DYE-TRACING METHODOLOGY FOR SOIL INFILTRATION ESTIMATION IN GUWAHATI CITY

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Abstract: Soil hydrologic condition is the result of interplay between soil and vegetation which to a great extent govern the infiltration capacity of the soil and hence generation of runoff. Rapid urbanization has significantly increased the risk of flash floods particularly in steep, hilly terrains of Guwahati city especially during high intensity - short duration rainfall events causing large-scale devastations to life and infrastructure. The objective of this paper is to estimate the soil infiltration depth and hydrophobicity useful for hydrological modeling of flash floods. The results illustrated that vegetative classes like bamboo, forests, plantation or shrubs favour deep infiltration through preferential pathways in the soils. However, homestead or residential areas have showed lesser depth of infiltration due to compressed and impervious areas. Vegetative classes like forest, plantation, bamboo and shrub classes have showed lesser hydrophobicity than homestead and residential classes. Therefore, Plantation and afforestation on the hills can also help reduce flash floods considerably in Guwahat city. Application of vetiver grass could also effectively detain runoff by conducting runoff to deeper subsurface as they have long, bushy root structure. Therefore dye-tracing is an effective methodology to measure infiltration depths under different landuse classes.

Keywords: infiltration depth; hydrophobicity; flash flood

1. Introduction:

Flash floods are a recurrent and serious problem in the rapidly urbanizing Guwahati city due to increase in impervious areas, thus increasing the runoff from the steep hilly areas surrounding the city. Many studies have illustrated that the infiltration capacity of soil varies under different vegetation (Thurow, 1986). Few studies have reported that vegetation cover enhanced infiltration capacity of soil and reduced runoff (Eldridge, 1993The objective of the present study is to estimate the infiltration depth and hydrophobicity that are essential for any flash flood modeling.

2. Methods and methodology:

2.1. Field Plots:

Three experiments were performed on six different landuse classes namely, Forest, Plantation, Bamboo, Shrub, Homestead, Residential areas in the hilly areas of Guwahati city. The coordinates of the experimental plots are enumerated in Table 1. The experiments performed were Dye-tracer test and Hydrophobicity test in six-replicate trials.

Table 1: Location of Field sites

Landuse	Coordinates		Elevation(m)
Forest	26˚07′	91˚36′	86
Plantation	26˚08′	91˚35′	72
Bamboo	26˚08′	91˚39′	103
Shrub	26˚09′	91˚38′	129
Homestead	26˚06′	91˚44′	125
Residential areas	26˚19′	91˚37′	125

2.2. Dye tracer test:

In this study two regular cookers with the bottoms cut off and saw-teeth of 1cm height at 45 º were made at the bottom of the rings for easy penetration into the soil without disturbing the soil properties. (Figure 1). The inner ring diameter was 30 cm and outer ring diameter was 60cm. The heights of the rings were 250 cm. The rings were pushed into the soil to appropriate depth of 150 cm as at this depth where leakage did not occur. The outer ring was filled with water and a relatively constant water level was maintained, in order to create a "buffer" outside the smaller ring. To find the pathway for infiltration into soil water, 3.5 litres of coloured water with the concentration of 5 g/l Brilliant Blue FCF was added into the inner ring (Figure 2).

Figure 1: Dye-tracing set-up

Figure 2: Double ring infiltrometer test

Brilliant Blue FCF (CI 42090) and chemical composition ($C_{37}H_{34}N_2Na_20_9S_3$) is a dye with minimum 85 dry mass % pure dye and is the best tracer available for vadose zone hydrological studies. It is popular for its good visibility, low toxicity and least adsorption in soils . This volume of water resembled a rainfall of approximately of 50 mm ponding depth. About one hour after the blue colour had infiltrated, the rings were removed and cross sections of the soil were excavated and photographed. For each land use six replicas were made (total 36 sites). Maximum depth of dye penetration was recorded. A qualitative analysis was made by visual inspection and comparing photos of different land uses (Borah et al, 2015). Maximum coloured depth was compared to the infiltration rate (Figure 3).

Figure 3: Dye tracer test

2.3. Hydrophobicity test:

Water repellency affects water and solute movement at the field-scale and has often been underestimated. To assess hydrophobicity or water repellency of soils, drop penetration tests were conducted in the field (Figure 4). Drop penetration tests were conducted by placing a drop of deionized water on the soil surface with a dropper and measuring the time interval of penetration into soil into soil (Borah et al, 2015). Three drop penetration tests were conducted per soil sample for six replicate trials in each landuse.

Figure 4: Hydrophobicity test

3. Results and discussion:

3.1 Dye-tracer test:

The Dye-tracer tests showed (Figure 5) that the maximum mean depth of dye-penetration is for vetiver (135 cm), bamboo (80cm), forest (45 cm), plantation (42cm), shrub (35 cm), homestead (19cm) and residential plots (10 cm). The results suggested that vegetative classes like bamboo, forests, plantation or shrubs favoured deep infiltration through preferential flow in the soils. Application of vetiver grass could effectively arrest runoff by channelizing runoff to deeper subsurface as they have long, bushy root system. However, homestead or residential areas have showed lesser depth of infiltration due to impervious areas. Similar results have been reported by Sonja Eliasson and Martin Larsson (2006) as Forest (54 cm) and Shrub (34 cm) respectively.

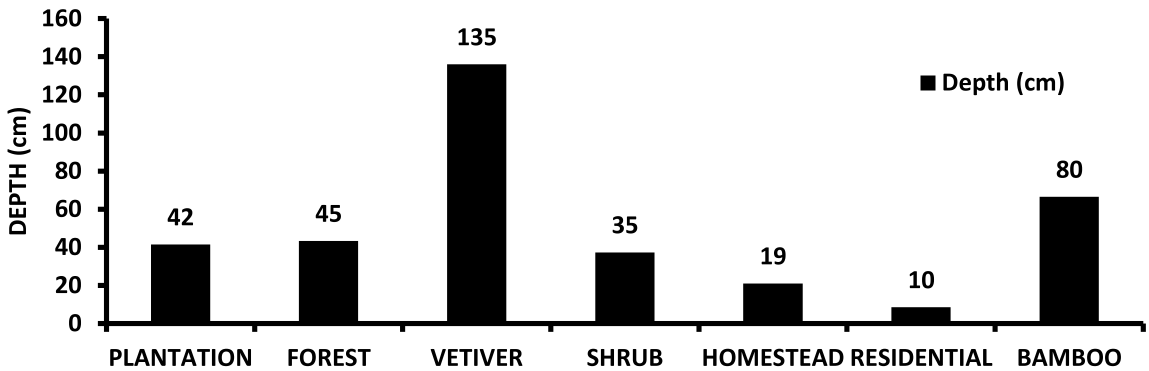

Figure 5: Dye penetration depth

3.2. Hydrophobicity test:

The hydrophobicity tests showed (Figure 6) that the mean total time required for penetration of a single drop of water into the ground for vetiver (25 sec), bamboo (38 sec), forest (30 sec), plantation (27 sec), shrub (39sec), homestead (45 sec) and residential plots (62 sec). This indicated that vegetative classes like forest, plantation, bamboo and shrub classes had less hydrophobicity than homestead and residential classes. Similar results have been reported by Dekker et al. (1994) for forest (15 sec) and shrub (25 sec) respectively.

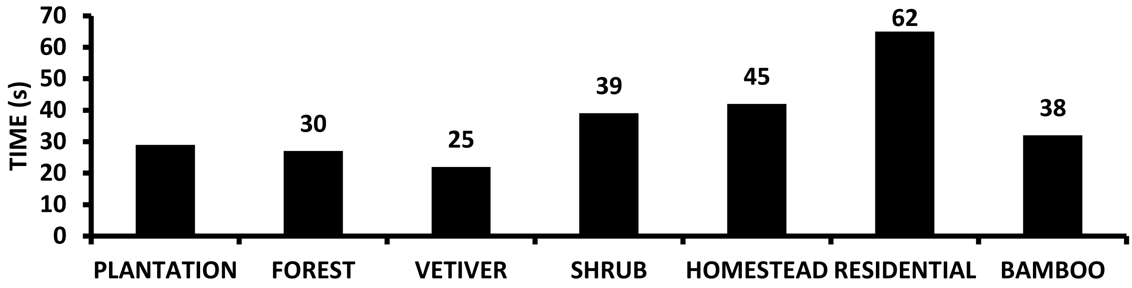

Figure 6: Hydrophobicity test result

4. Conclusion:

Therefore the results illustrated that vegetative classes like bamboo, forests, plantation or shrubs allowed deep infiltration through preferential pathways in the soils. However, homestead or residential areas have showed lesser depth of infiltration due to impervious areas. Vegetative classes like forest, plantation, bamboo and shrub classes had less hydrophobicity than homestead and residential classes. Therefore, application of vetiver grass could effectively arrest runoff by channelizing runoff to deeper subsurface as they had long, bushy root system. Therefore, the dye-tracing is an effective method for estimation of infiltration depth under different landuse classes.

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