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Organic carbon status in flood affected high hills of Kerala

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Abstract
The abnormally high rainfall received in Kerala from 1 June 2018 to 19 August 2018 resulted in severe flooding in 13 out of 14 districts in the state. Due to this heavy rainfall, flooding occurred in Kerala state and devastated most of the crops. The cumulative rainfall realised during 15-17 August 2018 resulted in a total of 414 mm for Kerala state with Idukki receiving 700 mm rainfall falling next to Peermade which received the highest rainfall of 800 mm. The paper focused on the effects of flooding on soil quality in southern high hills (AEU 14) of Idukki district, Kerala, for proper soil and flood management to avert soil degradation. The organic carbon content and the content of the available major primary nutrients nitrogen, phosphorus and potassium in these soils were determined. Survey was conducted to identify the flood affected areas of AEU 14 in Idukki district and details were collected. Representative surface soil samples (0-20 cm) were collected from these locations of AEU 14. Majority of the soils are high in organic carbon (70.5%), 25.6% samples recorded medium. Only 3 samples out of 78 samples were low.

Keywords: Flood, Kerala, nutrient status**,** organic carbon

Introduction
Agriculture being reliant to a large extent on weather, climate, land and water for its ability to sustain, is particularly vulnerable to natural disasters. Globally flood risk accounts for about a third of all losses due to natural hazards. Flood is one of the most destructive and devastating perpetual natural disasters in India (Ameen *et al*., 2019) [1] caused mainly during the monsoon season by irregular distribution and high-intensity precipitation. Kerala experienced an extremely high rainfall of 2346.6 mm from 1 June 2018 to 19 August 2018 which resulted in severe flooding in 13 districts of Kerala. In this devastating flood, only one district was left out (Sankar, 2018) [4]. A total of 57,000 hectares of agriculture crops were destroyed (Santhi and Veerakumaran, 2019) [5]. During the unprecedented floods of 2018, Idukki district was among the most seriously affected in Kerala. Idukki recorded the highest rainfall among the different districts of the state, which was almost 100 percent in excess compared to the average rainfall (3555 mm over the average 1852 mm). Peerumedu (>800 mm) and Idukki (>700 mm) of Idukki district (Fig. 1) were the two rain gauge stations that received maximum cumulative rainfall during 15-17 August 2018 (Sudheer *et al*., 2019) [6]. Floods displaced large quantities of surface soil particularly from slopy lands and deposited them at different locations. In this context, many paddy fields were affected by silt deposits. Based on the climate, geomorphology, land use and soil variability, 48.06 % of Idukki district is classified under Southern High Hills (AEU 14). Rajakkad, Vazhathope, Kanjikuzhy, Mariyapuram, Konnathadi and Kamakshi are the panchayats in AEU 14 that underwent extensive flooding which created both run off and deposits of debris and sediments in many places. Deposit scale may be graded from mild to extreme. The variety of sedimentary deposits that were brought in are liable to alter the physicochemical and biological soil characteristics of the soil. The rectification of the soil problems has to be scientifically addressed integrating traditional scientific methodology of surveying, sampling, analysing, correlating and interpreting the generated soil information.

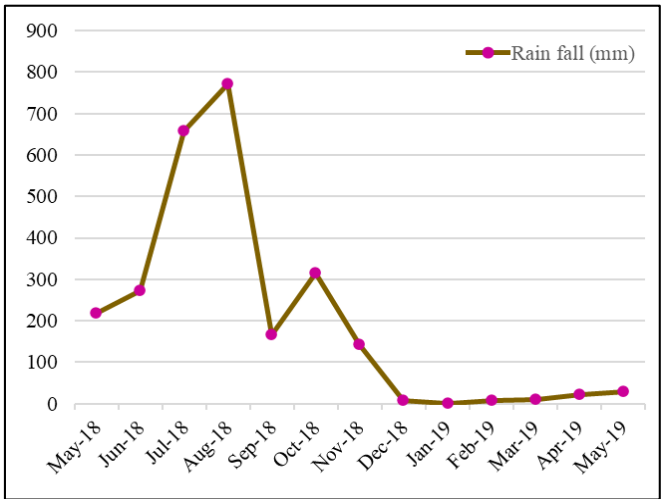

Fig 1: Monthly mean of weather parameters in AEU 14 of Idukki district

Materials and Methods

Six severely flood affected panchayaths, *viz*. Mariyapuram, Vazhathope, Kanjikuzhy and Kamakshy in Idukki block, Konnathady in Adimali block and Rajakkad in Nedumkandam block (Table 1) were selected in agro-ecological unit (AEU) 14 designated as Southern High Hills of Idukki district (Fig 2). Based on the detailed survey to identify the flood affected areas, random sampling technique was followed for the selection of sampling sites. Representative surface soil samples (0-20 cm) were collected from 78 sites from the six flood affected panchayaths. Each sample was air dried and properly ground using mortar and pestle and passed through a 2 mm sieve and stored in cloth bags. The processed soil samples were analysed for organic carbon by the Walkley and Black (1934) [7]. After analysing the samples, soil test values were categorised as low, medium and high for organic carbon using soil test rating chart (Table 1) and data were expressed in the form of graph. Mean values of organic carbon content in different panchayaths were calculated for comparison.

Table 1: Soil fertility ratings for Kerala

Nutrient	Low	Medium	High
Organic carbon (%)	<0.50	0.50-1.50	>1.50

Results and Discussion

Data pertaining to soil organic carbon status of different flood affected panchayaths of AEU 14 of Idukki district are furnished in Tables 2 to 4 and Figs. 2 to 4.

Table 2: Organic carbon status of post-flood soils of Vazhathope panchayath of AEU 14 in Idukki district of Kerala

Panchayath	Sample no.	Organic carbon (%)
Vazhathope	1	0.47
	2	1.35
	3	1.50
	4	1.47
	5	1.97
	6	0.47
	7	2.18
	8	1.65
	9	0.74
	10	1.92
	11	2.45
	12	1.94
Mean		1.51

Table 3: Organic carbon status of post-flood soils of Kamakshy panchayath of AEU 14 in Idukki district of Kerala

Panchayath	Sample no.	Organic carbon (%)
Kamakshy	1	0.93
	2	2.42
	3	2.52
	4	2.27
	5	1.71
	6	1.65
	7	2.30
	8	3.15
	9	2.76
	10	2.54
	11	0.93
	12	1.79
		1.47
Mean		2.03

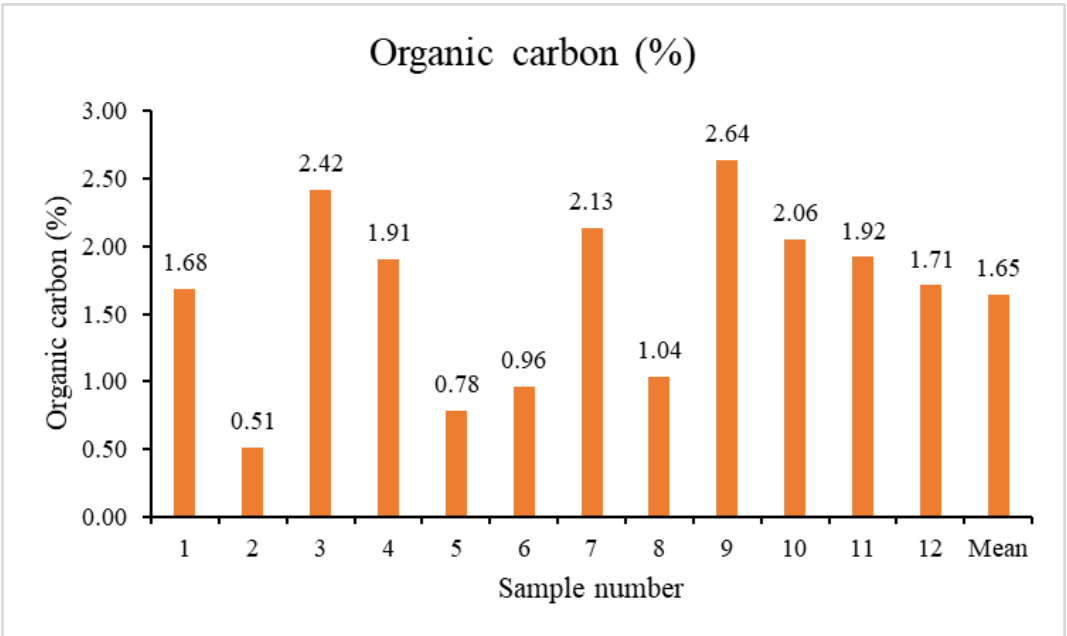

Fig 2: Organic carbon status of post-flood soils of Konnathady panchayath of AEU 14 in Idukki district of Kerala

Table 4: Organic carbon status of post-flood soils of Rajakkad panchayath of AEU 14 in Idukki district of Kerala

Panchayath	Sample no.	Organic carbon (%)
Rajakkad	1	1.94
	2	2.22
	3	2.25
	4	1.59
	5	1.67
	6	1.32
	7	2.27
	8	2.97
	9	2.75
	10	2.75
	11	2.75
	12	1.88
	13	1.89
	14	1.64
	15	1.16
Mean		2.07

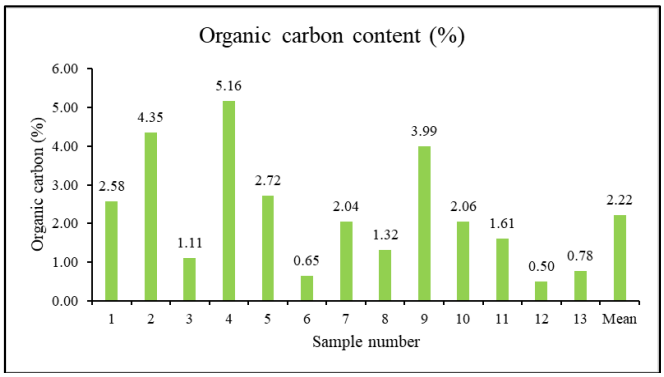

Fig 3: Organic carbon status of post-flood soils of Mariyapuram panchayath of AEU 14 in Idukki district of Kerala

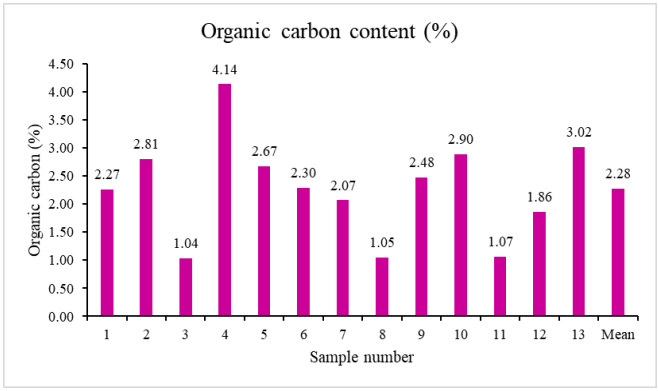

Fig 4: Organic carbon status of post-flood soils of Kanjikuzhy panchayath of AEU 14 in Idukki district of Kerala

Organic carbon: The organic carbon content of post-flood soils of Vazhathope panchayath (Table 2) ranged from 0.47 to 2.45 percent with a mean value of 1.51 percent. In Kamakshy panchayath, the soil organic carbon varied from 0.93 to 3.15 percent with a mean value of 2.03 percent. The post-flood soils of Konnathady panchayath had an organic carbon content between 0.51 to 2.64 with a mean value of 1.65 percent. The soils of Rajakkad and Mariyapuram panchayaths had an average organic carbon content of 2.07 and 2.22 percent respectively. The post-flood soils of Kanjikuzhy panchayath recorded the highest mean value for organic carbon content (2.28 percent) with an organic carbon content ranging from 1.04 to 4.14 percent. The soils of Vazhathope panchayath had the lowest mean value organic carbon content (1.51 percent).

Among total soils sampled, 70.5% samples recorded high organic carbon and 25.6% samples recorded medium. Only 3 samples out of 78 samples were low (Fig. 5). Majority of the soils are high in organic carbon. The physiographic location, the agroecology and the pedogenesis affecting factors pertaining to the Southern High Hills is of particular interest. The AEU 14 comprising of 2,09,695 ha covers 48.06 % of the district with a major part under forest cover. Plantations of pepper, cardamom, cocoa, coconut, coffee constitute the cultivated areas. Kanjikuzhy panchayath is peninsularly enveloped by forest cover. These characteristic physiographic features might have had its bearing on the pedogenesis of the soils of these panchayaths resulting in a high soil organic carbon content in the soils of the unit. High levels of organic matter enhance nutrient and water retention capacity of soils and create favourable physical, chemical and biological environment (Kavitha and Sujatha, 2015) [3]. Higher organic carbon recorded might be due to continuous addition of organic matter through perennial plantation crops. Gupta *et al*. (2010) [2] also reported higher soil organic carbon under plantations in the range of 1.5-1.95%. The enhancement in the organic carbon status can also be due to accumulation of organic sources under the influence of flood water.

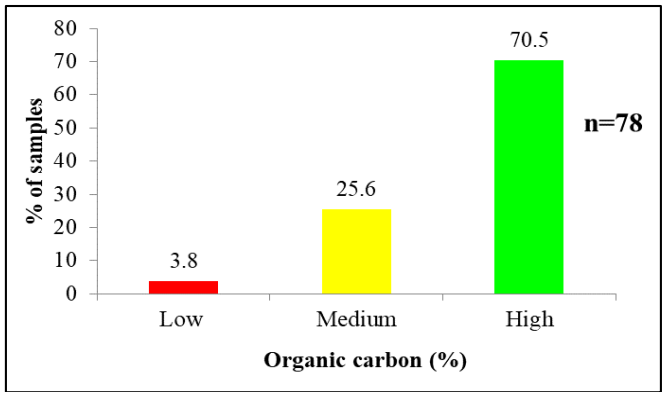

Fig 5: Frequency distribution of organic carbon of post-flood soils of AEU 14 in Idukki district of Kerala

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