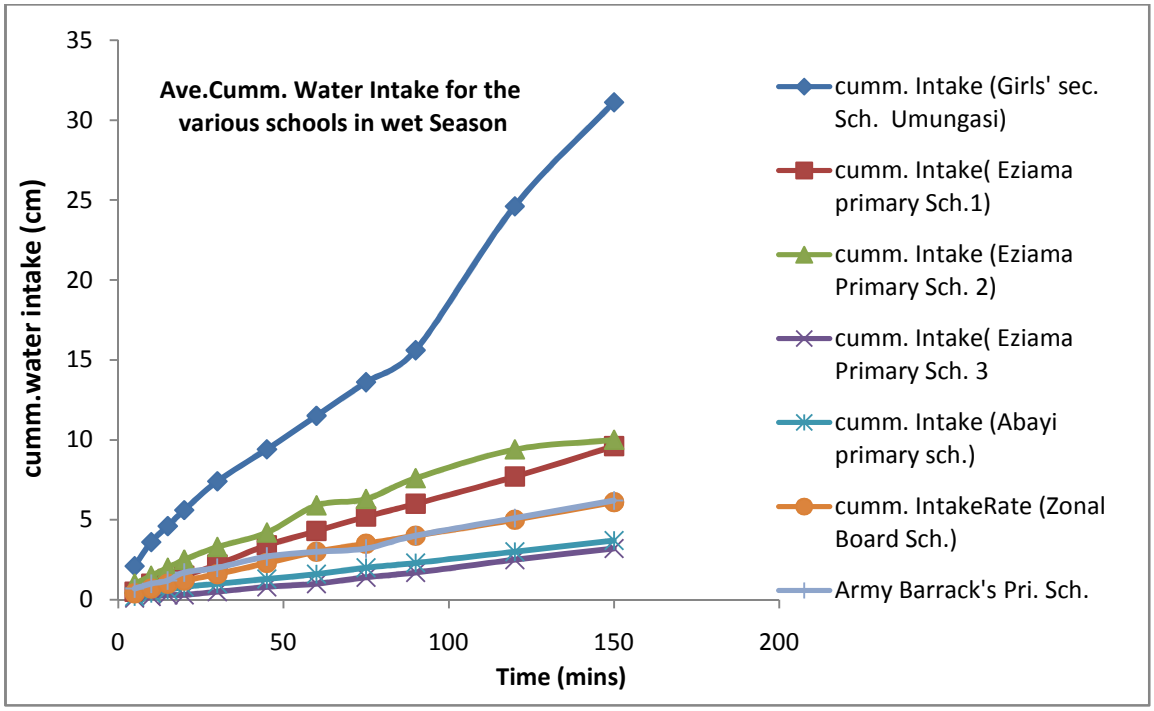

Fig 2: Ave. Cumm. Water Intake curves for the various schools in wet Season

DISCUSSION

Table 1 shows the average cumulative water intake (WI) of the various schools. Fig.1 shows the infiltration rate curves of the same locations. Table 2 shows the average infiltration rate (1R) of the various locations while Fig. 2 gives the WI curves. The average infiltration rate (1R) ranged from 1.2cm/hr – 4.28cm/hr for the fallow lands but appreciated reasonably in the farmland at Girls, 12.4cm/hr. The water intake ranged from 3.2cm-10cm, for the fallow lands but occurred highest also at Girls secondary school, Umungasi with a value of 31.1cm.

The soils of these schools were found to belong to two textural classes; sandy loam and clay loam (table 3). It was observed that the sandy loam soils accumulated greater water intake than the clay soils. While it ranged from 3.7cm-6.2cm for the clay loam soils, the average cumulative Intake for the sandy loam ranged from 3.2cm to 31.1cm, for the same time interval of 150mins. The infiltration rate seemed to follow the same trend. Higher values were obtained from the sandy loam soils then the clay loam soils. The highest value for the fallow lands was 4.28cm/hr while for sandy loam, (though it peaked at 12.4cm/hr for the farmland), while that of clay loam soils was 2.4cm/hr, This result shows the effect of soil texture on 1R, and is also in agreement with the result obtained by [12]. The higher clay content of the clay loam affected the 1R, causing it to be lower. [13] reported that the swellings and dispersion of clay particles cause the sealing of soil pores, which leads to low infiltration rate. [14] in his soil grouping of Federal University of Technology Minna, Nigeria obtained even lower values ranging between 0.17 cm/hr – 1.78cm/hr for clay loam soils.

Another possible reason is that sandy loam soils are coarse textured while clay loam soils have medium to fine texture. [15] noted that the 1R of coarse soil group is much higher than that of the medium to fine soil group. While he obtained values more than 100mm/hr for coarse soils, that of the medium fine soils were less than 50mm/hr.

The effect of initial moisture content on spatial variation on initial infiltration rate was noticed in this study. Initial moisture content was generally high, ranging from 32.6% -45.3% owing to the intense rainfall during the months the tests were conducted. [16] and [17] noted that the higher the initial moisture content, the lower the infiltration rate.

Bulk density was also observed to be high ($1.6g/cm^3 – 1.8g/cm^3$). The high values is closely related to compartment, which may be due to be due to the effect of trending, crusting and raindrop let on the soils. [18] found a strong relationship between high bulk density and 1R and noted that it affects 1R negatively.

The low infiltrating rates obtained must have been responsible for the real site situation in these schools during the periods of the wet season, when ponding and flooding are observed. [19] reported that soils with low infiltration rates are prone to ponding and run-off.

CONCLUSION

The infiltration characteristics of the soils of some schools in Aba, Abia State-Nigeria were determined. The two major soil types identified were sandy loam and clay loam soils. Sandy loam soils were observed to have higher infiltration rates and water intake than the clay soils. Some of the factors affecting the infiltration rates were observed to be the textural class, high initial moisture content due to the intensity of rainfall during the period the tests were conducted. (wet season). It was also observed that the farmland had both the highest infiltration rate and water intake. This implied that the land use practice also influenced the result. The pH was found to be between 5.5 – 6.8. this indicated that the soils were acidic. The result obtained seem to be generally low. Soils with low infiltration rates are liable to ponding and run-off. Run off accelerates erosion process and contributes to the flooding of regional low lands [20]. It is therefore recommended that soil treatment administration should be employed as a strategy for in proving the infiltration rates of these soils.

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