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Spatial Variation of Physico-Chemical Properties of Desurfaced Soils Due To Brick Kilns in NCR (India)

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ABSTRACT:

The study was carried out in National Capital Region (NCR) of Haryana state to assess the impact of soil desurfacing/soil mining due to brick kiln activity on some important physical and chemical properties of soil. Study revealed that the soil properties like organic carbon, available phosphorus, available potassium content invariably decreased significantly in desurfaced soil of the study area (Rohtak District) in the order of 55.00, 31.87, 65.11 % respectively, as compared to normal soil. Bulk density increased by 18.93 % and hydraulic conductivity decreased by 60.29 %, affecting water transmission adversely in desurfaced soil as compared to normal soil. The evaluation and delineation of desurfaced soil in the study area was done using geographical information system (GIS) and remote sensing technique. Significant area falling in National Capital Region (NCR) is prone to desurfacing process due to brick kiln activities, because of unprecedented spurt of infrastructural development in the study area.

Key words: Soil desurfacing, National Capital Region, Remote Sensing Technique, Geographical Information System,

1. INTRODUCTION

Land degradation is an increasing problem in many parts of the world. Success in fighting land degradation requires an improved understanding of its causes, impact, degree, and acquaintance with climate, soil, water, land cover, and socio-economic factors. Therefore, land degradation assessment is a primary goal in a decision support system for reversing degradation. Fortunately, scientists around the world started long ago to look at the problem and developed assessment and monitoring methods. Soil is basic to provide life on the earth and at the heart of terrestrial ecosystems in a systematic and dynamic order. From ozone depletion and global warming to rain forest destruction, water pollution and soil degradation, the world ecosystems affected in far-reaching ways by processes carried out in the soil. To a great degree, the quality of soil determines the nature of plant ecosystems and the capacity of land to support animal life and society. As human societies are turning to urban way of life, fewer people have intimate contact with the soil, and individuals tend to lose sight in many ways on which they depend for their prosperity and survival.

Management of natural resources particularly soil, is very essential for sustainable development of living beings on the land. The effect of ever increasing population pressure, urbanization and industrialization have put a great stress on our natural resources, resulting in decrease in net cultivable land area. To cater to the needs of ever-increasing population for

food, fiber, shelter, fodder, and fuel, the natural resources have been over-exploited, due to human interventions causing land degradation and ecological imbalance at a larger scale.
Land is the most valuable resource for production of food, and many other essential goods required to meet human and animal needs. However, it is facing serious threats of deterioration due to unrelenting human pressure and utilization incompatible with its capacity.

Soil degradation affects composition of fertile topsoil and changes in physical, chemical, and biological soil properties, which are inter-linked. Average fertile topsoil composition by volume is mineral matter 45 %, organic matter 5 % and 25 % each air and water, [2].

Soil desurfacing/soil mining is a major problem in the areas adjoining to mega cities like national capital, New Delhi and state capitals in the country. Adjoining areas, whether rural or urban, are highly engulfed into brick making activities with the sole aim to make faster money in a shorter period. The problem is more sever in National Capital Region (NCR), because of more industrialization and infrastructural development.

Soil desurfacing/soil mining is a process, top surface material is pulverized manually or mechanically and removed for other purposes such as for making bricks, foundations for buildings, railway tracks, roads, and land filling *etc*. leaving unproductive sub soil exposed to surface that are poorly suited to plant growth. With increased requirement for bricks due to rapid economic growth and the continued expansion of urban areas, large numbers of brick kilns established, throughout the country in the last two decades. The use of soil materials for making bricks not only contaminated the environment but also degraded large area of fertile land, [15].

2. PROBLEM STATEMENT

In the study of land degradation due to soil desurfacing/soil mining for brick making, remote sensing technique applied to monitor trends of land degradation as well as to identify and characterize form and their temporal dynamism. Methods and technique needed to be critically selected, taking into account their suitability, applicability and adaptability to prevailing situation and local conditions. In the light of that, it is imperative to assess the damage being caused due to soil desurfacing because of brick kiln activities in the surrounding of mega cities. For this purpose, following objectives have been envisaged:

3. OBJECTIVES

1. To study spatiotemporal variation of physico-chemical properties of desurfaced soils due to brick kiln activity in parts of National Capital Region (NCR) of Haryana state (India),
2. Integrating use of remote sensing technique in delineation of soil desurfaced area and fusing laboratory analysis data and field observations

4. MATERIAL AND METHODS

4.1 locations:

Study area (Rohtak District) lies in 28^{o} 23´´ to 29^{o} 6´´ North latitude and 76^{o} 13´´ to 76^{o} 58´´ East longitude of the National Capital Region (NCR) of Haryana state (India). It is 70 km in

northwest from national capital, New Delhi and located 235 km southeast of state capital, Chandigarh. More than 40 % area of Haryana state falls in NCR and whole of study area is the part of NCR. Geographical area of the study area is 1745 km^2. It is comprised of five community development blocks / zones (CDB/Z), *viz*. (Fig. 1)
1. Meham 2.Lakhan Majra 3.Rohtak 4. Sampla 5. Kalanaur

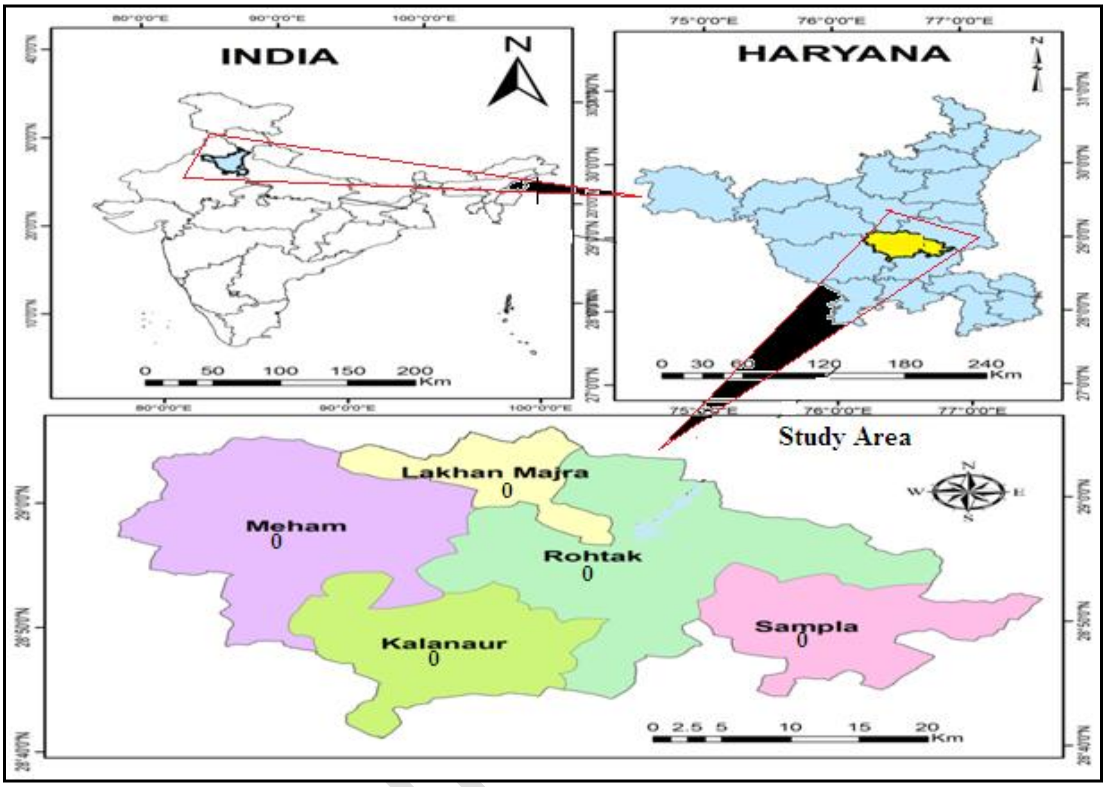

Fig. 1 Study area (Rohtak District)

4.2 Position of study area in survey of India (SOI) topographical sheet:
The study area falls in the survey of India (SOI) topographical sheet No. 53C/8, 53C/12, 53D/01, 53D/5, 53 D/6, 53D/9, 53D/10, 53D/13, 53D/14 (Fig. 2). Map-Scale 1:25000

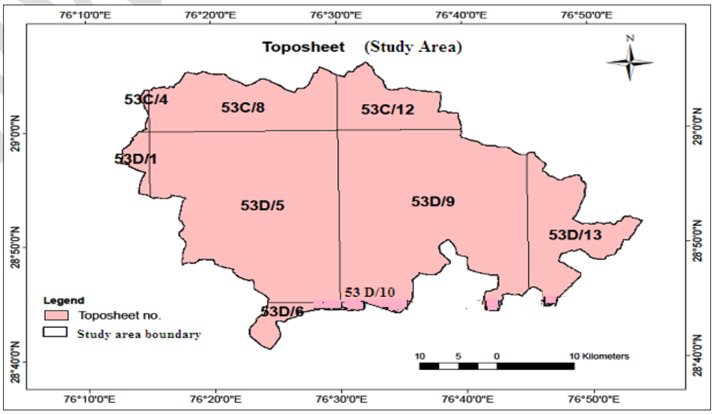

Fig. 2 Topographical Sheet Mosaic of study area

4.3 Climate:

The normal annual rain is 576.2 mm, which is unevenly distributed throughout the year. The southwest monsoon sets in from last week of June and withdraws in the end of September, contributing about 85 % of the rainfall. Hot in summer, highest day temperature ranging between 23^{o}C-45^{o}C. Sub-tropical, semi-arid, continental mainly rains bring by southwest monsoon in the season July- August- September. Rains are scanty to normal. The climate classified as tropical steppe, semi-arid and hot, which is mainly dry and hot with dry summer except monsoon months, *i.e.*, July to September when moist air of oceanic origin penetrates into the land. Winters are also extremely cold and mostly dry where night temperature falls to as low as 2-3^{o}C. The mean seasonal temperature during *kharif* and *Rabi* season are 29-31^{o}C and 16-18^{o}C with relative humidity of 70% and 55%, respectively. The area slopes towards Northeast to South-West with an average gradient of 0.19 m/km. The general elevation ranges between 215-222 m from sea level.

4.4 Soil:

The soil of the study area are fine to medium textured, sandy loam in Rohtak and Sampla block, Lakhan Majra, loamy sand with occasional clay loam in Kalanaur and Meham.

4.5 Data acquisition and use:

Data acquired from Haryana Space Application Center (HARSAC-CCS HAU-Campus), Hisar (INDIA)-125004, and on screen digitization of desurfaced soil in study area was performed for assessment.

4.6 Satellite details

1. Cartosat-I: Cartosat-I carries two state-of-the-art panchromatic (PAN) cameras that takes black and white stereoscopic images of the earth in the visible region of the electromagnetic spectrum. The swath covered by these high-resolution PAN cameras is 30 km and their spatial resolution is 2.5 meters (Table 1).

2. Worldview-II: Worldview-II is a commercial earth observation satellite owned by Digital Globe (DG). Worldview-II provides commercially available panchromatic imagery of 0.46 m resolution, and eight-band multispectral imagery with 1.84 m (6 ft) resolution. It launched on October 8, 2009 to become Digital Globe's third satellite in orbit, joining Worldview-II, which launched in 2007.

Table 1: Details of Satellite Data

Sr. No.	Satellite	Sensor	Month/Date of Acquisition	Number of Images
1.	Cartosat–I=Study Area	PAN and Multispectral	16 January, 27 February, 17April, 28 September, 12 December, 2007	1, 2, 2, 2, 1, respectively
2.	Worldview-II=Study Area	PAN and Multispectral	12 March, 12 April, 11 May, 12 May, 11 October, 11 December, 2012	31, 25, 73, 12, 7, 13, respectively

Cartosat-I satellite gathered stereoscopic images on 16 January (1), 27 February (2), 28 September (2), 12 December (1), 2012, and worldview-II, on 12 March (31), on 12 April

(25), 11 May (73), 12 May (12), 11 October (7), 11 December (13), 2012 with the help of, sensors PAN and Multispectral, Table 2. Number of images indicated in parentheses as shown in Table 1.

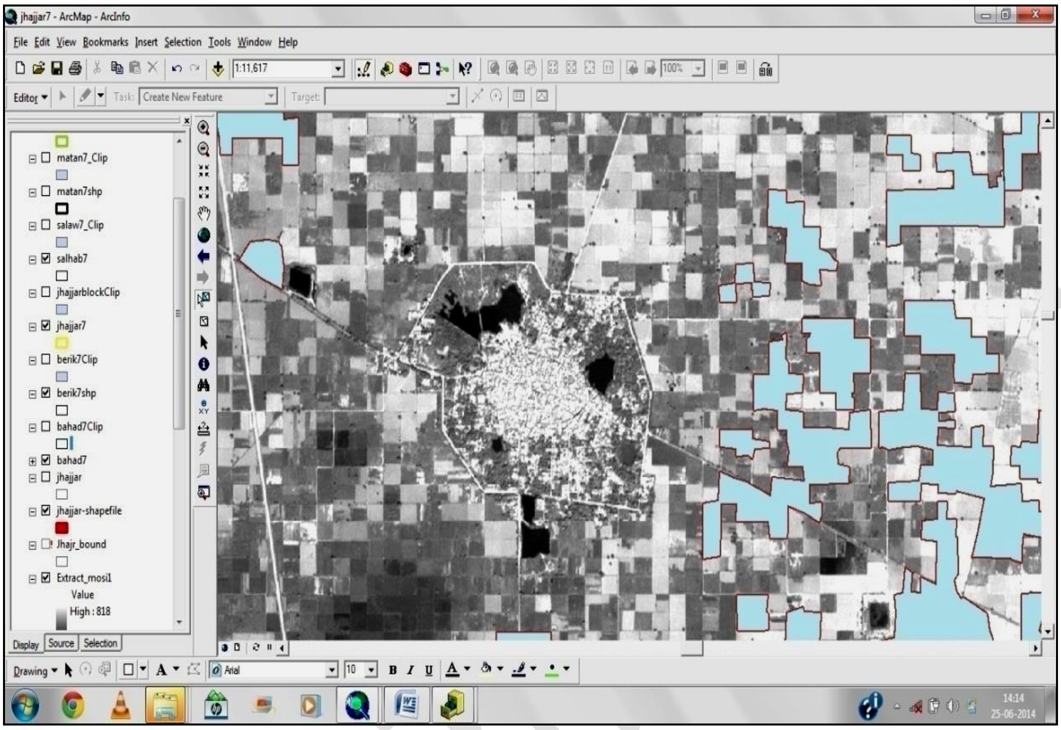

Fig. 4 Digitization of desurfaced soil in study area

Table 2: GPS locations of sampling sites (Ground Truth Points, Fig. 5**)**

Sr. No.	Block(Zone) (Study Area)	Latitude	Longitude
1	Meham	N 28°59′8.52″	E 76°19′45.228″
2	Lakhan Majra	N 29°02′29.148″	E 76°27′37.512″
3	Rohtak	N 28°56′32.208″	E 76° 43′5.628″
4	Sampla	N 28°49′48.612″	E 76°49′40.548″
5	Kalanaur	N 28° 51'.592"	E 76° 40'.520"

GPS locations of sampling sites in Meham (N 28°59′8.52″, E 76°19′45.228″), Lakhan Majra (N 29°02′29.148″, E 76°27′37.512″) Rohtak (N 28°56′32.208′, E 76° 43′5.628″) Sampla (N 28°49′48.612″, E 76°49′40.548″) and Kalanaur zones (N 28° 51'.592", E 76° 40'.520") are depicted in Table 2, along with latitude and longitude values indicated in parentheses.

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4.7 Ground truth points and sampling sites (Fig. 5)

Fig. 5 depicts GPS ground truth points visible in the figure, taken at the time of investigation survey of the study area.

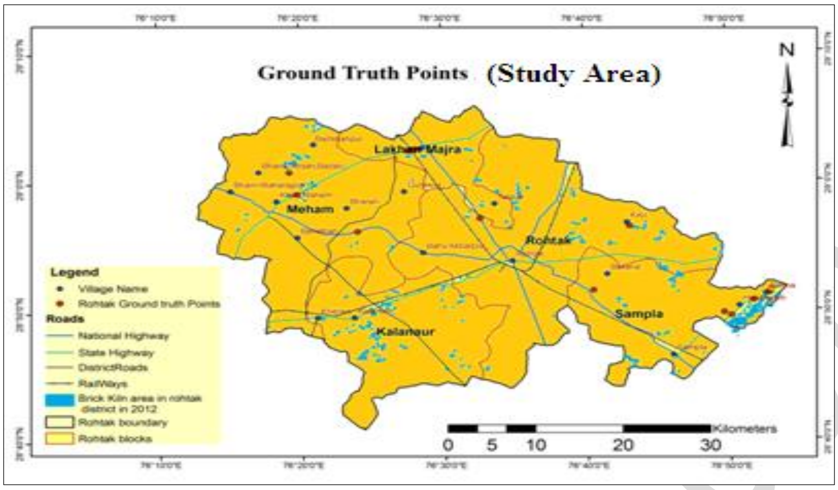

Fig. 5 Ground Truth Points and sampling sites

4.8 Physico-chemical analysis methods:

4.8.1 Mechanical analysis:

a. *Mechanical composition* of soil samples was determined using international pipette method [9] (Table 3)
b. *Bulk Density* was determined using method [1]
c. *Hydraulic Conductivity* was determined using method [11]

4.8.2 Chemical analysis methods:

i. *Soil pH:* Soil pH was determined in 1:2 soil: water suspension at room temperature with pH meter having glass electrode
ii. Electrical *Conductivity*: The EC of soil samples was determined in 1:2 soil: water suspension with a conductivity bridge at 25^{o}C, [11]
iii. *Organic Carbon*: Organic carbon was determined using Wakley and Black method [13] and Organic matter by multiplying OC with 1.724, Van Bemmelen factor
iv. *Available Phosphorus:* Available phosphorus determined using method [8]
v. *Available Potassium:* Available potassium was determined by flame-Photometer extracting with N Ammonium acetate, [11]

5. RESULTS AND DISCUSSION

5.1Physical properties

5.1.1 Soil fractions / texture:

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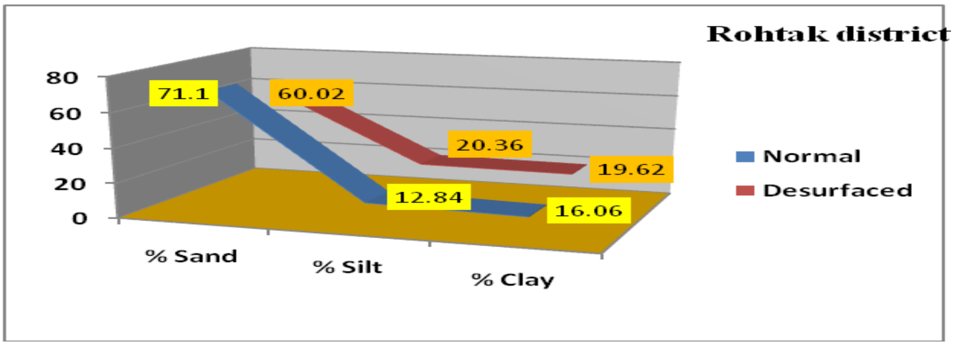

Fig. 6 Different fractions of soil in normal and desurfaced soils of the study area

Graphical representation in Fig. 6 reveals that sand percentage is higher in normal soil (71.10 %) as compared to exposed soil (60.02 %) in study area, [3]. The silt and clay content increased in exposed soil, *i.e*. silt from 12.84 - 20.36 % and clay from 16.06 - 19.62 %. That is because of migration of finer particles like silt and clay to lower depth with the movement of water in the soil profile.

5.1.2 Bulk Density:

The bulk density in normal soil of study area ranged between 1.19-1.47 Mg m^{-3} (Mean=1.32 Mg m^{-3}) and desurfaced soil ranged between 1.51-1.63 Mg m^{-3}(Mean=1.57 Mg m^{-3}) Bulk density of desurfaced soil found higher as compared to normal topsoil (Table 3.Fig. 7). Increase was of the order of 18.93 % in desurfaced soil as compared to normal soil. Higher bulk density in desurfaced soil attributed to decrease in organic matter content due to topsoil removal. Another reason of high bulk density values attributed to migration of finer particles, like clay and $CaCo_3$ to lower horizon and mechanization with heavy machinery in farm practices resulting into increased bulk density and decreased hydraulic conductivity of soil in lower horizon, [7] [5] [10].

Table 3 Effect of desurfacing on some physical properties of soil of selected sites

site location Block wise/Zone wise	Textural Class		Bulk Density (Mg m^{-3})		Hydraulic Conductivity (cm h^{-1})	
	N	D	N	D	N	D
Meham	**SL**	**L**	**1.33**	**1.60**	**0.79**	**0.31**
Lakhan Majra	**SL**	**L**	**1.47**	**1.63**	**0.68**	**0.29**
Rohtak	**SL**	**L**	**1.41**	**1.57**	**0.71**	**0.28**
Sampla	**SL**	**L**	**1.22**	**1.52**	**0.63**	**0.25**
Kalanaur	**SL**	**L**	**1.19**	**1.51**	**0.61**	**0.24**
Mean	**SL**	**L**	**1.32**	**1.57**	**0.68**	**0.27**

SL=Sandy Loam, L=Loam, N=Normal Soil, D=Desurfaced Soil,

Textural class in normal soil was sandy loam in all zones and in desurfaced soil, loam. Bulk density, Meham zone, 1.33 Mg m^{-3} in normal soil and 1.60 Mg m^{-3} in desurfaced soil was observed. Lakhan Majra, 1.47 Mg m^{-3} in normal soil and 1.63 Mg m^{-3} in desurfaced soil was observed. Rohtak zone, 1.41 Mg m^{-3} in normal soil and 1.57 Mg m^{-3} in desurfaced soil was observed. Sampla zone, 1.22 Mg m^{-3} in normal soil and 1.52 Mg m^{-3} in desurfaced soil was observed. Kalanaur zone, 1.19 Mg m^{-3} in normal soil and 1.51 Mg m^{-3} in desurfaced soil was observed.

Hydraulic conductivity, Meham zone, 0.79 cm h^{-1} in normal soil and 0.31 cm h^{-1} in desurfaced soil was observed. Lakhan Majra zone, 0.68 cm h^{-1} in normal soil and 0.29 cm h^{-1} in desurfaced soil was observed. Rohtak zone, 0.71 cm h^{-1} in normal soil and 0.28 cm h^{-1} in desurfaced soil was observed. Sampla zone, 0.63 cm h^{-1} in normal soil and 0.25 cm h^{-1} in desurfaced soil was observed. Kalanaur zone, 0.61 cm h^{-1} in normal soil and 0.24 cm h^{-1} in desurfaced soil was observed Table 3.

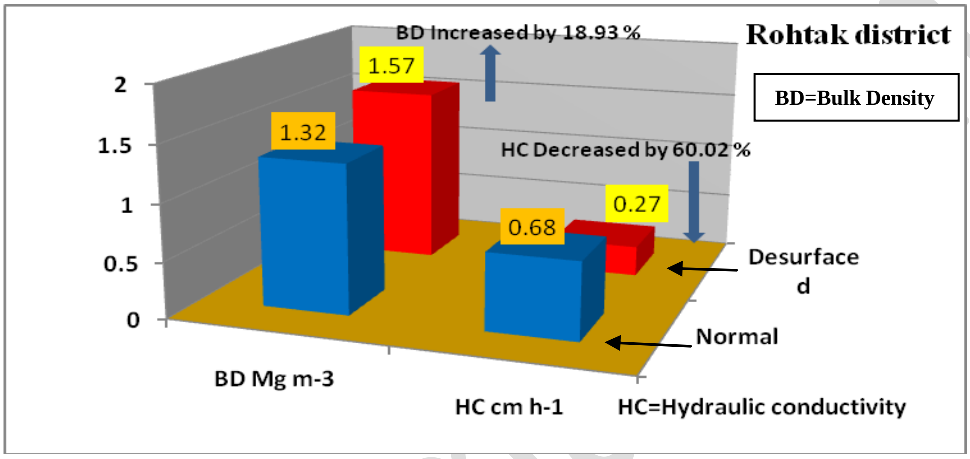

Fig. 7 Bulk Density (Mg m^{-3}) and Hydraulic Conductivity (cm h^{-1}) of Normal and Desurfaced soils of study area

Bulk density of soil of study area increased from 1.32 to 1.57 Mg m^{-3} in desurfaced soil. This adds to soil compaction and strength, which hinders root proliferation and penetration [5] [14], observed delayed plant emergence and reduced corn plant population.

5.1.3 Hydraulic Conductivity:

The hydraulic conductivity of normal soil of study area was recorded o.68 cm h^{-1} and desurfaced soil 0.27 cm h^{-1}. There is 60.29 % decrease in hydraulic conductivity in desurfaced soil as compared to normal soil in study area, affecting transmission of water adversely (Fig.7). It attributed to the fact that topsoil removal alters the resistance of surface aggregates of dispersion from surface flow providing rain drops energy, [4] where stability of aggregates for desurfaced soil was lower than normal soil. Unstable aggregates easily be broken down and can be transported through suspension, which can lead to crust formation and inhibits transmission of air and water into the soil profile.

5.2 Chemical properties:

Table 4 Effect of desurfacing on different chemical properties of soil of study area

Site	pH (1:2)		EC(dSm^{-1})(1:2)		O.C (%)		P (Mg ha^{-1})		K (Mg ha^{-1})	
Block/Zone	N	D	N	D	N	D	N	D	N	D

Meham	8.1	8.5	0.40	0.23	0.39	0.15	10.92	8.73	421.5	117.4
L.Majra	8.1	8.5	0.32	0.24	0.36	0.15	10.04	5.68	398.4	185.9
Rohtak	8.1	8.4	0.53	0.40	0.38	0.20	7.42	5.68	386.8	95.0
Sampla	8.0	8.6	0.41	0.20	0.44	0.15	7.42	5.24	555.4	201.7
Kalanaur	8.2	8.5	0.51	0.23	0.40	0.25	11.79	7.42	466.9	175.2
Mean	8.1	8.5	0.43	0.26	0.39	0.18	9.61	6.55	445.5	155.4

OC=Organic Carbon, EC=Electrical Conductivity, SL=Sandy Loam, L=Loam, N=Normal Soil, D=Desurfaced Soil, P=Phosphorus, K=Potassium

pH in normal soil ranged between 8.0-8.2, in desurfaced soil 8.4-8.6, slightly higher than normal soil.

Electrical conductivity (EC) ranged between 0.32 - 0.53 (d S m^{-1}) in normal soil and 0.20 - 0.40 (d S m^{-1}). Organic carbon (OC) ranged between 0.36 - 0.44 % in normal and 0.15 - 0.25 % in desurfaced soil, respectively.

Available phosphorus (P) content in normal soil ranged between 7.42 - 11.79 (kg ha^{-1}) and in desurfaced soil 5.24 - 8.73 (kg ha^{-1}).

Available (exchangeable) potassium (K) in normal soil ranged between 555.40 (kg ha^{-1}) - 386.80 (kg ha^{-1}) and desurfaced soil 95.60 - 201.70 (kg ha^{-1}),

Table 5 Descriptive Statistics of the soil of the study area

Character	Group	Assumptions	t	d.f.	Probability
BD	1&2	Equal Variances Assumed	5.9 **	16	0
		Unequal Variances Assumed	5.9	10.96	0.0001
HC	1&2	Equal Variances Assumed	18.6 **	16	0
		Unequal Variances Assumed	18.61	12.16	0
pH	1&2	Equal Variances Assumed	2.92 *	16	0.01
		Unequal Variances Assumed	2.92	15.5	0.0103
EC	1&2	Equal Variances Assumed	4.15 NS	16	0.0008
		Unequal Variances Assumed	4.15	15.42	0.0008
OC	1&2	Equal Variances Assumed	6.93 **	16	0
		Unequal Variances Assumed	6.93	14.06	0
P	1&2	Equal Variances Assumed	4.07 **	16	0.0009
		Unequal Variances Assumed	4.07	14.43	0.0011
K	1&2	Equal Variances Assumed	11.3 **	16	0
		Unequal Variances Assumed	11.34	13.43	0

** Significant ($LSD_{0.01}$), * Significant ($LSD_{0.05}$), NS=Non significant

Bulk density, hydraulic conductivity, organic carbon, available phosphorus, and available (exchangeable) potassium were found to be significant at $LSD_{0.01}$, and pH significant at $LSD_{0.05}$.

Electrical conductivity was found non-significant in all zones of Rohtak district, as depicted in Table 5.

5.2.1 pH of soil

Mostly soils under study are alkaline in nature, pH values ranging between 8.0 - 8.1 in normal soil and 8.1 - 8.5 in desurfaced soil of study area. Slightly higher pH observed in desurfaced soil as compared to normal soil (Fig.8).

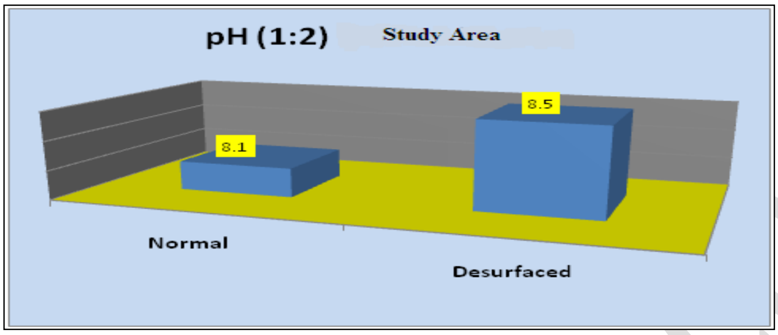

Fig. 8 pH values in normal and desurfaced soil of study area

5.2.2 Electrical Conductivity of soil

Slightly higher values of EC observed in case of normal soils as compared to desurfaced soils (Fig. 9) in soils of study area and ranged from 0.32 -0.51 dSm^{-1}. This may be associated with the fact that top soil gets loaded with excessive salts because of capillary rise due to high temperature and low rainfall, contributing to slightly high EC values to surface soil. Leaching of salts does not seem to be effective due to comparatively scanty rainfall in the region.

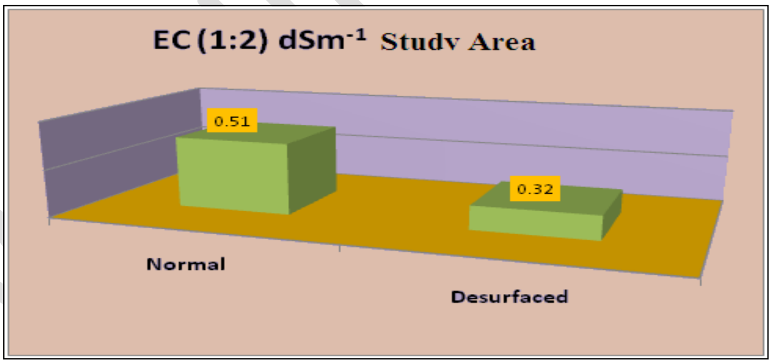

Fig. 9 EC (1:2) of normal and desurfaced soil of study area

5.2.3 Organic carbon in soil

Organic matter contains 58 % labile organic carbon. Organic carbon content was higher in normal soils of study area as compared to desurfaced soils as is evidenced in (Fig.10), and there is net reduction of 55 % organic carbon due to soil desurfacing [5], [14] observed similar results in their findings corroborating present study.

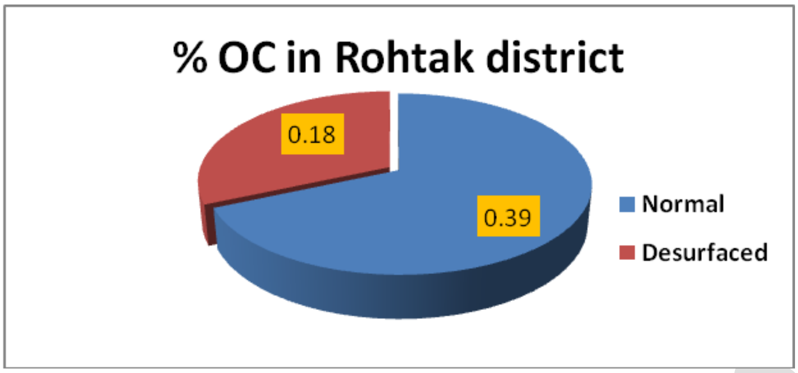

Fig. 10 Organic carbon content in normal and desurfaced soil of study area

This is attributed to the fact that in case of desurfaced soil, topsoil is completely lost in desurfacing process exposing lower horizon, which is inherently poor in organic matter content. Main seat of organic matter lies in topsoil (surface soil); continuous incorporation of crop residues in topsoil in presence of optimum moisture and temperature, soil microorganisms hasten the soil decomposition process and help in building organic matter level in topsoil, which is important for sustaining soil fertility, [12]. Because of desurfacing/surfacing mining, this reserve organic matter is lost in the process, leaving behind completely deprived of the organic matter, which is reservoir (storehouse) of all essential plant nutrients, macro as well as micro.

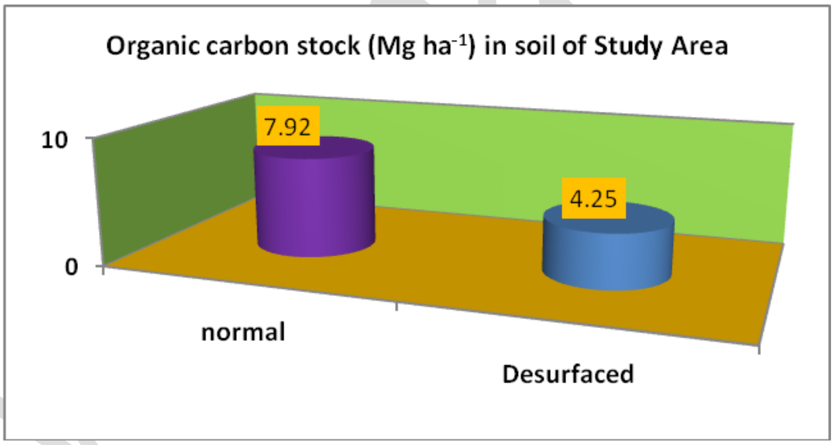

Fig. 11 Organic carbon stock in soils of the study area

Organic carbon stock (Mg ha^{-1}) = OC (%) x BD (Mg m^{-3}) x Soil Depth (cm)

Organic carbon stock in desurfaced soil of study area decreased by 46.46 % (From 7.92 Mg ha^{-1} - 4.25 Mg ha^{-1}) as compared to normal soil (Fig.11), Soil organic matter has profound influence on soil functions and various properties whether physical or chemical in nature. This ever-changing soil component exerts a dominant effect on many soil physical, chemical, and biological properties, especially in the surface horizons. Soil organic matter provides soil, cation exchange capacity, and water-holding capacity. Certain components of soil organic matter are largely responsible for the formation and stabilization of soil aggregates. Soil organic matter also contains large quantities of plant nutrients and acts as a slow-release nutrient storehouse. Organic matter also provides energy and bodybuilding constituents for microorganisms, which are responsible for various processes in soil system, bearing growth-

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stimulating effects on plants. Soil organic carbon is the index of soil organic matter in the soil.

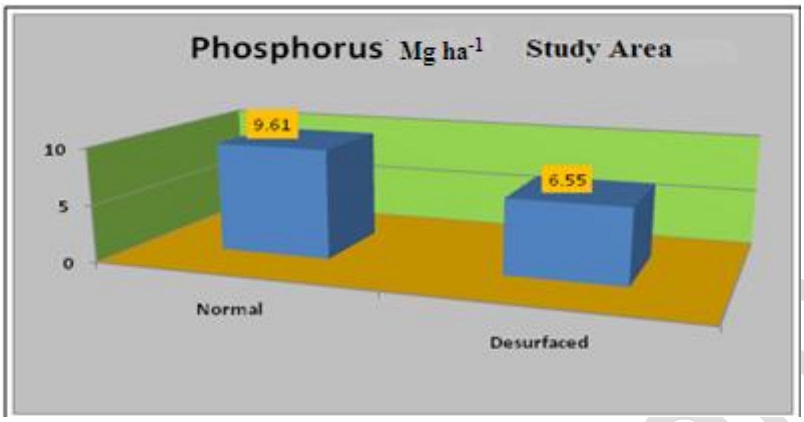

Fig. 12 Phosphorus (Mg ha^{-1}) content in normal and desurfaced soil

5.2.4 Available phosphorus

The process of land desurfacing significantly affects the availability of phosphorus in soil. Desurfacing of Soil invariably decreased available content of P by 31.87 % (Fig.12) at all locations in study area, significantly (Table 5). In normal soil, P ranged between 7.42 to 11.79 Mg ha^{-1} (Mean=9.61 Mg ha^{-1}) and in desurfaced soil 5.24 to 8.73 Mg ha^{-1} (Mean=6.55 Mg ha^{-1}) in study area. Among the nutrient elements, phosphorus is second only to nitrogen in its impact on the productivity and health of terrestrial and aquatic ecosystem. The total quantity of phosphorus in most native soils is low, with most of what is present in the forms quite unavailable to plants. Neither plants nor animals can survive without phosphorus. It is an essential component of the organic compound like adenosine triphosphate (ATP), which is the *energy currency* that drives most of the biochemical processes. Phosphorus is also an essential component of deoxyribonucleic acid (DNA), the seat of genetic inheritance.

5.2.5. Available (exchangeable) potassium

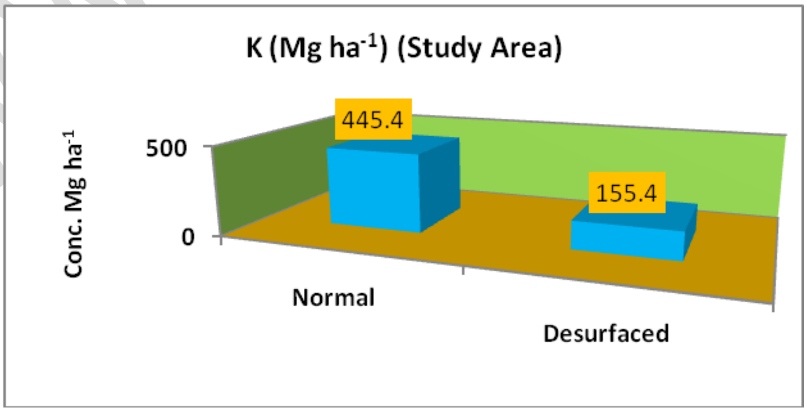

Fig. 13 Potassium content (Mg ha^{-1}) in normal and desurfaced soils

Depletion of available K content occurred more pronouncedly in desurfaced soil and was of the order of 65.11 per cent or even more at some locations in study area. Available (exchangeable) potassium in normal soil (Fig.13) ranges between 386.8 to 555.37 Mg ha^{-1}In desurfaced soil ranges between 95.04 to 201.65 Mg ha^{-1} (Mean=445.4 Mg ha^{-1} in normal soil and 155.4 Mg ha^{-1} in desurfaced soil)

The original sources of potassium in soil are the primary minerals, such as biotite, muscovite, and feldspar and mica and held between 2:1 type crystal layers (lattice), which become available to plants only after going through weathering processes. After weathering of primary minerals, there is formation of secondary minerals like silicate clays (2:1 and 3:1 type). Illite type (2:1) of secondary minerals is reach source of potassium, which are much prevalent in Haryana soils. However, weathered part of potassium in surface layer of soil is lost due to soil desurfacing/surface mining, leaving behind k deficient exposed soil.

CONCLUSION

Soil desurfacing by brick kilns for making bricks is on exponential increase and a potential threat to the soil health and soil productivity, particularly in rapidly developing urban areas of national capital region (NCR) of Haryana state (India). The present study demonstrates that the study area is highly engulfed in brick kiln activity. The study revealed that in this area in the year 2007, soil desurfaced area was 629.29 ha, which increased to 888.80 ha in the year 2012 (41.24% increase). There was about 40 % decline in wheat yield in desurfaced fields, [12] due to depleted fertility status of soils of study area. There was poor emergence of seedlings and tillering, resulting into poor yield. Study also demonstrates that almost all physical and chemical properties of soils of study area have deteriorated in their capacity to support plant growth and productivity of soil expressing in the form of dwindling soil fertility status of the study area.

- Bulk Density (Mg m^{-3}): Increased by 18.93 % in desurfaced/surface mined soil
- Hydraulic Conductivity (cm h^{-1}): Decreased by 60.02 % in desurfaced/surface mined soil
- Organic Carbon (%): Decreased by 53 % in desurfaced soil/surface mined soil
- Organic Carbon Stock Mg ha^{-1}): Decreased by 46.46 % in desurfaced/surface mined soil
- Available Phosphorus (kg ha^{-1}): Decreased by 31.87 % in desurfaced/surface mined soil
- Available/Exchangeable Potassium (kg ha^{-1}): Decreased by 65.11 % in desurfaced soil

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