SOIL FERTILITY LOSS AND HEAVY METAL ACCUMULATION IN AND AROUND FUNCTIONAL BRICK KILNS IN CACHAR DISTRICT, ASSAM, INDIA: A MULTIVARIATE ANALYSIS

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ABSTRACT

Observations from the study show that most of the brick industries in Cachar district of Assam have been established on agricultural land. The main objectives of the present study are (i) to find out the quality of soil in selected brick kilns: its degradation and (ii) heavy metal contamination due to making and firing of bricks. Available Nitrogen was estimated using Micro-Kjeldhal distillation unit, SOC was determined by Wet-digestion method, Potassium was estimated by Ammonium acetate method, Phosphorus was estimated by Bray-1 method and Sulphur was estimated by Turbidimetric method. ICP-OES (Perkin Elmer, Optima 2100 DV) was used for estimation of heavy metals in soil samples. The study reports that the level of soil Organic Carbon (OC) and available Nitrogen, Phosphorus, Potassium increased with the increase in distance i,e. 10m, 50m, 100m and 200m from the brick kiln chimneys. Soil pH ranged from 4.14 -5.9. The soil Sulphur level and selected heavy metals i,e. Pb, Cd, Cr and Ni were found in higher range at 10m distance from the kiln in comparison to 200m distance and considered as major environmental impact factor. The ANOVA result of soil physical, chemical factors and heavy metals show significant difference among the variables at $p<0.05$. The result of Pearson correlation matrix shows high significant positive correlations among the soil nutrient factors i,e. SOC and NPK but negative correlations with the heavy metal concentrations i,e. Pb, Cd, Cr, Ni and Sulphur with decrease in distance from the brick kilns. The Principal Component Analysis results show high loadings of Pb, Cd, Cr and Ni and considered as anthropogenic constituents released from the emissions from the brick kilns and cause hazardous impact. Hierarchical Cluster Analysis results reveal the deterioration and degradation of soil quality nearer to the brick kiln then compared to 200m distance. The results indicate that loss of fertility is an important impact along with accumulation of heavy metals which can have severe affect on biodiversity. Awareness camps and training programs can be arranged for the brick kiln workers regarding the guidelines of EIA and mitigation strategies to overcome soil quality deterioration and nutrient loss due to brick kilns.

***Key Words*:** Land degradation, Fertility loss, anthropogenic factors, deterioration, ANOVA.

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INTRODUCTION

Environmental pollution has become a serious environmental problem following industrialization. In our country fired clay brick is one of the most important building materials. These brick industries are unorganised small scale rural industries. Brick industries in Cachar district have great economic importance. The brick industries are responsible for large scale environmental pollution like land degradation, loss of fertility, water and air pollution etc. Singh & Asgher (2005) studied that bricks are made up of clay and good quality soil and as a result soil productivity reduces and causes loss of vegetation. Soil is generally regarded as the ultimate sink for heavy metals discharged into the environment and many of them are bound to soil. Anthropogenic inputs of heavy metals are associated with industrialization, agricultural practices, urban effluents and traffic emissions (Zakir *et al*., 2015). Brick kilns also make significant contribution to the heavy metal content in soil as observed by Bisht & Neupane (2015). Brick industries in Cachar are source of livelihood for local people but much of the agricultural land has been converted into brick industries which is a serious environmental issue. Air pollutants like Carbon monoxide, Sulphur dioxide, Nitrite, Nitrate and suspended particulate matters are produced by the combustion of coal, firewood, furnace oil, fuel gas and tyres in brick kilns as revealed by Maithel *et al*., (1999). The acid deposition from the brick kiln creates serious threat to human health also, as it contaminates air, agricultural land, drinking water and even food (Uprety, 2001). Bharnarker *et al*., (2002) reported that brick kilns are responsible for release of toxic substances which adversely affect soil quality, plant, amenity, heritage, animals and people residing in their vicinity. Brick kilns have become a serious environmental issue especially in developing countries and hence the present study was undertaken to assess physico-chemical properties like pH, available N, P, K, S, Soil Organic Carbon and accumulation of some heavy metals in soil i,e. Pb, Cd, Cr and Ni. There is a need to study brick kiln pollution with its impact on environment. The study will help understand the impact of soil degradation on agriculture, quality of biodiversity and the environment.

MATERIALS AND METHODS

Study Area

6 brick kilns (BK1, BK2, SC1, SC2, NB1, NB2) were selected from three localities i,e. Bariknagar, Silcoorie and Natunbazar from Cachar district for the study. Selection of brick kiln sites was based on their nearness to agricultural land to determine the contamination due to brick kilns. Soil sample collection was done through soil corer, at the depth of 0-30 centimetres from around the brick kilns. A total of 96 number of soil samples were collected seasonally from 6 brick kilns at the distance of 10m (Site S1,S5,S9,S13, S17,S21), 50m (SiteS2,S6,S10,S14,S18,S22), 100m (Site S3,S7,S11,S15,S19 andS23) and 200m (S4,S8,S12,S16,S20 and S24) in four directions from the chimney respectively. 16 soil samples were collected from each

brick kiln area and composite sampling was done. The soil samples were then transferred into sealed plastic bags and labelled appropriately. The soil samples were air dried after removal of external substances. Dried soil samples were then sieved using sieving apparatus with size >2mm. Sieved samples were then kept for further determination of soil properties and selected heavy metals following the methods used by Villanueva *et al*., (2008).

Determination of physico-chemical properties of soil

Available Nitrogen was estimated using Micro-Kjeldhal distillation unit given by Subiah & Asija (1956). SOC was determined by Wet-digestion method of Walkley & Black (1934). Measurement of pH was done (soil and water ratio 1:25) by glass electrode pH meter (Systronics digital pH meter 802). Potassium was estimated by Ammonium acetate method given by Hanway & Heidel (1952). Phosphorus was estimated by Bray-1 method (Bray & Kurtz, 1945). Sulphur was estimated by Turbidimetric method (Williams & Steinbergs, 1959).

Determination of Heavy metals (Pb, Cd, Cr and Zn) of soil samples

5gm of dry soil samples were taken in a beaker and mixed with 2 ml of aqua regia 1:3 (1 conc. HCL: 3 conc. HNO_3). The mixture was digested using fume chamber at 95°C for 1 hr and allowed to cool to room temperature. The supernatant was filtered and then diluted to 50 ml using distilled water. Pb, Cd, Cr and Zn were analyzed in the soil samples using ICP-OES (Perkin Elmer, Optima 2100 DV). The calibration standards were prepared using stock solutions of 100ppm (Perkin Elmer multi-element). For the multi-element calibration, 2% nitric acid (HNO_3) was used as blank.

Statistical Analysis

ANOVA and multivariate statistical analysis of data was done with the help of SPSS-21

RESULTS AND DISCUSSION

Impact on physico-chemical parameters of soil

In the present study higher level of pH ie 5.9 has been reported from Site S20 and lower pH was seen in Site S9 i,e. 4.14 (Table.1). The acidic level of pH in Site S9 indicates the presence of heavy metals which made the soil acidic also as acidity increases, the losses of the nutrients by leaching increases and their availability to plant decreases as also reported by Deshmukh (2013). The value of SOC ranged from 0.07% to 1.02%. SOC level was very low in Site S1 which might be due to the absence of flora and fauna which includes grasses, trees, bacteria, fungi, protozoa, earthworm and animal manure but higher in Site S16 which is at 200m away from the chimney and has sufficient similar observations was made by Piper (1966). The value of available Nitrogen ranged from 57.7 kg/hac in Site S9 to 202.4 kg/hac in Site S24 (Table.1). The low level of nitrogen is probably due to lack of vegetation, free living bacteria and rhizomes which plays a key role in nitrogen fixation and maintains the soil fertility level as also observed by Orlov (1992). The value of available Phosphorus ranged from 13.23 kg/hac in Site S9 to 43.3 kg/hac in Site S16 (Table.1). Phosphorus has been called the "Master key to agriculture". Lower level of

Phosphorus in soil occurred due to lack of vegetation and indicates poor soil quality as also reported by Tandon (1997). Potassium is a master nutrient for superior quality crop production. The value of available Potassium ranged from 49.7 to 170 kg/hac. Lower level of Potassium has been reported from Site S1 and higher level in site S24 which is possibly due to the release of Potassium ions from clay under high pH conditions or might be due to the use of fertilizers also observed by Singh & Ahuja (1990). The Sulphur level ranged from 3.9 to 16.73 kg/hac (Table.1). Higher level of S in Site S12 might be due to the presence of coal ingredients in the area as it is closest to the brick kiln i,e.10m where coal is used for brick making. Similar report has been made by Xing *et al*., (2013).

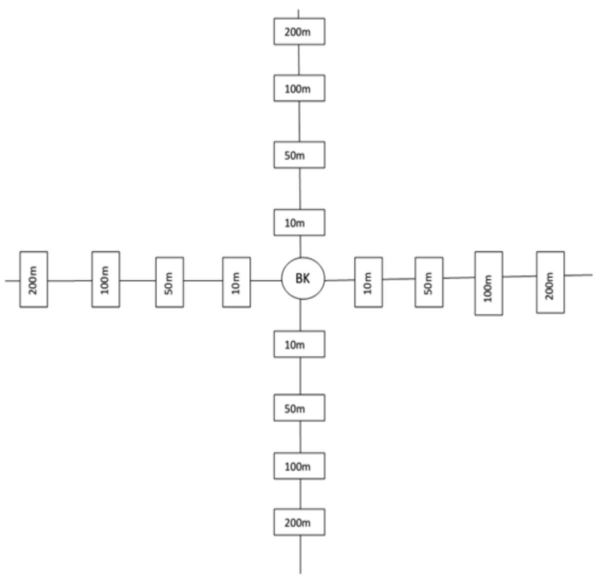

Fig.1. Pattern of soil sample collection from each site

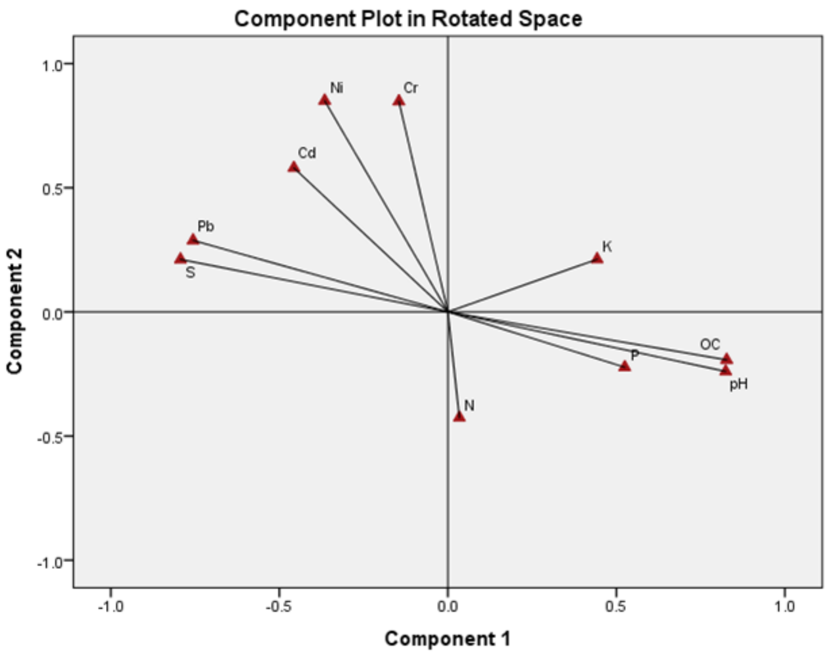

Fig.2. Principal component analysis loading plots for the rotated components

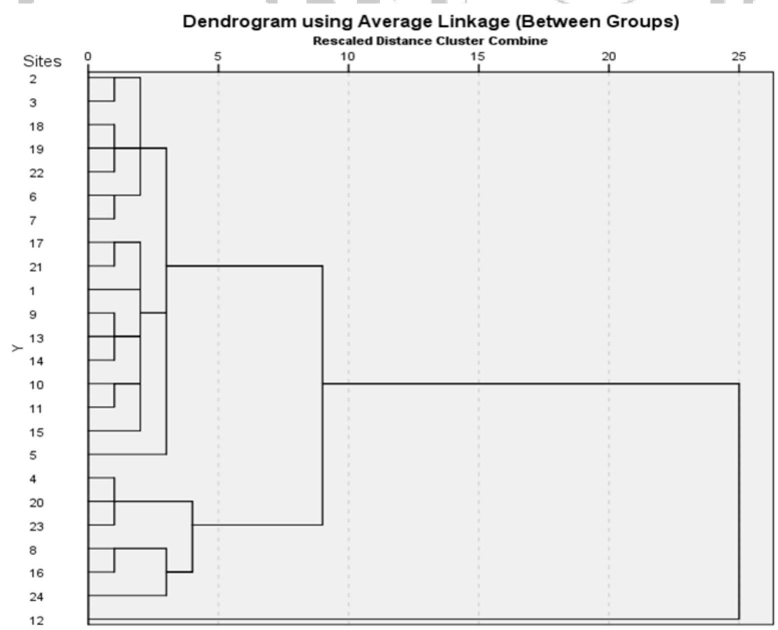

Fig.3. Cluster analysis of soil properties and heavy metals in different study sites

Table.1. Variation in soil physico-chemical parameters of 24 sites at different distances from the brick kilns

DISTANCE	SITES	pH	SOC (%)	N (kg/hac)	P (kg/hac)	K (kg/hac)	S (kg/hac)
10m	S1	4.16±0.11 (4.04-4.3)	0.07±0.02 (0.06-0.11)	93.56±4.8 (88.1-99.1)	15.69±0.9 (13.8-16.7)	49.7±3.9 (45.3-54.6)	15.8±1.1 (14.4-16.8)
	S5	4.44±0.25 (4.06-4.9)	0.15±0.03 (0.11-0.19)	106.7±7.02 (98.63-115.7)	20.6±2.5 (17.8-23.9)	115.03±7.6 (103.8-121.1)	16.73±2.8 (13.6-19.8)
	S9	4.15±0.29 (3.3-4.8)	0.15±0.04 (0.11-0.21)	57.7±7.4 (50.1-67.8)	13.23±1.9 (10.9-15.6)	56.25±6.4 (50.3-65.4)	6.96±1.2 (5.7-8.1)
	S13	4.4±0.34 (4.07-4.9)	0.21±0.05 (0.15-0.28)	73.72±3.9 (69.12-78.61)	16.8±3.2 (15.5-21.3)	107.5±6.8 (98.9-115.3)	9.9±1.3 (8.4-11.4)
	S17	4.25±0.43 (3.73-4.7)	0.19±0.03 (0.15-0.24)	98.46±4.3 (92.5-102.4)	22.07±2.5 (19.9-25.6)	104.75±6.8 (96.8-113.4)	13.04±1.7 (11.2-15.3)
	S21	4.28±0.25 (4-4.6)	0.15±0.03 (0.12-0.19)	171.03±4.42 (165.6-176.1)	17.5±1.8 (15.7-19.9)	112.42±8.1 (103.2-121.1)	9.2±0.8 (8.2-10.1)
50m	S2	4.31±0.2 (4.1-4.24)	0.09±0.03 (0.03-0.11)	104.06±7.9 (95.7-113.5)	16.1±0.5 (16.1-17.5)	51.16±3.1 (47.7-54.6)	11.3±1.4 (9.8-12.9)
	S6	4.5±0.35 (4.1-4.9)	0.29±0.02 (0.26-0.31)	128.67±5.7 (123.4-136.3)	27.17±4.1 (21.4-31.2)	131.7±9.7 (120.4-143.5)	14.45±1.3 (12.5-15.8)
	S10	4.3±0.36 (3.9-4.7)	0.17±0.02 (0.14-0.2)	64.2±4.9 (59.8-71.4)	17.47±2.6 (15.2-21.3)	77.37±6.5 (68.6-84.3)	4.12±0.5 (3.6-4.8)
	S14	4.3±0.36 (4.1-4.6)	0.55±0.07 (0.45-0.63)	89.96±7.2 (80.3-97.7)	16.92±2.8 (14.4-18.6)	111.75±10.2 (98.3-121.3)	7.4±0.9 (6.3-8.7)
	S18	4.19±0.19 (3.9-4.4)	0.38±0.06 (0.31-0.47)	112.8±2.9 (108.6-115.4)	16.95±3.4 (12.4-20.3)	120.9±8.9 (109.6-129.8)	11.28±1.5 (9.7-13.2)
	S22	4.23±0.21 (4.03-4.5)	0.31±0.03 (0.28-0.35)	177.5±6.8 (167.7-183.4)	21.6±2.6 (18.2-24.5)	72.23±5.1 (67.1-78.6)	7.9±0.5 (7.2-8.5)
100m	S3	4.54±0.22 (4.4-4.7)	0.14±0.02 (0.11-0.18)	127.4±4.34 (122.8-132.4)	17.36±1.7 (15.5-19.2)	64.75±4.3 (59.7-69.5)	10.09±1.1 (8.9-11.3)
	S7	5±0.36 (4.8-5.1)	0.38±0.07 (0.29-0.44)	137.22±5.7 (129.8-143.4)	26.4±3.7 (21.5-30.1)	134.13±5.7 (127.5-140.4)	13.17±1.7 (10.9-15.1)
	S11	4.5±0.21 (4-4.8)	0.29±0.04 (0.25-0.34)	74.98±4.7 (70.5-81.5)	23.8±4 (19.8-28.7)	81.6±5.5 (75.6-88.3)	4.8±0.1 (4.1-5.8)
	S15	4.37±0.22 (4.1-4.7)	0.15±0.07 (0.64-0.82)	154.03±9.3 (145.3-167.1)	37±3.2 (32.9-40.4)	139.1±3.8 (133.6-142.1)	8.4±1.08 (7.4-9.9)
	S19	4.5±0.22 (4.2-4.7)	0.56±0.05 (0.49-0.62)	141.46±5.8 (136.6-149.6)	21.27±5.1 (16.8-28.4)	120.1±5.7 (114.2-127.1)	10.21±1.7 (8.4-12.6)
	S23	4.3±.13 (4.1-4.4)	0.68±0.02 (0.64-0.71)	189.2±4.6 (183.6-194.6)	33.3±2.8 (30.7-36.5)	85.32±4.1 (79.6-89.6)	5.75±0.4 (5.1-6.6)
200m	S4	5.77±0.12 (5.5-6.1)	0.47±0.03 (0.43-0.5)	144.35±4.6 (139.6-150.3)	21.3±1.9 (19.8-24.1)	97.75±2.8 (95.03-101.6)	6.83±0.8 (5.9-7.6)
	S8	5.5±0.13 (5.2-5.9)	0.66±0.05 (0.59-0.73)	146.47±6.7 (138.6-154.3)	40.9±7.4 (31.3-47.5)	150.8±6.2 (143.5-157.8)	7.48±0.9 (6.4-8.6)
	S12	5.25±0.17 (4.8-5.6)	0.43±0.06 (0.36-0.52)	83.8±5.5 (75.8-88.1)	31.3±2.6 (28.3-34.4)	90.52±6.3 (84.2-98.4)	3.9±0.5 (3.2-4.4)
	S16	5.35±0.13 (5.2-5.5)	1.02±0.1 (0.89-1.12)	160.63±7.12 (152.3-189.3)	43.3±4.6 (38.3-49.3)	156.3±6.35 (150.4-163.5)	5.25±0.6 (4.6-5.9)
	S20	5.9±0.13 (5.5-6.1)	0.66±0.05 (0.59-0.73)	151.97±5.3 (146.6-157.2)	24.47±5.9 (16.5-30.1)	144.2±10.2 (132.2-156.3)	4.88±0.9 (3.6-5.6)
	S24	5.5±0.22 (5.3-5.8)	0.8±0.03 (0.77-0.85)	202.4±3.2 (194.6-213.2)	41.17±3.2 (37.2-44.8)	170.03±5 (163.5-175.6)	4.9±0.4 (4.3-5.4)

Table.2. Heavy metals concentrations at 24 sites at different distances from the brick kilns

DISTANCE	SITES	Pb	Cd	Cr	Ni
10m	S1	72.94±17.9 (53.5-96.9)	3.32±2.6 1.09-6.5	31.61±8.6 (24.8-43)	29.53±3.1 (27.06-33.3)
	S5	55.4±8.8 (44.5-59.19)	3.19±1.8 (1.4-5)	92.53±21.3 (74-123.05)	105.45±20.6 (83-126.55)
	S9	94.75±21.8 77-125.7	6.03±2.2 (3-8)	45.62±8.2 (34.5-54.35)	43.37±16.1 (29.35-64.6)
	S13	75.65±18.3 (522-95.6)	8.48±2.2 (5.5-10.9)	62.18±8.03 (53-70.5)	76.15±19.7 (57.8-98.68)
	S17	154.43±16.5 (137.63-170.5)	2.8±1.1 (1.6-4)	27.59±16.1 (9.5-44.7)	34.67±5.9 (26.5-39.4)
	S21	117.22±26.3 (84.5-148.06)	8.28±0.9 (7-9.2)	23.31±8.6 (15.5-34.4)	41.18±11.8 (28.4-56.7)
50m	S2	49.02±13.2 (32.5-64.16)	1.1±0.6 (0.4-1.8)	14.14±11.9 (3.5-27.06)	22.95±4.3 (17.8-28.25)
	S6	46.52±19.7 (24.5-68.59)	0.74±0.3 (0.3-1.23)	58.36±26.2 (34.5-93.6)	59.49±25.3 (37.28-93.75)
	S10	50.67±11.3 (37.5-65.05)	3.75±1.2 (2.5-5.5)	24.35±13.8 (10-39.15)	26.93±7.08 (16.9-322.6)
	S14	51.35±7.8 (44.8-62.5)	5.3±1.5 (4-7.5)	37.78±14.8 (24-52.1)	54.19±26.5 (37.1-93.2)
	S18	79.23±18.08 (59-102)	2.28±1.2 (1.29-4)	14.95±14.5 (5.5-36.57)	23.21±9.01 (11.26-32.85)
	S22	77.05±12.9 (61.5-89.5)	2.27±1.8 (0.5-4.84)	10.83±10.1 (4.5-26.01)	38.39±13.5 (21.15-51.5)
100m	S3	35.86±6.7 (27-42.7)	1.19±0.7 (0.4-2.1)	14.12±3.3 (10.15-18.74)	13.08±4.2 (7.6-15.9)
	S7	36.64±21.3 (16-63.8)	0.96±0.6 (0.3-1.4)	23.39±11.5 (14-39.07)	39.65±16.1 (17.52-53.91)
	S11	33.67±6.6 (29-43.16)	2.73±1.2 (1.9-4.5)	33.6±8.2 (27.4-45.3)	20.86±4.7 (16.25-27.38)
	S15	32.72±4.2 (27.6-37.5)	4.05±1.6 (2.5-5.9)	32.79±12.3 (21.5-47.08)	33.9±6.8 (27.49-34.35)
	S19	48.90±9.4 (36.2-58.9)	1.52±1.04 (0.6-3)	9.13±8.5 (4-21.81)	15.67±9.5 (5.96-28.22)
	S23	49.53±13.02 (37-65.9)	0.71±0.5 (0.3-1.5)	78.47±4.5 (2.5-13.27)	19.18±6.3 (9.98-24.31)
200m	S4	12.42±6.5 (3-17.66)	0.59±0.3 (0.5-0.21)	4.99±4.8 (1-11.7)	9.19±5.6 (5.12-17.4)
	S8	2.8±2.6 (nd-5.5)	0.49±0.7 (nd-1.5)	4.64±5.2 (0.5-1.8)	28.31±12.2 (10.62-37.81)
	S12	1.11±0.9 (nd-1.9)	0.014±0.02 (0-0.036)	8.16±2.7 (5.1-11.73)	14.9±3.1 (11.85-18.85)
	S16	2.19±1.3 (0.14-3.15)	0.46±0.3 (0.14-1)	19.6±8.8 (12-31.51)	25.72±4.9 (21.3-32.7)
	S20	25.20±4.4 (21.5-31.5)	0.4±0.7 (nd-1.5)	8.96±2.3 (5.5-10.37)	8.47±3.4 (5.4-13.26)
	S24	5.9±4.3 (0.94-10.5)	0.15±0.16 (0.02-0.4)	4.66±2.7 (1.6-7.8)	7.9±2.4 (5.18-11.05)

Table.3.Pearson Multiple Correlation matrix among different soil parameters (pH,OC,N,P,K,S) and heavy metals (Pb,Cd,Cr,Ni) in 24 different study sites

Parameters	pH	OC	N	P	K	S	Pb	Cd	Cr
OC	**0.71****	1							
N	**0.27****	**0.37****	1						
P	**0.52****	**0.65****	**0.59****	1					
K	**0.45****	**0.54****	**0.53****	**0.58****	1				
S	**-0.64****	**-0.77****	**-0.31****	**-0.64****	**-0.46****	1			
Pb	**-0.65****	**-0.67****	**-0.30****	**-0.63****	**-0.38****	**0.62****	1		
Cd	**-0.47****	**-0.48****	**-0.45****	**-0.61****	-0.24*	**0.48****	**0.66****	1	
Cr	**-0.38****	**-0.40****	**-0.48****	**-0.37****	-0.17	**0.40****	**0.43****	**0.45****	1
Ni	**-0.56****	**-0.48****	**-0.33****	**-0.35****	-0.03	**0.47****	**0.42****	**0.58****	**0.70****

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table.4. Principal Component analysis of different experimented variables at different study sites

Rotated Component Matrix			
Soil quality factors	**Component**		
	PC1	**PC2**	**PC3**
pH	**0.82**	-0.24	0.09
OC	**0.83**	-0.19	0.29
N	0.03	-0.43	**0.84**
P	**0.53**	-0.22	**0.67**
K	0.44	0.21	**0.76**
S	**-0.79**	0.21	-0.23
Pb	**-0.76**	0.29	-0.22
Cd	-0.46	**0.58**	-0.28
Cr	-0.15	**0.85**	-0.21
Ni	-0.37	**0.85**	0.06
Eigen value	3.40	2.27	2.06
% of variance	34.01	22.77	20.61
Cumulative %	34.01	56.78	77.39

Impact of heavy metal on soil

The average metal concentration showed a diverse variation with respect to the distance. Based on the mean value the abundance of the heavy metals in the study sites followed the order Pb>Ni>Cr>Cd. The analyzed soil samples observed across all directions revealed that Pb concentration ranged from 1.11-154.43 mg/kg (Table.2). Higher concentration of Pb was observed almost among all the sites at 10 m distance from the brick kiln chimney and maximum in site S17 i,e. 154.43 mg/kg which is more than the desirable value i,e. 85 mg/kg in unpolluted soil according to WHO (1996). It may be due to burning of coal and tyres during baking of bricks, while at 200m distance i,e site S12 it was low, indicating the fact that there is decrease in soil contamination along with the increase in distance from the kiln chimney (Achakzai *et al*., 2015). Hassan *et al*., (2012) reported that Nickel has been considered to be an essential trace element for human and animal health. The soil concentration of Nickel was found in the range of 7.9 to 105.45 mg/kg (Table.2). The desirable limit of Ni is 35 mg/kg and maximum permissible limit is 210 mg/kg according to WHO (1996) which shows that the range of Ni was found to be more than the desirable limits in the study sites. The highest concentration of Ni was found in site S5 i,e.105.45mg/kg which is more than the target value and lowest concentration in site S24 i,e. 7.9 (Table.2). The concentration of Chromium ranged from 4.64-92.53 mg/kg. Highest concentration was reported in site S5 i,e. 92.53 mg/kg which was found to be more than the desirable value when compared to WHO standards; similar observations were also made by Iqbal *et al.*, (2011). Lowest concentration of Cr was observed in site S8 i,e. 4.64 mg/kg at 200m distance from the brick kiln chimney (Table.2). Similar results were reported earlier (Achakzai *et al.*, 2015; Ismail *et al*., 2012) where they also noticed variations of Cr concentration with distance from brick kilns. The Cd concentration in soil samples ranged from 0.014mg/kg in site S12 to 8.48mg/kg in site S13 which is at 200m distance from brick kiln (Table.2). The highest concentration of Cd in site S13 may be due to the fallout from the brick kiln chimneys which consist of heavy load of dust possess heavy metals that contaminate the soil at 10 m distance indicated higher pollution near the brick kiln chimneys. Similar observations were also made earlier by Ismail *et al.*, (2012) where they found heavy metals in the dust samples showing that Cd and Cr are added into environment from brick kiln chimney.

Statistical analysis Results

All data were checked for normality and homogeneity of variances using one-sample Kolmogorov-Smirnov test prior to statistical analysis. Then the entire data was log transformed to perform further statistical analysis like One Way ANOVA, Pearson Correlation, PCA and HCA.

One Way ANOVA

One way ANOVA was performed to find out the significant difference among the soil quality variables i,e. pH, OC, N, P, K, S and heavy metals Pb, Cd, Cr and Ni in twenty four different sites ($p<0.05$). The result of one way ANOVA shows significant difference in the mean value of soil physico-chemical factors and heavy metals in twenty-four different sites at $p \leq 0.05$. The data was then further analyzed to find out the correlation among the different soil parameters.

Multiple Correlation

Table.3. presents Pearson Correlation matrix and shows that that soil pH has strong negative correlation with Sulphur and the level of heavy metals Pb, Cd, Cr and Ni in the soil indicates the fact that acidic condition of the soil may be due to the presence of heavy metals also recorded by Gupta (2009). Soil OC shows strong positive correlation with soil pH, Nitrogen, Phosphorus and Potassium and shows strong negative correlation with Sulphur and other heavy metals present in the soil i,e. Pb, Cd, Cr, Ni which shows that soil fertility is inversely proportional to the soil toxicity. Table.3.shows that heavy metals Pb, Cd, Cr and Ni had an negative relationship between their accumulation rate and concentrations of SOC, nitrogen, phosphorus, potassium and pH which indicates that with an increase in heavy metal concentration a significant decrease in the fertility factors of soil, as the distance reduced from the brick kiln chimney. Similar studies were also carried out by Bisht &Neupane (2015). Soil nitrogen shows high positive relation with soil pH, Phosphorus and Potassium as they are all soil nutrient factors and responsible for soil fertility status, so they directly influence the presence of each other while moving away from the brick kiln as also reported by Rai *et al*., (2009). Soil Phosphorus and Potassium shows strong positive correlation with soil pH. Sulphur shows strong negative correlation with soil pH, SOC, N, P and K are highly positively significant with Pb, Cr and Ni which suggested that Sulphur accumulation was directly proportional to heavy metal accumulation and can be considered as an anthropogenic factor added to the soil due to brick kiln emissions also observed by Zakir *et al*., (2015), Ismail *et al*., (2012).

PCA

The results of PCA for physico chemical properties and heavy metal contents in soil near brick kilns are shown in Table.4. Out of total 10 factors three factors has been extracted having Eigen values more than 1. Three component model accounts for 77.39% of all the data variation. In the rotated component matrix, the first PC (PC1, variance of 34.01 %) included pH, SOC, P, S, Pb while the second PC (PC2, variance of 22.77%) was constituted by Cd, Cr and Ni and PC 3 with 20.61% variance includes N, P, K (Table.4). Spatial representation of the two rotated components is shown in Figure.2 and its high-variability observed in the present study. In PC1 pH, SOC, S, and Pb show high loading points and P shows moderate loadings. pH, SOC,P are negatively correlated with S and Pb along with the increasing distance from the brick kiln chimneys. In PC2 Cr and Ni show high loading points while Cd shows moderate loading. These may be considered as anthropogenic constituents released from the brick kiln chimneys as also observed by Quishlaki & Moore, (2007) and Sena *et al*., (2002). In PC3 N and K shows high loadings and P shows moderate loading points (Fig.2).

HCA

Fig.3 illustrates the resulting dendrogram using Bray –Curtis similarity index obtained by clustering soil property data. The result of HCA shows two clusters. The sites which are at 10m and 50m distances are in cluster one and sites at 200m distances are in cluster two. The result shows no similarity in soil quality between the study sites at 10m distances and 200m distances and also have different nutrient level, similar findings were made by Das *et al*., (2012).

CONCLUSION

It can be concluded after the analysis of soil samples taken from different distances from brick kilns that the soil quality is degrading due to increase in heavy metal content and decrease in soil nutrient factors like soil OC, N, P, K and S. The soil nutrient factors were increasing slowly with the increasing distance from the brick kiln chimneys. The soil pH was acidic near the brick kiln chimney indicating contamination due to heavy metals which decreased with the increasing distance from the chimneys. Gupta, (2009) and Deshmukh, (2013) also reported similar findings. The soil OC content and available N, P, K level examined had similar trend with increasing distance from the brick kilns. The increase in heavy metal concentrations nearer the chimney of the kiln clearly indicates the fact that soil quality soil quality, productivity and soil health is degrading, as was also observed by Rahman *et al*., (2001). The fertile agricultural land is used for manufacturing of clay brick per kiln resulting in land degradation, degradation of herb density, soil micro flora and fauna also micro-nutrient disorder in plants and trees in the immediate vicinity and thus contributing towards global warming, also revealed by Pawar *et al*., (2011). Therefore, it is highly recommended to follow several conservation strategies to protect land from degradation and loss. Periodic survey and monitoring of brick kilns are required to know whether they are following the EIA guidelines or not. Also as per the present study distance from brick kilns is an important factor, therefore residential areas, schools, and roads should be at least 500m (or preferably more) away from the brick kiln chimneys. Proper plantation is required, as per study 200m distance is suitable for vegetation so we can minimize the soil degradation and environmental pollution from the brick kiln chimneys by planting trees along with proper mitigation strategies.

ABBREBIATION

SOC- Soil Organic Carbon, ANOVA- Analysis Of Variances, PCA- Principal Component Analysis, HCA- Hierarchical Cluster Analysis, EIA- Environmental Impact Assessment

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