Original Research Article

Impact of landslides on physicochemical and biological properties of Western Ghats Soils

ABSTRACT

Landslides cause major loss of natural forest ecosystem and it is negatively impact on forest land by depleting soil biological, physical and chemical properties to reduce crop productivity. The present study was conducted to assess the impact of landslides on soil quality of central Western Ghats regions of Karnataka. Soil samples were collected from Adlur, Kavalalli, Dongri, Artibail and Mastikatta to study the variation of soil biological physical and chemical properties in eroded and pristine soils. The results of the present investigation has revealed that the soil physicochemical properties such as water stable aggregates(60%), organic carbon(1.23%), organic matter(2.12%) and available N, P and K(323.41, 18.23 and 328.71 kg/ha respectively) were found to be higher in pristine ecosystem compared to eroded soils. Furthermore, soil biological properties like microbial biomass carbon, glomalin content and mycorrhizal spores and soil enzyme activity were found to be greater extent in the pristine ecosystem compared to eroded soils. The study highlights the impact of landslides on soil physicochemical and biological properties such that suitable remedies can be undertaken in order to prevent soil loss such that soil biological properties can be maintained which is pre-requisite for plant growth and development.

Keywords: Western Ghats, Landslides, Physicochemical and Biological properties

Introduction

The central Western Ghats are well known for their abundant and unique diversity of micro flora and fauna. Recently due to the Climatic changes the central Western Ghats soils are affected from the landslides which directly and indirectly affect the growth and productivity of forests (Geertsema *et al*., 2009; Cheng *et al*., 2016) which alter soil properties primarily by exposing parent material (C horizon) by removing the upper fertile organic layer which is carried slope lands. Variations in soil characteristics may include degradation of its structure, loss of nutrients and fertility, loss of organic matter, compaction, erosion of soil particles and distracted effete on soil microbial properties (Goyal *et al*., 2022).

Physicochemical characteristics of forest soils vary spatially and temporally due to variations in elevation, topography, climate, physical weathering processes, vegetation cover, microbial activities, and several other biotic and abiotic variables (Paudel & Sah, 2003; Sapkota *et al*., 2017). Organic matter, being one of the most important constituents of soil, supplies energy and cell building constituents for most microorganisms and is a critical factor that enhances soil fertility. Soil quality relates the ability of soils to function effectively as a component of a healthy system (Schoenholtz *et al*., 2005).

However, the impact of decreasing the soil biological, physical and chemical properties which has been altering the soil properties and it has not been carried out so far (Saravanan *et al*., 2013). Keeping the above points in view the present study was aimed to characterize the variation of the soil physicochemical and biological properties due to landslides compare to pristine soils of central Western Ghats of Karnataka region.

Materials and Methods

Study area

The study area is a central part of Western Ghats of Karnataka, India, spreads across six places namely Adlur, Kavalalli, Dongri, Artibail, Mastikatta and Gangavali river. It is located between geographical coordinates $14^0$68'5950'' to $14^0$89'3557'' Latitude $74^0$46'2812'' and $74^0$65'3665'' Longitude.

Soil sampling

The soil samples were taken after removing the top litter layer (2 cm) and digging out an appropriate amount of soil. The soil samples were collected with three replication from six localities and packed in polythene bags and stored at 4-8 ^{0}C to sustain the viability of microorganisms.

Mycorrhizal parameters

The chlamydospores in rhizosphere of host plant were determined by wet sieving and decantation method as outlined by Gerdemann and Nicholson (1963). Spores counts were taken under a stereo zoom microscope. Mycorrhizal root colonization was determined as per the procedure proposed by Philips and Hayman (1970). The percentage of roots colonized by mycorrhizae was calculated by the formula.

Glomalin extractions and quantifications from different species of AM Fungi.

Extraction of glomalin from AM fungal mycelium was performed using the procedure of Wright and Upadhyaya (1996). Protein was determined by the Bradford dye-binding assay with bovine serum albumin as the standard (Bradford, 1976).

Microbial biomass carbon

Microbial biomass carbon was estimated chloroform fumigation method given by (Alef and Nannipieri, 1995).

Soil enzymes activity

Estimation of dehydrogenase activity

Dehydrogenase activity in the soil samples were determined by following the procedure as described by Casida *et al*. (1964).

Estimation of phosphatase activity

Phosphatase activity of soil samples were determined by following the procedure of Evazi and Tabatabai (1979).

Estimation of urease activity

Urease activity of soil samples was determined by following the procedure of Tabatabai and Bremner (1972).

Soil physico-chemical parameter

The soil phsico-chemical parameters was analysis was done by following procedure Water stable aggregate analysis (Yoder, 1936) Soil P^{H} (Sparks, 1996)Electrical conductivity (Sparks, 1996) Organic carbon (%) (Sparks, 1996).

Chemical analysis of soil sample

Estimation of nitrogen

The total nitrogen content in the soil was estimated following the microkjeldahl method as outlined by Jackson (1973).

Estimation of phosphorus

Phosphorus was estimated by vanadomolybdate phosphoric yellow colour method (Jackson, 1973).

Estimation of Potassium

Potassium in the aliquot was estimated with the help of flame photometer after appropriate dilution (Tandon, 1998).

Statistical analysis and data interpretation

The data collected at different locations were subjected to statistical analysis. Based on mean values obtained, analysis and interpretation of data were studied using one way ANOVA technique as described by Gomez and Gomez (1984).

Results and discussion

The comparative analysis of soils at two different ecosystems (pristine and eroded soils) under the influence of landslides was conducted based on soil physicochemical and biochemical properties in this study. The effect of global warming can be reduced by mitigating the issues in the maintenance of soil organic matter content (Tang *et al*., 2018). Landslides results in serious soil related problems such as original vegetation destruction and rapid reduction of soil quality (Walker *et al*., 1996). Based on survey the suitable sites for soil sampling representing the pristine ecosystem were Dongri, Mastikatta and Gangavali river site and eroded regions selected were Adlur, Kavalalli, Dongri and Artibail. The soil pH was found to be acidic less than 7 in all sampling sites of both the ecosystems, the range of pH observed in soils of pristine ecosystem was 5.2 to 6.1, and the range of pH observed in eroded soils/ecosystem was 5.1 to 6.8. The pH of the soils on the landslide determines the intensity of nutrient uptake by the young seedlings (Lasota *et al*., 2020) and the neutral pH and slightly acidic pH combination will always benefits the plants with adequate amount of nutrient supply (Błońska *et al*., 2015). Our study found no significant difference with respect to pH change denoting the capacity of soils still efficient enough to supply required nutrient to plants (Bai *et al*., 2013). The range of electrical conductivity in pristine ecosystem soils was found to be 68.5-125.6 µS/m and in the range of 86.6-186.4 µS/min case of eroded soils indicating more EC in eroded soils reported by (Blonska *et al*., 2015). The percentage of water soluble aggregates different among both the ecosystems but not significantly, the percentage will vary at the greater depths in soil and if the landslides eliminate the soil at deeper depths in case of WSA (Gudiyangada Nachappa *et al*., 2020). The percentage organic carbon contentwill be affected due to the action of landslides as it disturbs the carbon pool management index (Jiang *et al*., 2021) as our results showed that increased organic carbon percentage and organic matter percentage in case of pristine ecosystems (1.23 and 2.12 %) and less in eroded soils (1.17 and 2.01 %) which is the main factor to be consider and effective measures for soil erosion is required for maintaining organic carbon percentage in soil. Our results showed the decrease in amount of nitrogen (N) and phosphorous (P) significantly but potassium (K) content was found to be in par with both the ecosystems. The effect of soil degradation due to landslides results in depletion of phosphorous content considering the sheet and rill erosion 4-19kg per hectare (Alewell *et al*., 2020). The studies based on nitrogen and potassium content and its deterioration due to landslides correlated to coal mining aspects which is the artificial manmade landslide action that loosen the soil and major nutrients such as available nitrogen (ammonical form), phosphorous and potassium were found to be significantly lower than undisturbed soils (pristine ecosystems in our study) (Yang *et al*., 2019). Soil microbial biomass, which can be either a source or sink of available nutrients, plays a critical role in nutrient transformation in terrestrial ecosystems (Singh *et al*., 1989). The range of MBC (µg) per gram of soilin pristine ecosystem (394-640) µg $g^{-1}$of soil which is higher compared to the soils of degraded ecosystems (232-439) µg $g^{-1}$of soil. Based on fumigation extraction method, the analysis showed decreased range of MBC in degraded soils compared to undisturbed soils (Yang *et al*., 2010). The mycorrhizal spores and glomalin content play an important role in restoration of degraded soils by improving the soil organic matter, reducing the soil fertility loss, microbial activity and reducing the effect of drought and saline stress (Liu et al., 2020). Our results showed the increased amount of mycorrhizal spores and glomalin content in case of pristine ecosystems (471 spores (per 50g of soil) and 3.11 mg/g) compared to eroded ecosystems (451 spores (per 50g of soil) and 1.89 mg/g) respectively. The various mechanisms used by mycorrhizae and glomalin in the recovery process of degraded areas confer to provide more importance in monitoring of AMF and glomalin in the soil to identify the stage of soil degradation/recovery (Matos *et al*., 2021). Thesoil urease and alkaline phosphatase activities in agricultural (slightly degraded) and garden soil (slightly disturbed or cultivated soils) showed the significant decrease of soil urease and phosphatase enzymes (Shao *et al*., 2018). Our results showed minor decreased variations in degraded soils compared to pristine ecosystem soils.

Conclusion

The comparative analysis of soil samples collected from different regions such as pristine and degraded ecosystems based on physicochemical and biological parameters was the major objective of the study. The loss of uppermost layers of the soil upto certain depth that is considered as habitat for various microorganisms and enriched with organic matter and nutrients in the available form majorly affect the plant growth and development. The landslides results in eroded environment which deteriorates the cultivable ability of soils. Our study showed major differences in organic carbon and organic matter content between pristine and degraded ecosystems that may be the result of landslides that shifted the microbial population resulted in decreased microbial biomass carbon. The mycorrhizal population was also found to be decreased that directly proportional to the decrease in glomalin content. The glomalin is a glycoprotein which facilitates soil aggregation which in-turn contributes to reduce soil loss. The study highlights the importance of mitigation of soil erosion and maintenance of soil microbial population for maintaining the natural ecosystem.

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Appendix:

PRISTINE ECOSYSTEM													
	Location	**Latitude**	**Longitude**	**Altitude**	**P^H**	**EC (µS/m)**	**WSA (%)**	**OC (%)**	**OM (%)**	**Available nitrogen (kg/ha)**	**Available phosphorus (kg/ha)**	**Available potassium (kg/ha)**	**Available Sulphur (kg/ha)**
A	**Dongri**												
1.	Dongri	14^{0}68’9045’’	74^{0}52’5544’’	79.19	5.22	125.6	61	1.2	2.06	311.20	18.23	328.71	46.87
2.	Dongri	14^{0}69’4414’’	74^{0}52’2611’’	24.96	6.12	52.59	58	1.17	2.01	293.64	15.14	316.20	39.37
B	**Mastikatta**												
1.	Mastikatta	14^{0}68’6280’’	74^{0}46’3084’’	45.46	5.38	64.2	56	1.19	2.05	323.41	12.47	297.75	38.64
2.	Mastikatta	14^{0}68’5950’	74^{0}46’2812’’	50.27	6.09	53.64	60	1.2	2.06	301.4	11.37	310.50	37.5
	Gangavali river site												
1	Gangavali river	14^{0}71’1679’’	74^{0}52’2188’’	62.41	5.80	72.4	58	1.08	1.86	261.64	14.02	280.34	39.64
2	Gangavali river	14^{0}70’9928’’	74^{0}52’1074’’	63.46	6.01	68.5	53	1.23	2.12	312.47	14.31	320.71	33.75

Appendix 1

ERODED ECOSYSTEM													
	Location	**Latitude**	**Longitude**	**Altitude**	**P^H**	**EC (µS/m)**	**WSA (%)**	**OC (%)**	**OM (%)**	**Available nitrogen (kg/ha)**	**Available phosphorus (kg/ha)**	**Available potassium (kg/ha)**	**Available Sulphur (kg/ha)**
A	**Adlur**												
1.	Adlur	14^{0} 68’6659’’	74^{0}37’3951’’	104.88	6.78	186.4	48	1.08	1.86	267.31	11.32	310.64	36.94
2.	Adlur	14^{0}68’6486’’	74^{0}37’3896’’	110.66	5.99	166.3	53	1.17	2.01	263.39	9.34	298.34	34.35
B	**Kavalalli**												
1.	Kavalalli	14^{0}71’7125’’	74^{0}51’4696’’	65.56	5.81	86.6	58	1.12	1.93	279.34	13.41	308.64	32.45
2.	Kavalalli	14^{0}71’7141’’	74^{0}51’4738’’	64.65	5.10	126.6	61	0.89	1.53	278.34	10.47	304.37	28.64
	Dongri												
1	Dongri	14^{0}69’4977’’	74^{0}50’7887’’	46.22	5.47	90.70	47	1.07	1.84	218.34	08.64	298.37	32.66
	Artibail												
1	Artibail	14^{0}89’3557’’	74^{0}65’3665’’	77.24	6.02	70.10	51	1.01	1.74	279.36	12.34	316.39	24.37

Appendix 2

ERODED ECOSYSTEM										
	Location	**Latitude**	**Longitude**	**Altitude**	**MBC µg g^{-1}of soil**	**Mycorrhizal spore (50g of soil)**	**Glomalin content (mg/ g soil)**	**Dehydrogenase activity (µg TPF formed g^{-1} soil d^{-1}**	**Alkaline Phosphatase activity (µg pnp released g^{-1} soil h^{-1})**	**Urease activity (µg NH^{+} N g^{-1}soil day^{1})**
A	**Adlur**									
1.	Adlur	14^{0} 68’6659’’	74^{0}37’3951’’	104.88	439	451	2.21	40.12	316.37	20.31
2.	Adlur	14^{0}68’6486’’	74^{0}37’3896’’	110.66	310	366	2.00	30.45	319.35	22.39
B	**Kavalalli**									
1.	Kavalalli	14^{0}71’7125’’	74^{0}51’4696’’	65.56	253	421	1.89	37.52	332.44	20.69
2.	Kavalalli	14^{0}71’7141’’	74^{0}51’4738’’	64.65	291	378	2.18	41.02	294.05	23.43
	Dongri									
1	Dongri	14^{0}69’4977’’	74^{0}50’7887’’	46.22	283	401	2.01	38.80	215.18	26.12
	Artibail									
1	Artibail	14^{0}89’3557’’	74^{0}65’3665’’	77.24	232	374	1.18	36.87	263.69	22.44

Appendix 3

PRISTINE ECOSYSTEM										
	Location	**Latitude**	**Longitude**	**Altitude**	**MBC µg g^{-1} of soil**	**Mycorrhizal spore (50g of soil)**	**Glomalin content (mg/ g soil)**	**Dehydrogenase activity (µg TPF formed g^{-1} soil d^{-1}**	**Alkaline Phosphatase activity (µg pnp released g^{-1} soil h^{-1})**	**Urease activity (µg NH^{+} N g^{-1} soil day^{1})**
A	**Dongri**									
1.	Dongri	14^{0}68’9045’’	74^{0}52’5544’’	79.19	571	421	3.11	41.45	363.20	23.98
2.	Dongri	14^{0}69’4414’’	74^{0}52’2611’’	24.96	434	399	2.99	39.81	312.69	21.46
B	**Mastikatta**									
1.	Mastikatta	14^{0}68’6280’’	74^{0}46’3084’’	45.46	481	437	3.01	40.98	331.78	22.78
2.	Mastikatta	14^{0}68’5950’	74^{0}46’2812’’	50.27	640	461	2.73	43.12	329.64	24.39
	Gangavali river site									
1	Gangavali river	14^{0}71’1679’’	74^{0}52’2188’’	62.41	421	471	2.97	51.66	371.40	31.69
2	Gangavali river	14^{0}70’9928’’	74^{0}52’1074’’	63.46	394	428	2.33	49.33	361.12	28.4

Appendix 4