An Assessment of Land Use Resistivity to Surface Erosion from Infiltration Data in Abini Region of Cross River State of Nigeria

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Abstract
Precipitation incidence upon a place above threshold level of soils has the ability of initiating overland flow, surface runoff and erosion especially where there is a high intensity of land cover removal. Infiltration capacity of soils is a major determinant of soil behavioural response to water absorption during storm. This implies that deductions on soils susceptibility to surface erosion could be derived from infiltration records of regional land uses which this study attempted in Abini rural watershed of Cross River State, Nigeria. Thus, infiltration data were generated from experimental runs with the aid of infiltrometer designed by Hillel (1970). Equilibrium or steady state of water infiltrating into the soils of different land uses were established after 3 hours or 180 minutes, indicating the maximum limit soils could absorb water during storm. The threshold values of 3.6cm/hr^{-1} (fallow land), 0.6cm/hr^{-1} (wetland), 9.6cm/hr^{-1} (forest) were discovered. This suggests that, of the three land uses studied, forest has the strongest resistance to surface erosion than others. With infiltration capacity of 0.6cm/hr^{-1}, wetland ecosystem is more prone to ecological risk than other land uses. The study recommends sustainable land management measures such as afforestation and mulching to boast the functioning of land resources within the region.
Keywords: Infiltration capacity, surface erosion, precipitation incidence, sustainable land management, land uses.

Introduction

Infiltration capacity of soils are required in many hydrological investigations such as runoff estimation, soil moisture budgeting, ground water pollution, and irrigation. The maximum rate at which the soil in any given condition in capable of absorbing water is called infiltration capacity (Raghunath, 2008). Empirical evidence showed that water in excess of infiltration capacity of soils will flow overland as surface runoff or erosion once the minor undulations in the surface (depression storage) have been filled.

Runoff and erosion occur most frequently on degraded soils, depending on topography, land use type and rainfall intensity. Runoff resulting from low infiltration capacity of soils accelerates erosion process and contributes to the flooding of regional lowlands and streams (Ukata, 2012). This phenomenon is common in tropical landscapes of the world dominated by unwholesome land use practices. It is a truism that human activities for livelihood sustenance especially in rural communities of developing economy thrive on land.

Land as a resource has a storing, filtering and transforming capacity that regulates atmospheric hydrologic and nutrient cycle (Manion, 2000). It implies that the modification of this asset through unsustainable land use practices as bush clearing and burning, tillage and short term fallowing commonly found among rural farmers of the study region could interrupt its buffering capacity overtime with negative consequences on the ecosystems.

Studies have shown that the decline in soil infiltration capacity is mostly caused by land use patterns, not easily noticeable as they occur very slowly (Reddy, 2001; Astil,2002; Hendry and Sambrook, 2006). The trend predisposes the inhabitants of this region who are predominantly farmers to such ecological risks as surface runoff, erosion, soil nutrient loss and flooding.

Besides, there is a perceived threat to land productivity in terms of decision making on industry location and construction activities as corollary to anticipated ecological events. Consequently, this study assessed the resistance of soils to surface erosion using infiltration data obtained from land uses of fallow land, wetland and forest to infer the best land use practice to be encouraged in order to forestall environmental hazards common in Abini region.

Study area

The study area is Abini in Biase, Cross river State of Nigeria it is located between longitude $8^0$06 and $8^0$10 E and latitudes $5^0$0N. The area is characterized by humid tropical climate with distinct wet and dry seasons. Rainfall amount ranges from 3.500 mm to 4,000 mm per annum. The rainy season falls between April and October, with a short dry spell usually referred to as August break during the month of August (NIMEST, 2009).

It also has a relative humidity of between 80 and 90 per cent (N.A.A, 2006) the temperature is moderately hot and does not fluctuate greatly with a mean range of 27^0C to 33^0C (Ayoade, 2004). The geologic environment comprise of phyllites, schist's with structural features as foliation, joints, fold intrusion, pegmatite and barite. The rocks uncomformably overlain by sedimentary sequence of calcareous sandstones with mineral contents of quartz, clay, calcite and fossils occurring as ridges (Ekwueme, 2004). The soils are mostly derived from cretaceous sediments of Eze Aku group (Amajor, 1987) and are mostly lateritic in the upland area as essential residue products (deposits) formed under distinctive climate conditions in tropical and subtropical regions. There are also calcareous soils containing quartz, calcite and fossils as dominate minerals. Being acted upon by human induced and natural processes. The solid occur in separate, but close ranges as silt loam, silt day, loamy, sandy loam and clay loam, with varying textural characteristics of coarse gritty, powders smooth to sticky and plastic feel.

The forest land cover is made up of woody and non-woody plants (parasitic, saprophyte and epiphyte climbers which constitutes luxuriant and dense tree canopy, shading the soils from the vagaries of nature across seasons. This, in conjunction with other highlighted environmental variables influence the infiltration rates of regional soils at different scales which can either be detrimental or beneficial to the local land resources.

Method of study

Infiltration data were generated through field measurements with the aid of a cylinder (flooding) infiltrometers designed by Hillel (1970) across land uses of fallow land, wetland and forest. A metal tube was driven into the ground to a depth of 10cm with a sledge hammer. This was to prevent lateral flow of water during experiment and care was taken to avoid damage to soil structure in the process.

As a rule, a constant ponding level of 5cm was maintained in the metal tube (ring) throughout the experimental runs. Using a timer, readings were taken at various intervals until a state of equilibrium, usually 180 minutes (3 hrs) was reached. The experiment was conducted to establish the maximum quantity of water (infiltration capacity) a soil in a given land use could absorb beyond which overland flow or erosion might occur during storm within a period of 3 hours.

Result and discussion

Tables I, II, and III show the equilibrium rate or the maximum water absorption capacities of soils during storm from three land uses studied. The values range from 3.6 cm/hr^{-1}(fallow land 0.6cm/hr^{-1} (wetland) and 9.6 cm/hr^{-1} (forest).This result indicate the degree of resistance of each soil type under a given land use to surface erosion in the event

Table I

Equilibrium infiltration rate of fallow land

Interval (mins)	Cumulative time (min)	Cumulative intake (cm)	Infiltration rate (cm/hr^{-1})
0	0	0	-
5	5	1.4	16.8
5	10	1.8	10.8
5	15	2.2	9.0
5	20	2.4	7.2
5	25	2.8	6.6
5	30	3.1	6.0
10	40	3.4	5.4
10	50	3.8	4.8
10	60	4.8	4.8
15	75	5.2	4.2
15	90	6.0	4.2
30	120	6.8	3.6
30	150	8.4	3.6
30	180	10.2	3.6

Source: Authors' fieldwork, 2014

Table II

Equilibrium infiltration rate of wetland

Interval (mins)	Cumulative time (min)	Cumulative intake (cm)	Infiltration rate (cm/hr^{-1})
0	0	0	0
5	5	1.4	4.8
5	10	1.6	3.6
5	15	0.6	2.4
5	20	0.7	2.4
5	25	0.8	1.8
5	30	0.8	1.8
10	40	0.9	1.2
10	50	0.9	1.2
10	60	1.2	1.2
15	75	1.8	1.8
15	90	1.8	1.2
30	120	1.8	1.2
30	150	1.8	0.6
30	180	1.8	0.6

Source: Authors' fieldwork, 2014

Table III

Equilibrium infiltration rate of forest land cover

Interval (mins)	Cumulative time (min)	Cumulative intake (cm)	Infiltration rate (cm/hr^{-1})
0	0	0	0
5	5	1.6	12.0
5	10	2.0	11.8
5	15	2.5	10.2
5	20	4.0	12.0
5	25	4.5	11.0
5	30	5.3	11.0
10	40	7.2	11.0
10	50	8.8	11.0
10	60	10.6	11.0
15	75	11.6	10.0
15	90	14.8	9.6
30	120	18.6	9.6
30	150	24.4	9.6
30	180	28.8	9.6

Source: Authors' fieldwork, 2014

of precipitation upon the place; implying that, of the three land uses, forest, having water absorption capacity of 9.6cm/hr^{-1} contributes to soil protection against surface erosion than other land uses. Studies have proved that infiltration rates of forested areas are higher than those of other land uses during experimental runs (Akintola, 1974, Zake, 2000, Tilman, 2001, Watherhead, 2009). This is followed by fallow land (3.6cm/hr^{-1}) and the least being wetland (0.6cm/hr^{-1}).

From this findings, it is advisable to encourage aforestation and the protection of wetlands by the locals, as conservation measures to ensure sustainable land resource use.

Conclusion

The incessant flooding of Abini regional lowlands at the slightest storm event is traceable to high surface runoff down the basin resulting from low infiltration capacity of degraded soils. To avert this, there is the need to adopt proactive and sustainable measures as afforestation, crop rotation, mulching and the enlightenment of farmers to concentrate their cultivation practices in certain areas.

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