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Assessment of physical properties of soil and organic carbon distribution in Srinagar city of Kashmir Himalaya

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Abstract
Urban soils are victimized hotspots of compaction and other anthropogenic pressures. Present study deliberated on bulk density, moisture content, coarse fraction and distribution of soil organic carbon in Srinagar city of Kashmir Himalaya. In this study, 3 highly polluted roadsides sites (Pantha Chowk, Bemina and Dalgate) and a control site (Dara) were selected. The results show that overall mean value for bulk density was highest at Pantha Chowk (1.38 g cm^{-3}) and lowest value of 1.11 g cm^{-3} at Dara. The mean maximum soil moisture (21.03 %) was recorded at Dara and lowest value at Pantha Chowk (11.03 %). Similarly, overall mean of coarse fraction was highest at Patha Chowk, whereas, lowest value corresponded to Dara. Mean values of soil organic carbon were highest (1.02 %) at Dara, and Pantha Chowk exhibited minimum mean value of 0.35 %. It is concluded that soils with low moisture content, high bulk density and high coarse fraction have comparatively less organic carbon content which reveal that site is highly disturbed and subjected to some degree of compaction due to anthropogenic pressures.

Keywords: Srinagar city, urban soils, vehicular pollution, bulk density, coarse fraction

Introduction
Soils are the vital pedestal for most of terrestrial ecosystem services. It is storehouse of nutrients and water which help plants in manufacture of food, sustenance and in various life processes and in due course soils absorb and store carbon dioxide (sequester). Besides, soils alleviate likelihood of floods, play important role in purification of water by acting as a filter and also help to immobilize various air pollutants. In addition, provide strong structural support to buildings and roads (Dominati *et al*. 2010) [1]. However, these functions have been subjected to impairment due to widespread soil degradation (Edmondson *et al*. 2011) [2]. The detrimental impacts of urbanization on physical and chemical properties have drawn little attention of stakeholders thus need to be addressed.

Physical properties of soil include bulk density, moisture content and coarse fraction. Bulk density is defined as the mass of dry soil per unit of its volume (g cm^{-1}). It is a realistic indicator of the structure of a soil, and can aid in envisaging its porosity, permeability, infiltration rate and water holding capacity. As a general rule, when the bulk density of a given patch of soil increases, it will produce more surface runoff and allow less infiltration. More bulk density results in compaction of soil thereby hamper biological as well as biochemical processes in underlying soil. Organic matter content and bulk density are inversely proportional to each other. Soil moisture is one of the known factors which are essential for soil microorganisms and their functioning (Sylvia *et al*. 2005) [3]. Excessive soil moisture can result in depletion of rhizospheric oxygen while as the lack of soil moisture can create drought like conditions that hamper nutrient transport and photosynthesis in trees. Soil samples contain fine fractions (silt and clay) as well as variable amounts of coarse fractions (stone and sand) that significantly contributes to the total soil organic carbon stock and affect the determination of the bulk density and the quantification of the soil organic carbon (Corti*et al*. 2002; Schrumpf *et al*. 2011; Zabowski *et al*. 2011) [4, 5, 6]. The disturbance has increased the coarse fractions and decreased the fine fractions and the difference between low and high disturbance is stronger when stone contents are more than 20%, and especially when they are more than 40% (Jim 2003) [7].

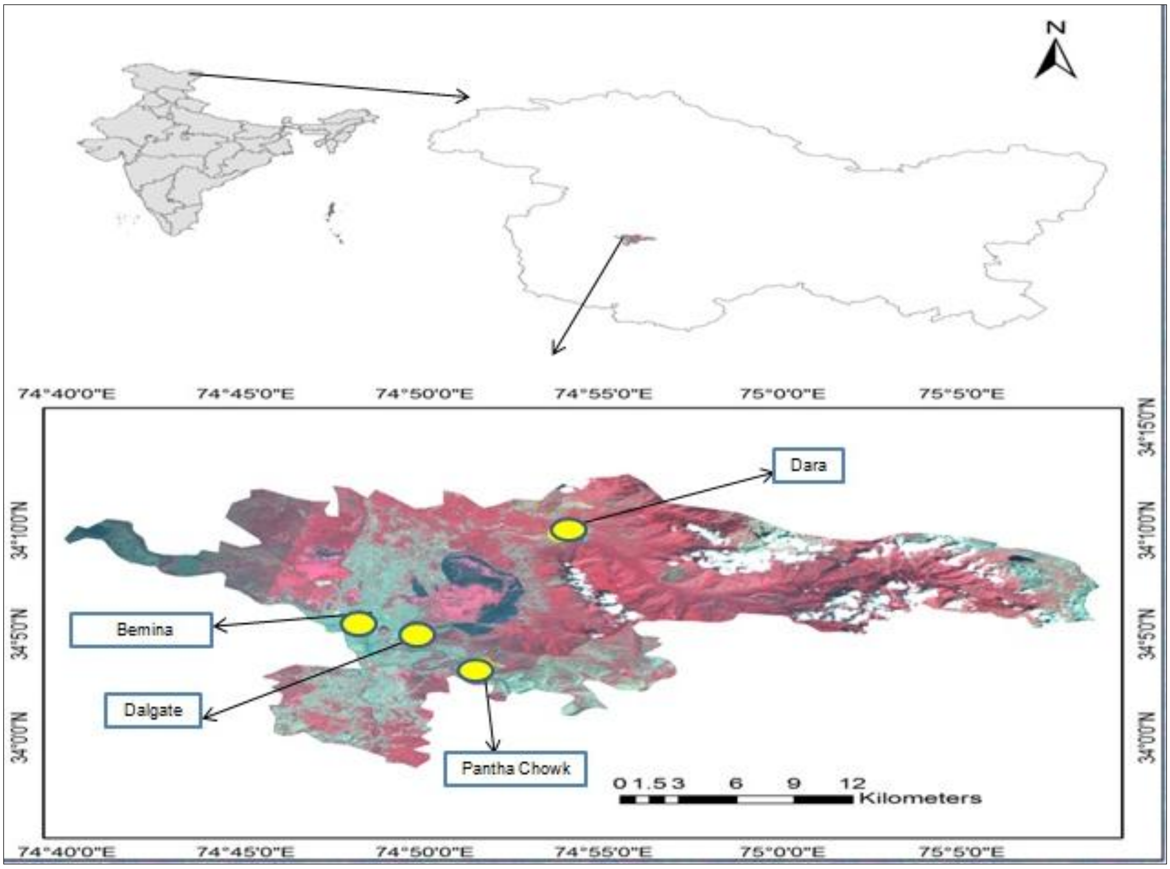
Soil organic carbon constitutes about 58 percent of organic matter (Nelson and Sommers, 1982) [8]. The organic matter in soil represents the remains of the plants, animals and micro organisms in various stages of decomposition. Soil organic matter controls many of the chemical, physical and biological properties of the soil (Doran and Parkin, 1994) [9].

Its dynamics is not only important to productivity and sustainability of soil but also helps to mitigate excessive CO_2 from the atmosphere. The ever-increasing pace of urbanization has completely changed the natural set ups that have managed the functioning of ecosystems for hundreds of years. Along with deforestation, topsoil along the roadsides that supports native species has been deteriorated on the tag of novel means of urban constructions. The remaining subsoil has been compacted to such an extent that that it has literary transformed into pavements with high bulk densities which negatively influence the physical, chemical and biological processes in soil. Surfaces have been sealed with asphalt and concrete, often leaving only small remnants of green spaces within which few orderly trees with some turf grass beneath can be planted which later wilt due to enormous pressures in urban roadsides. The incredible diversity of the native plants has been replaced by few sterile, imported species of trees and shrubs and adaptability have been casually abandoned without any scientific background.

Materials and methods

Study Area Description

The present study was undertaken in Srinagar city which is the largest city and summer capital of Jammu and Kashmir. It lies between 33°59′14″ N to 34°12′37″ N latitude and 74°41′06″ E to 74°57′27″E longitude. Srinagar city is the hub of whole district with heterogeneous amalgam of sensitive zones and offices of commercial, cooperative, institutional sectors. It is the busiest route of state in terms of vehicle plying.



Study Sites

The study area was subdivided into 3 highly polluted roadsides sites (Pantha Chowk, Bemina and Dalgate) and a control site (Dara). All the sites were having four common tree species (*Salix alba*, *Populus deltoides*, *Platinus orientalis* and *Aesculus indica*).

The description of sampling sites are presented as under:

a) Pantha Chowk (34°02′27.7″, 74°52′40.1″)

Pantha Chowk is a Y shaped road junction with three distinct arteries, one leading towards National highway and results in formation of connecting link to South Kashmir, the other leads towards main city (Dalgate and Lal Chowk) while as the last one towards towns like Sempora, Zewan, Pattan etc. The area is known for stone quarrying which contributes in remarkable number of carriage trucks along this junction. Besides, Sonwar-Pantha Chowk highway progresses through B.B. cantonment area which results in adding up of non civilian vehicles (army convoy) in addition to civilian transport which make this route busiest.

b) Bemina (34°04′23.0″, 74°47′03.0″)

Bemina is situated about 4 kms from Lal Chowk. Bemina is focal point for various government and private workplaces like Hajj House, Srinagar Development Authority, J & K State Board of School Education, J & K Lower court, Degree College, J & K Department of Ecology, Environment & Remote Sensing etc. It is also considered as one of the major growing colonies of South Asia with more than 60 residential colonies.

c) Dalgate (34°04′37.6″, 74°49′40.2″)

Dalgate road is located in the lap of hillock and has a prime position in map of Srinagar city. It is arterial road which connects to Khayam, Nehru park, Sonwar and Moulana Azad Road. It is hub of commercial and business avenues. It is one of the vehicular hotspot.

d) Dara (34°10′57.6″, 74°54′46.6″)

Dara is situated in outskirts of Srinagar city which connects to Harwan, Fakeergujri, Darda Howur, Saida Pora, etc. It has comparatively very lean vehicular flow which made it more appropriate to be labeled as a control site.

Sample collection

The soil samples were collected from each 0.1 ha plot using standard methodology (Ravindranath and Ostwald, 2008) [10]. Three random points (replications) were chosen and top organic matter was removed from each location and samples scraped from (O) horizon (0-30 cm). The soil was thoroughly mixed and gravels were removed. The soil samples were air dried and then ground using pestle and mortar and sieved through 2 mm mesh sized sieve. Powdered samples thus prepared were stored in well labeled bags for subsequent analysis. Bulk density (g cm^{-3}) was determined by using standard core method (Wilde *et al.*, 1964) [11], moisture content (%) by gravimetric method (Michael, 1984) [12], organic carbon through rapid titration method (Walkley and Black, 1934) [13].

Statistical analysis

Statistical analysis was carried out by using Microsoft excel 2007 and IBM SPSS (version 20) to demonstrate the results in terms of Mean±SE (Standard Error).

Results

The results for bulk density for various study sites are summarized in Table 1. The overall mean values recorded were highest at Pantha Chowk (1.38 g cm^{-3}), followed by Bemina (1.24 g cm^{-3}) and Dalgate (1.22 g cm^{-3}), while as, lowest value of 1.11 g cm^{-3} was recorded at Dara. Bulk density is an indicator of degree of compaction and is majorly influenced by various anthropogenic factors.

The moisture content for various sites is summarized in Table 2. The mean maximum soil moisture (21.03 %) was recorded at Dara followed by Dalgate (14.44 %), Bemina (12.41 %) and lowest value was found at Pantha Chowk (11.03 %).

The overall mean of coarse fraction for various sites in the present investigation was found to be 38.97, 30.22, 26.36 and 23.56 percent for Pantha Chowk, Bemina, Dalgate and Dara, respectively as presented in Table 3.

The data presented in Table 4 signified that the overall mean values of soil organic carbon were highest (1.02 %) at Dara followed by Dalgate (0.66 %) and Bemina (0.53 %). However, the overall minimum mean value (0.35 %) for organic carbon was obtained at Pantha Chowk.

Table 1: Bulk density (g cm^{-3}) of soil under various test species at all the study sites

Sites / Species	Year	Pantha-Chowk	Bemina	Dalgate	Dara (control)
Salix alba	2016	1.38	1.29	1.28	1.10
	2017	1.38	1.29	1.28	1.10
	Mean±SE	1.38±0.03	1.29±0.01	1.28±0.01	1.10±0.01
Populus deltoides	2016	1.50	1.23	1.31	1.12
	2017	1.50	1.23	1.31	1.12
	Mean±SE	1.50±0.01	1.23±0.01	1.31±0.02	1.12±0.01
Platinus orientalis	2016	1.44	1.16	1.21	1.09
	2017	1.44	1.16	1.21	1.09
	Mean±SE	1.44±0.02	1.16±0.001	1.21±0.01	1.09±0.01
Aesculus indica	2016	1.26	1.36	1.20	1.13
	2017	1.26	1.36	1.20	1.13
	Mean±SE	1.26±0.02	1.36±0.04	1.20±0.03	1.13±0.01
Overall Mean		1.38±0.01	1.24±0.01	1.22±0.01	1.11±0.01

Table 2: Moisture content (%) of soil under different tree species at various study sites

Sites / Species	Year	Pantha Chowk	Bemina	Dalgate	Dara (control)
Salix alba	2016	10.19	13.42	15.23	20.70
	2017	9.64	12.81	14.05	20.43
	Mean±SE	9.91±0.55	12.98±0.56	14.64±0.40	20.57±0.27
Populus deltoides	2016	9.90	11.72	11.96	21.06
	2017	9.22	11.55	11.28	20.65
	Mean±SE	9.56±0.51	11.63±0.33	11.60±0.46	20.86±0.19
Platinus orientalis	2016	10.88	16.15	14.74	21.14
	2017	10.31	15.92	14.63	21.33
	Mean±SE	10.60±0.45	16.04±0.34	14.68±0.24	21.23±0.14
Aesculus indica	2016	14.16	13.57	15.44	22.00
	2017	13.94	13.54	14.80	21.60
	Mean±SE	14.05±0.62	13.55±0.95	15.12±1.06	21.80±0.30
Overall Mean		11.03±0.33	12.41±0.28	14.44±0.22	21.03±0.12

Table 3: Coarse fraction (%) under different tree species at various study sites.

Sites / Species	Year	Pantha Chowk	Bemina	Dalgate	Dara (control)
Salix alba	2016	39.36	28.72	26.30	23.58
	2017	39.37	28.99	26.45	23.64
	Mean±SE	39.36±0.70	28.86±0.46	26.38±0.39	23.61±0.20
Populus deltoides	2016	41.65	30.66	27.10	23.97
	2017	41.66	30.84	27.14	23.98
	Mean±SE	41.66±0.56	30.75±0.36	27.12±0.71	24.98±0.23
Platinus orientalis	2016	39.79	28.45	26.05	23.01
	2017	39.49	28.57	26.49	23.05
	Mean±SE	39.63±0.53	28.51±0.20	26.27±0.17	23.03±0.29
Aesculus indica	2016	35.90	34.10	26.60	23.17
	2017	35.92	34.55	27.10	23.21
	Mean±SE	35.91±0.35	34.33±1.67	26.87±20.03	23.19±0.37
Overall Mean		38.97±0.35	30.22±0.29	26.36±0.16	23.56±0.14

Table 4: Organic carbon (%) under different tree species at various study sites.

Sites / Species	Year	Pantha Chowk	Bemina	Dalgate	Dara(control)
Salix alba	2016	0.31	0.52	0.31	0.92
	2017	0.33	0.56	0.32	1.02
	Mean±SE	0.32±0.02	0.54±0.04	0.32±0.05	0.97±0.03
Populus deltoides	2016	0.21	0.46	0.57	0.98
	2017	0.23	0.52	0.65	1.10
	Mean±SE	0.23±0.01	0.49±0.03	0.61±0.06	1.04±0.03
Platinus orientalis	2016	0.29	0.69	0.66	1.05
	2017	0.31	0.72	0.68	1.21
	Mean±SE	0.30±0.01	0.70±0.03	0.67±0.01	1.13±0.06
Aesculus indica	2016	0.50	0.55	0.74	0.85
	2017	0.54	0.61	0.80	0.96
	Mean±SE	0.52±0.03	0.58±0.22	0.77±0.11	0.91±0.03
Overall Mean		0.35±0.01	0.53±0.02	0.66±0.01	1.02±0.02

Discussion

As a general rule, when the bulk density of a given patch of soil increases, it will produce more surface runoff and allow less infiltration. More bulk density results in compaction of soil thereby hamper biological as well as biochemical processes in underlying soil. Organic matter content and bulk density are inversely proportional to each other. Perusal of the data presented in Table 1 showed that during entire period of investigation, the maximum mean value of bulk density was recorded under Pantha Chowk (1.38 g cm^{-3}). Higher bulk densities in highly stressed roadside urban soils were also reported by Yang *et al*. (2005) [14]. The soils at Pantha Chowk are more or less compacted and high value of bulk density is attributed to joint influence of limestone quarrying and higher traffic density. These results are in agreement with Chaudhari *et al.* (2013) [15]. Similarly, minimum mean 1.11 g cm^{-3} was recorded at Dara. The accumulation of organic matter along the roadsides near forested areas promotes more microbial activity, stabilization of aggregates, porosity, and water infiltration rates than the urban roadside soils; which in turn results in lower bulk density. Our argument is in consonance with Bonini and Alves (2010) [16] and Sakin (2012) [17]. Thus verifies our argument that why lowest bulk density was recorded at Dara near the forest system.

Soil moisture is one of the known factors which are essential for soil microorganisms and their functioning (Sylvia *et al*., 2005) [3]. Excessive soil moisture can result in depletion of rhizospheric oxygen while as the lack of soil moisture can create drought like conditions that hamper nutrient transport and photosynthesis in trees. Soil organic matter impart the underlying soil the power of absorbing and holding significant quantities of water, up to 20 times its mass (Stevenson, 1994) [18]. Higher moisture content of 21.03 percent was found at Dara and is in accordance with the above cited explanation. While as, lowest moisture content was recorded at Pantha Chowk 11.03 percent at Pantha Chowk. Moisture content is inversely proportional to bulk density (degree of compaction) and directly proportional to organic matter. Therefore, low moisture content at Pantha Chowk can be attributed to low soil organic carbon (Bonini and Alves, 2010) [16].

The maximum mean value of coarse fraction was recorded at Pantha Chowk (38.97 %) as result of stone quarrying and transportation. It can be attributed to the fact that presence of coarse fragments in urban soils is ubiquitous, as a result of artificial transportation of natural rocks and, more often, the incorporation of artificially made materials such as concrete and building bricks (Jim 1998) [19]. Therefore, the stone and sand contents are commonly very high in urban soils (Short *et al*. 1986; Greinert 2000; Jim 2001) [20, 21, 22]. Although, urban soils contain coarse fragments, the infiltration rate is often low due to heavy compaction (Yang and Zhang, 2011) [23].

Urban soils usually have less organic matter than in forests and therefore have lower nutrient availability for tree development. Because of the limited moisture and aeration in urban soils, nitrifying and nitrogen-fixing bacteria are limited. Maximum mean value for organic carbon (1.02 %) was recorded at Dara, whereas, minimum mean value (0.35 %) at Pantha Chowk because organic matter in forests is replenished each year by organisms in the duff decomposing fallen leaves. It has also been reported that in urban environments, leaves are often raked up, bagged, and removed. (Lee *et al*. 2012) [24]. A significant deficiency of soil organic matter and microbial biomass is attributed to compacted roadway soils.

Conclusion

Comparatively low organic carbon content at polluted sites (Pantha Chowk followed by Bemina>Dalgate) is due to high bulk density, low moisture content and high coarse fraction which reveal that the site is highly disturbed and subjected to some degree of compaction due to anthropogenic pressures and its escalation in roadside soils is a matter of concern and shall hamper the organic carbon content and fertility of soil to sustain urban trees in near future. Therefore, focus on organic soil amendments is fundamental.

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