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Spatial Variation in Soil Organic Carbon and Moisture Content in Forest Soil around Jharia Coalfield, Dhanbad

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Abstract

Soil Organic Carbon is the major determinant of soil quality because of its impact on other physical, chemical and biological properties of soil. Soil moisture is the water present in the soil and determines soil carbon dynamics by controlling litter degradation, microbial decomposition and other processes. Soil moisture and soil organic carbon shows a direct relationship and soil organic carbon increases with increase in moisture. Spatial observation of changes in soil organic carbon and moisture gradient, greatly helps in site selection for different soil quality assessment, flooding and drought prediction, irrigation plan, agricultural management and land use programme which may lead to simultaneous improvement in productivity and conservation. In the present study, we reported this relationship in a coal contaminated region situated in the eastern part of India. The whole study area is under the direct/indirect impact of the coal mining activities. This was found that around the Jharia coalfield region, both Soil organic carbon and moisture content shows a high positive correlation of 0.81 (Co-efficient of determination (0.66).

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Introduction

Soil moisture is the quantity of water present in a particular amount of soil at the specific magnitude of energy (Romano, 2014). It controls various hydro-geochemical cycles and regulates various biological processes. Soil water vaporization, atmospheric precipitation, ground water availability are interrelated with each other and also greatly affected by soil moisture. Soil water presented in the rhizosphere is of great importance for vegetational root-water uptake, solute-exchange, plant respiration and microbial community. Soil organic carbon is a small but vital component of surface soils, contributing to a number of soil chemical and physical properties. Soil moisture may affects spatial distribution of Soil Organic carbon (Post and Kwon, 2000).In drier regions, increase in soil moisture directly increases biomass productivity (Briggs and Knapp, 1995; Knapp *et al.*, 2001). A large number of papers reported a high rate of change in carbon dynamics with a small change in soil water content (Epstein *et al.*, 2002; McCulley *et al.*, 2005; Bontti *et al.*, 2009). In some cases the excessive increase in moisture content resulted in anaerobic conditions which reduces microbial activity and lowers the rate of changes in carbon (Linn and Doran, 1984; Neckles and Neill, 1994; Conn and Day, 1997).

Coal plays an important role in energy generation and approximately 27 % of the world's energy consumption originates from the incineration of coal (Bhuiyan *et al.*, 2010). In India, open cast mines produced 463 MT during 2012-13 (Ministry of Coal, 2013) and such a huge amount of coal production results in 1850 Mm^3 of overburdens (Juwarkar and Jambhulkar, 2008). For producing this much amount of coal it is estimated that land is degraded at the rate of about 60 km^2 in direct mining and approximately 75 km^2 per year for external overburden and spoil dumps (Kundu and Ghose, 1997). Soil is a prominent sink for coal dust originated from coal mining areas. Recent studies on soil contamination of Jharia Coal Field (JCF) reveal a pollution load due to coal mining activities, mine fires, windblown dust, Overburden dumps, etc. (Masto *et al.*, 2011; Pandey *et al.*, 2016). The risk of soil contamination due to coal dust deposition around coal mining areas is of extreme importance for environmental health. The information obtained by the analysis of soil may be useful to better understand the soil contamination in forest soils of the JCF region. The aim of the study is to find out the spatial variation in soil organic carbon and moisture content in forest soil around Jharia coalfield.

Materials and methods

Study area

Jharia Coal Field (JCF) is located in Dhanbad district of Jharkhand and lies between 23°39'N to 23°50'N latitudes and 86°05'E to 86°30'E longitudes.

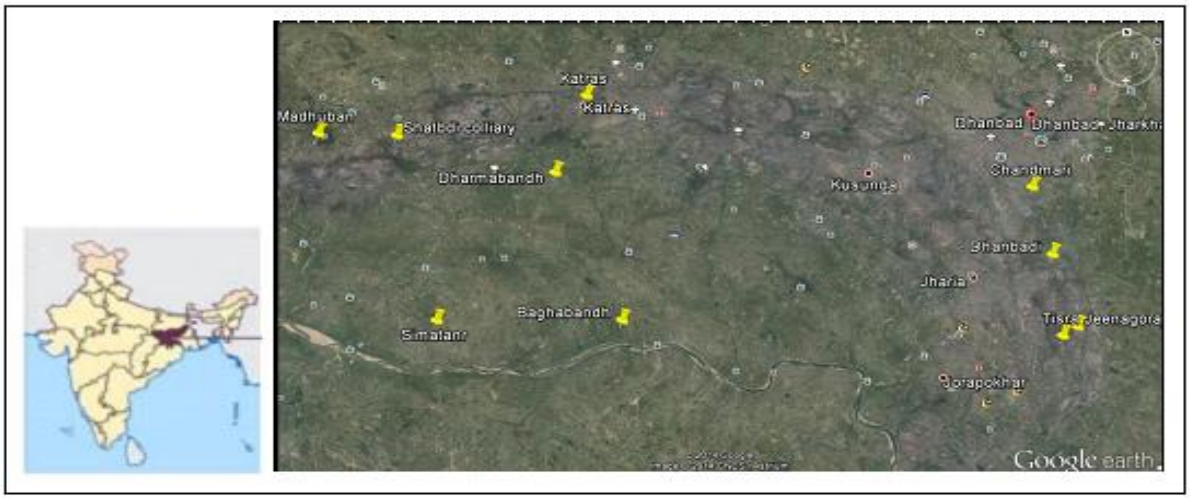

Fig. 1. Map depicting sampling points.

The main natural drainage in JCF is the Damodar River, with some of its small perennial streams. The JCF is important for its large coal mines and has the potential of contributing significantly to resolving the current energy crisis in the subcontinent. The cumulative effects of exploration activities at multiple sites have the potential to drive environmental change, particularly from a larger regional perspective. Climatically the JCF is tropical monsoon in nature. The annual average temperature is about 25°C and it receives annually about 900-1300 mm of rainfall. The total land covered in the JCF is 392.85 Km^2.

Sample Collection and Preparation

Ten soil samples were collected in the monsoon (August 2014) from different forest lands located around the coal mines of Jharia, Dhanbad (Table 1, Fig. 1). In each sampling location, a plot of one hectare was selected and five soil cores (5 cm inner diameter) of 0-15 cm depth were randomly sampled from five points (north, south, east, west and central) and mixed to obtain a composite sample.

The soil samples were stored in plastic zip bags and transported to the laboratory for analytical processing. In laboratory, the bulk soil samples air-dried, broken into pieces, grinded well in the mortar and pestle to crush the aggregate particles for further physico-chemical analysis.

Analysis

Soil organic carbon is analysed by Walkley and Black dichromate oxidation method (1934). For analysis of soil moisture content, the samples were weighed ("wet weight") and then placed in a thermostatically controlled oven. Samples were dried at a temperature of 105°C ± 5°C for 24 hours. The samples were then weighed again ("dry weight") whereby their soil moisture percentage could be calculated (Equation 1).

$$\text{Percent moisture} = \frac{\text{wet weight(g)} - \text{dry weight (g)}}{\text{wet weight (g)}} \times 100$$

(Eq.1)

The descriptive statistical analysis was carried out by the Microsoft Excel.

Results and discussion

In the present study, Organic carbon and moisture have similar spatial variations (Fig. 2). The moisture content percentage of different locations of Jharia ranged from 4.23 - 1.72, higher at North Tisra and lower at the Topchachi site (Table 2). The Organic carbon percentage of soil varied from 2.71- 0.54. This range shows a high similarity to soil organic carbon of control site described by Masto *et al.* (2011 b). This indicates a lower sensitivity of soil organic carbon determined by Walkley-Black method or lower effect of coal dust deposition due to seasonal variation (Masto *et al.*, 2011 b; Mandal *et al.*, 2012). Mandal *et al.* (2012), reported lower coal dust deposited in monsoon (12.68 t/km²/month) than summer (26.56 t/km²/month). The high Organic carbon is observed at Dhanwadih and lower at Bhagaband.

Table 1. Locations of sampling points.

Sampling Site	Location	Latitude	Longitude	Elevation	Land Use
F1	Chandmari	N23°46'10.1"	E086°25'48"	199 m	Forest
F2	Dhanwadih	N23°44'49.9"	E086°26'11.3"	207 m	Forest
F3	North Tisra	N23°43'38.6"	E086°26'44.8"	183 m	Forest
F4	Jeenagora	N23°42'20.9"	E086°26'41.6"	168 m	Forest
F5	Bhagaband	N23°43'33"	E086°24'56.6"	198 m	Forest
F6	Katras Area	N23°40'13.6"	E086°25'18.2"	227 m	Forest
F7	Madhuband	N23°47'14.4"	E086°11'24.3"	224 m	Forest
F8	Dharmaband	N23°47'10.8"	E086°15'52.1"	207 m	Forest
F9	Shatabdi	N23°47'41.3"	E086°12'59.9"	263 m	Forest
F10	Topchachi	N23°49'06.7"	E086°14'43.6"	228 m	Forest

Table 2. Overall descriptive statistics of percent Carbon and Moisture.

Statistics	Organic Carbon (%)	Moisture Content (%)
Mean	1.562601	2.550791
Standard Error	0.273185	0.272837
Median	1.288122	2.102153
Standard Deviation	0.863886	0.862786
Sample Variance	0.746299	0.7444
Range	2.166934	2.501279
Minimum	0.544142	1.728774
Maximum	2.711075	4.230053

Organic carbon and moisture content showed a positive correlation of 0.81 (co-efficient of determination R^2=0.66; Fig. 3) with each other. The moisture showed a positive relationship with Soil Organic Carbon which is an indication of stable soil physico-chemical condition in the monsoon season. In soil carbon dynamics, changes in moisture content are one of the important factors controlling productivity and decomposition rates (Esser, 1992; Raich and Potter, 1995; Epstein *et al.*, 2002).

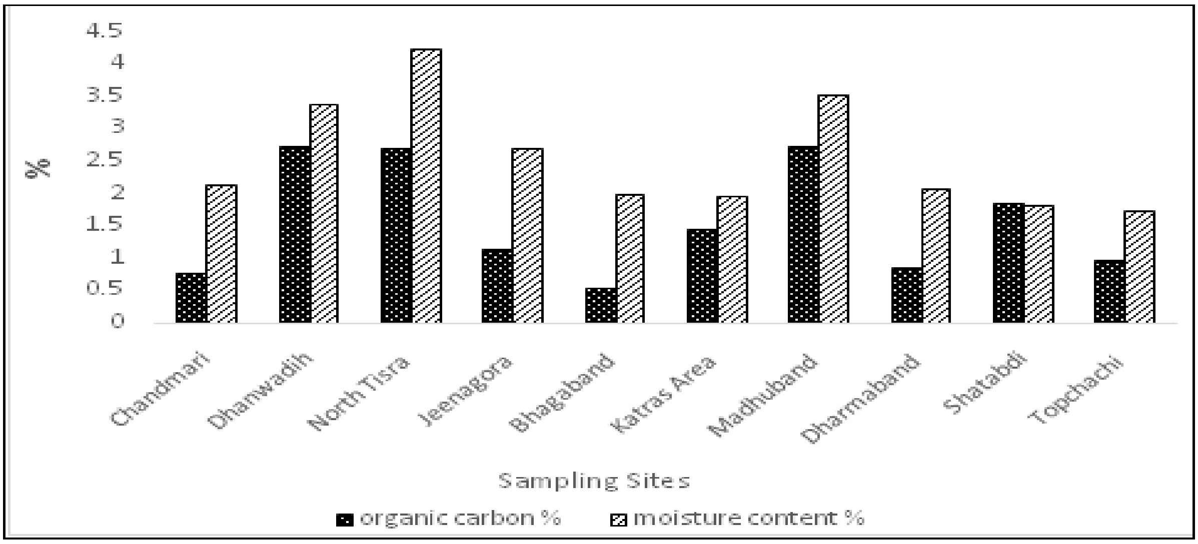

Fig. 2. Spatial variation in Soil Organic Carbon and Moisture Content.

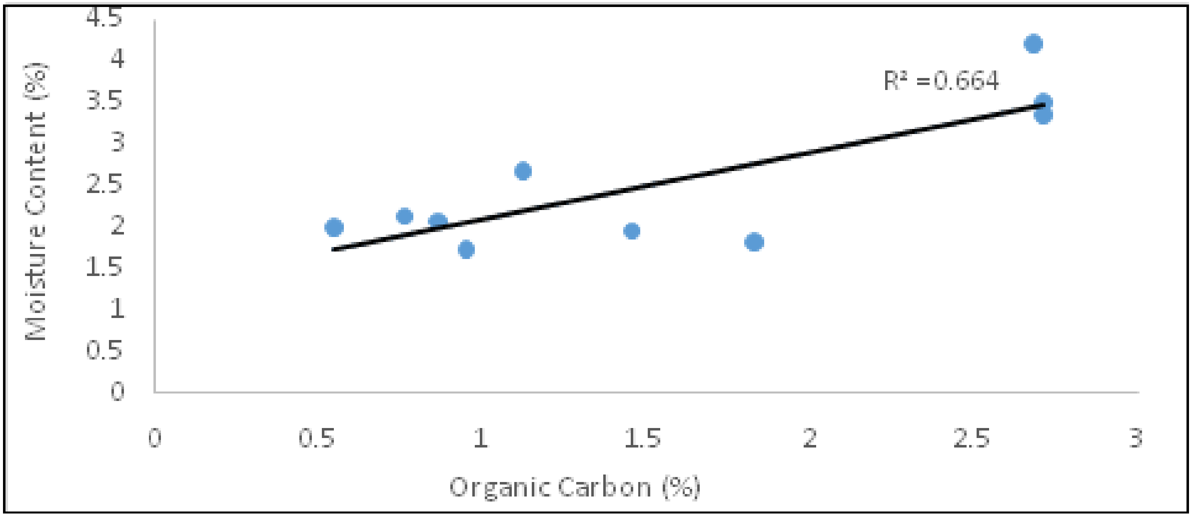

Fig. 3. Regression analysis between Soil Organic Carbon and Moisture Content.

High correlation between moisture content and soil organic carbon content shows that there is not any effect of coal dust on the moisture assisted carbon dynamics in the forest land of Jharia.

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