SKUAST Journal of Research 27(4): 557-564; (2025)
(*DOI No. 10.5958/2349-297X.2025.00065.2*); NASS rating: 4.88

Research Paper

Physico-chemical properties of soils as affected by cement dust pollution around Khrew industrial area of Kashmir valley

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(Received May 30, 2025; accepted July 21, 2025)

ABSTRACT

The present study was conducted to assess the effect of cement dust pollution on Physico-chemical properties of soil around Khrew Industrial area of Kashmir. Three cement industries (Max, Arco and JK) were selected for the purpose and a total of one hundred composite soil samples were collected from different distances around the cement plants and analyzed. The results showed that soil pH ranged from 6.92-8.77, 6.90-8.75 and 6.95-8.80, with mean values of 8.10, 8.11 and 8.13 around Max, Arco and JK cement factories, respectively. The soils were slightly to moderately alkaline in nature. The average value of EC of soils was found to be 0.17, 0.17 and 0.19 dSm^{-1} at Max, Arco and JK cement industries respectively. The per cent organic carbon content of soils of Max, Arco and JK cement plants ranged from 0.22-1.22, 0.23-1.14 and 0.21-1.10, respectively. The average $CaCO_3$ content of soils around Max, Arco and JK cement industries was 17.11, 17.17 and 17.20%, respectively. Cation exchange capacity of soils ranged from 13.88-17.00, 13.83-17.00 and 13.92-17.10 Cmol (P^+) kg^{-1}), around Max, Arco and JK cement factories, respectively. The organic carbon content was lower towards the polluted sites i.e., closer to cement plants, whereas, soil pH, EC, $CaCO_3$ content and CEC showed an increasing trend towards the cement polluted sites. Cement industries were found to adversely affect the physico-chemical properties and nutrient status of the soil.

Key words: Agriculture, cement dust, pollution, physico-chemical properties

Cement industry is one of the 17 most pollutant industries listed by central pollution control board. Air pollutants generated by the cement manufacturing process consist primarily of alkaline particulates from the raw and finished materials. The soil no longer has its natural cover of vegetation and the natural exchange of gases between soil and air is greatly reduced. These soils lack organic matter and soil organisms die due to lack of food. The direct effects of cement dust pollution are alkalization of the ecosystem and change of the chemical composition of soils. Cement dust pollution has a negative effect on the physico-chemical properties and the biological activity of the soil. Pollutant particles can enter into soil as dry, humid or occult deposits and can undermine its physico-chemical properties (Laj and Sellegri, 2003). Al-Omran *et al.* (2011) collected soil samples at two depths (0-5 and 20-30 cm) in the vicinity of cement factory and indicated that the soil samples were calcareous in nature with 22.1 to 35.5% $CaCO_3$ with higher percentages in the surface soil samples taken near the cement factory, sandy loam to loamy sand in texture and moderately to slightly alkaline pH. Exchangeable calcium contents ranged from 1.4 to 5.44 c.mol.kg^{-1} while the mean values of exchangeable potassium reached 0.32 cmol.kg^{-1}.

The cation exchange capacity (CEC) was low to medium (1.94 to 8.14 cmol.kg^{-1}). Khamparia *et al.* (2012) reported that cement dust pollution significantly increased the soil pH, electrical conductivity and calcium carbonate content. Cement dust accumulation resulted in increase in soil solution pH, salinity, calcium carbonate, electrical conductivity, and total alkalinity and sulphate contents beside the disturbance of soil texture (Amal *et al.*, 2012). The increasing number of cement factories in Kashmir because of government promotion and local demand led to the blooming of major industry which is mainly operational near Khrew area. Cement dust forming a thin layer get deposited on the adjacent agricultural fields and thus has resulted degradation of soil quality and soil health. In comparison to gaseous air pollutants, only limited studies have been carried out to study the effect of cement dust on soil physico-chemical properties in temperate Kashmir. Thus, keeping in view, the present investigation was carried out to study the impact of cement dust on soil physico-chemical properties around cement factories of Kashmir.

MATERIALS AND METHODS

Study area and study sites: The present research work was carried in 2018-19 on comparative basis between polluted and pollution-free sites selected from the cement manufacturing plant of Jammu and Kashmir located at Khrew (Pulwama). Ninety seven (97) composite soil samples were collected from surface soils (0-15 cm) at an interval of 100 m distance from three cement plants in all directions, besides this three reference/control composite soil samples one from each cement plant were collected at a distance of 6 km.

Collection and processing of soil samples: One Hundred composite surface soil (including three reference/control) samples were collected at a depth of 0-15 cm around three cement industries in order to give due representation to the micro-environment at each site. The soil samples after thoroughly mixing were collected in air tight polythene bags and brought to the laboratory. Coarse concretions, stones and pieces of roots, leaves and other undecomposed organic residues were removed. The soil samples were then air-dried and ground using wooden mortar and pestle and sieved through 2 mm sieve for laboratory investigations.

Soil analysis: Soil pH was determined in 1:2.5 soil: water suspension using pH meter as described by Jackson (1973). Electrical conductivity was measured in the supernatant solution of 1:2.5 soil:water suspension using digital conductivity meter (Jackson, 1973). The organic carbon content was determined by wet digestion method of Walkley and Black (1934). Schollenberger's method of leaching the soil with neutral ammonium acetate and determination of ammonical nitrogen (Jackson, 1973) was followed to determine cation exchange capacity of the soils. Calcium carbonate was estimated by adopting the rapid titration method as outlined by Piper (1966).

RESULTS AND DISCUSSION

Physico-chemical characteristics of the soils: The data on soil physico-chemical properties around different cement plants is presented "Table 1(a)", 1(b)"and 1(c)" and "Figure 1(a)", 1(b)", and 1(c)", are discussed as below: The data revealed that soil pH ranged from 6.92-8.77, 6.90-8.75 and 6.95-8.80, with mean values of 8.10, 8.11 and 8.13 around Max, Arco and JK cement factories, respectively. The soil pH showed an increased trend towards the polluted sites and was highest at 0.1 km distance from the cement plants, and decreased when moved away from the industries. The soils around the studied cement industries were slightly to moderately alkaline in nature. This elevation of soil pH at nearer sites of cement industry was due to high level of dust deposition characterized by elevated salinity because of high content of mineral salts, like $CaCO_3$, K_2O etc. and presence of Ca in the cement dust as oxide, hydroxide and carbonates of lime that increased the pH. Similar findings were earlier reported by Raajasubramanian *et al.* (2011) and Khamparia *et al.* (2012). The EC of soils around Max, Arco and JK cement industries varied from 0.06-0.28, 0.05-0.26 and 0.08-0.30 dSm^{-1}, with average values of 0.17, 0.17 and 0.19 dSm^{-1}, respectively. The cement dust showed a positive effect on EC of soils as the EC increased when one moved towards the cement plants. The results could be attributed to increased ionic concentration in the soil as a result of cement dust. Lone (2005) also reported an increase in the electrical conductivity of soils in the vicinity of Khrew cement factory.

Table 1a: Physico-chemical characteristics of soils around max cement industry, Khrew

Sample No.	pH (1:2.5)	EC (dS m^{-1})	OC (%)	$CaCO_3$ (%)	CEC (Cmol (P^+) kg^{-1})
1	8.77	0.28	0.22	20.00	17.00
2	8.75	0.25	0.22	19.96	17.00
3	8.72	0.24	0.23	19.95	16.97
4	8.72	0.24	0.27	19.85	16.92
5	8.70	0.22	0.27	19.76	16.66
6	8.70	0.22	0.28	19.77	16.68
7	8.70	0.23	0.30	19.77	16.72
8	8.69	0.24	0.30	19.80	16.74
9	8.68	0.24	0.32	19.82	16.74
10	8.68	0.26	0.32	19.92	16.88
11	8.65	0.20	0.33	19.00	16.59
12	8.61	0.20	0.35	18.53	16.31
13	8.57	0.18	0.35	18.12	16.22
14	8.50	0.18	0.37	17.86	16.12
15	8.47	0.17	0.39	17.73	16.00
16	8.40	0.16	0.42	17.48	15.96
17	8.32	0.16	0.43	17.36	15.78
18	8.24	0.16	0.44	17.26	15.72
19	8.10	0.15	0.44	17.12	15.60
20	8.00	0.15	0.44	16.68	15.50
21	7.92	0.14	0.47	16.36	15.41
22	7.84	0.13	0.57	16.25	15.33
23	7.77	0.13	0.62	15.92	15.20
24	7.62	0.13	0.64	15.78	15.11
25	7.53	0.13	0.66	15.40	15.00
26	7.50	0.12	0.70	15.00	15.00
27	7.43	0.12	0.75	14.87	14.95
28	7.38	0.11	0.77	14.68	14.71
29	7.35	0.11	0.78	14.30	14.59
30	7.30	0.10	0.80	14.18	14.50
31	7.30	0.10	0.82	13.88	14.44
32	7.28	0.10	0.84	13.77	14.40
33	7.27	0.09	0.84	13.50	14.40
34	6.92	0.06	1.12	12.16	13.88
Range	**6.92-8.77**	**0.06-0.28**	**0.22-1.12**	**12.16-20.00**	**13.88-17.00**
Mean	**8.10**	**0.17**	**0.50**	**17.11**	**15.74**
S.D	**0.59**	**0.05**	**0.13**	**2.35**	**0.94**
C.V (%)	**7.28**	**29.41**	**26**	**13.73**	**5.97**

Table 1b: Physico-chemical characteristics of soils around Arco Cement Industry, Khrew

Sample No.	pH (1:2.5)	EC (dS m^{-1})	OC (%)	$CaCO_3$ (%)	CEC (Cmol (P^+) kg^{-1})
1	8.75	0.26	0.23	19.96	17.00
2	8.74	0.26	0.23	19.90	16.98
3	8.72	0.24	0.24	19.90	16.95
4	8.70	0.23	0.28	19.82	16.84
5	8.68	0.21	0.28	19.80	16.80
6	8.68	0.22	0.29	19.80	16.80
7	8.70	0.23	0.30	19.80	16.82
8	8.70	0.24	0.30	19.82	16.82
9	8.71	0.24	0.33	19.82	16.85
10	8.69	0.25	0.33	18.88	16.88
11	8.64	0.20	0.34	18.65	16.47
12	8.61	0.20	0.36	18.40	16.30
13	8.58	0.18	0.36	18.30	16.22
14	8.49	0.17	0.37	17.93	16.12
15	8.47	0.17	0.40	17.70	16.00
16	8.32	0.16	0.43	17.48	15.90
17	8.20	0.15	0.43	17.34	15.78
18	8.12	0.15	0.45	17.26	15.71
19	8.10	0.15	0.45	17.10	15.60
20	8.00	0.15	0.46	16.68	15.50
21	7.88	0.13	0.46	16.36	15.41
22	7.80	0.13	0.58	16.25	15.31
23	7.76	0.13	0.62	15.90	15.20
24	7.60	0.13	0.65	15.78	15.11
25	7.51	0.13	0.68	15.40	14.98
26	7.50	0.11	0.70	15.00	14.96
27	7.41	0.11	0.75	14.84	14.93
28	7.36	0.10	0.78	14.66	14.70
29	7.32	0.10	0.79	14.30	14.57
30	7.29	0.09	0.81	14.15	14.50
31	7.28	0.09	0.83	13.86	14.44
32	7.24	0.09	0.85	13.75	14.40
33	6.90	0.05	1.14	12.16	13.83
Range	**6.90-8.75**	**0.05-0.26**	**0.23-1.14**	**12.16-19.96**	**13.83-17.00**
Mean	**8.11**	**0.17**	**0.50**	**17.17**	**15.78**
S.D	**0.59**	**0.05**	**0.13**	**2.26**	**0.94**
C.V (%)	**7.27**	**29.41**	**26**	**13.16**	**5.95**

Table 1c: Physico-chemical characteristics of soils around JK Cement Industry, Khrew

Sample No.	pH (1:2.5)	EC (dS m^{-1})	OC (%)	$CaCO_3$ (%)	CEC (Cmol (P^+) kg^{-1})
1	8.80	0.30	0.21	20.10	17.10
2	8.79	0.29	0.21	19.96	17.00
3	8.74	0.27	0.22	19.86	16.95
4	8.71	0.27	0.25	19.88	16.83
5	8.70	0.24	0.25	19.80	16.83
6	8.71	0.25	0.27	19.82	16.80
7	8.73	0.26	0.29	19.83	16.82
8	8.74	0.26	0.30	19.83	16.83
9	8.74	0.26	0.31	19.84	16.85
10	8.77	0.27	0.31	18.86	16.85
11	8.65	0.22	0.32	18.67	16.89
12	8.62	0.20	0.33	18.52	16.63
13	8.59	0.20	0.35	18.31	16.46
14	8.51	0.20	0.37	17.90	16.34
15	8.44	0.18	0.39	17.75	16.10
16	8.32	0.18	0.40	17.48	15.98
17	8.22	0.17	0.41	17.36	15.78
18	8.15	0.17	0.41	17.27	15.74
19	8.12	0.16	0.42	17.12	15.60
20	8.10	0.16	0.42	16.69	15.53
21	7.90	0.15	0.45	16.36	15.41
22	7.81	0.14	0.48	16.27	15.35
23	7.77	0.14	0.52	15.92	15.20
24	7.62	0.13	0.61	15.80	15.13
25	7.53	0.13	0.65	15.43	15.10
26	7.52	0.13	0.67	15.10	15.10
27	7.44	0.13	0.71	14.89	14.97
28	7.36	0.12	0.73	14.68	14.72
29	7.33	0.12	0.75	14.38	14.59
30	7.31	0.11	0.77	14.20	14.52
31	7.29	0.11	0.78	13.88	14.44
32	7.25	0.11	0.79	13.77	14.42
33	6.95	0.08	1.10	12.20	13.92
Range	**6.95-8.80**	**0.08-0.30**	**0.21-1.1**	**12.20-20.10**	**13.92-17.10**
Mean	**8.13**	**0.19**	**0.47**	**17.20**	**15.84**
S.D	**0.59**	**0.05**	**0.12**	**2.26**	**0.95**
C.V (%)	**7.25**	**26.31**	**25.53**	**13.13**	**5.99**

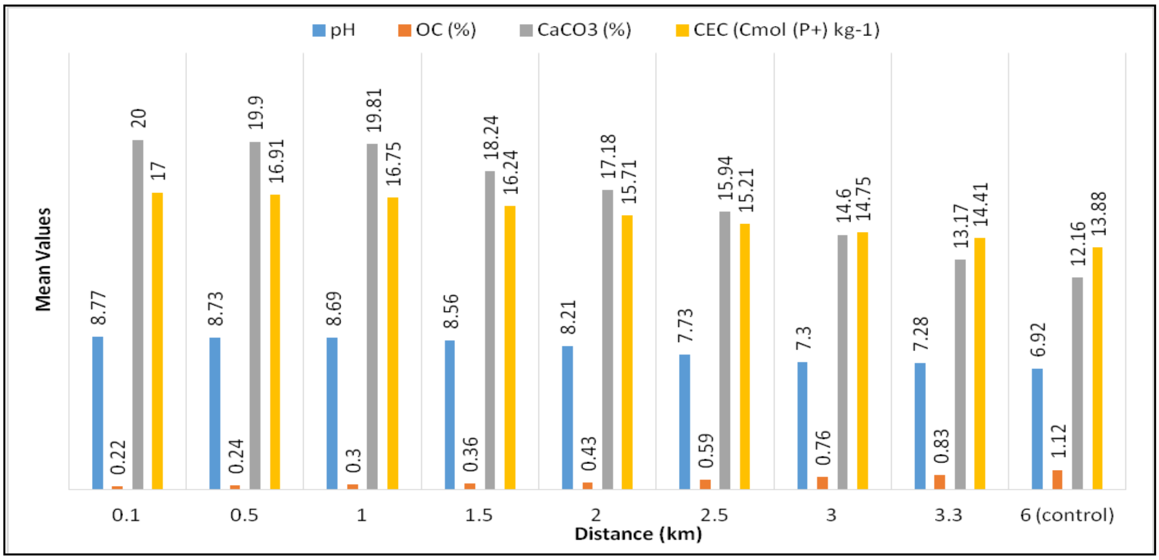

Fig. 1a: Physico-chemical characteristics of soils around Max Cement Industry, Khrew

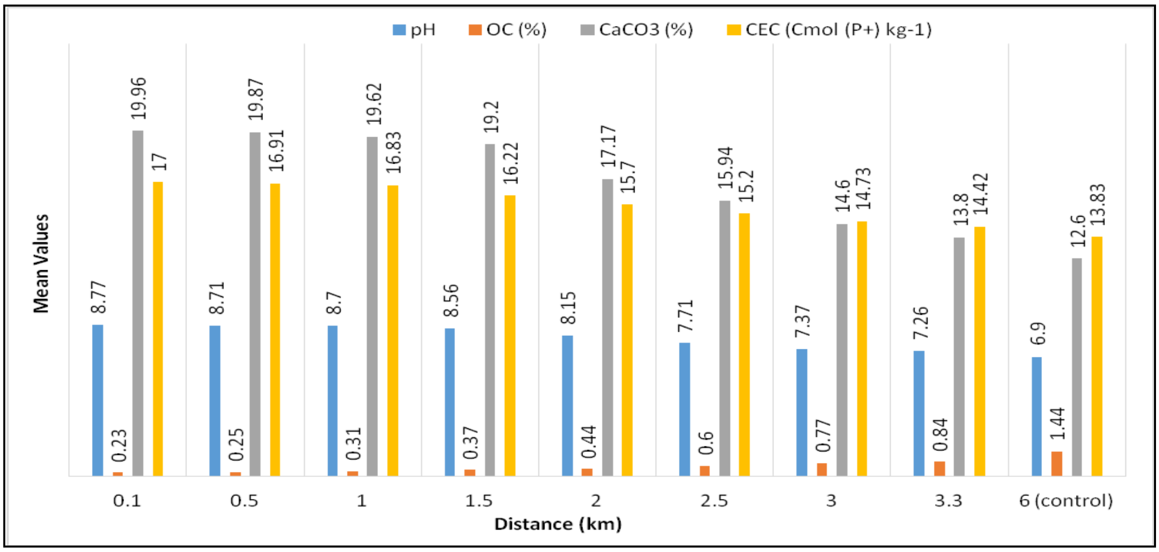

Fig. 1b: Physico-chemical characteristics of soils around Arco Cement Industry, Khrew

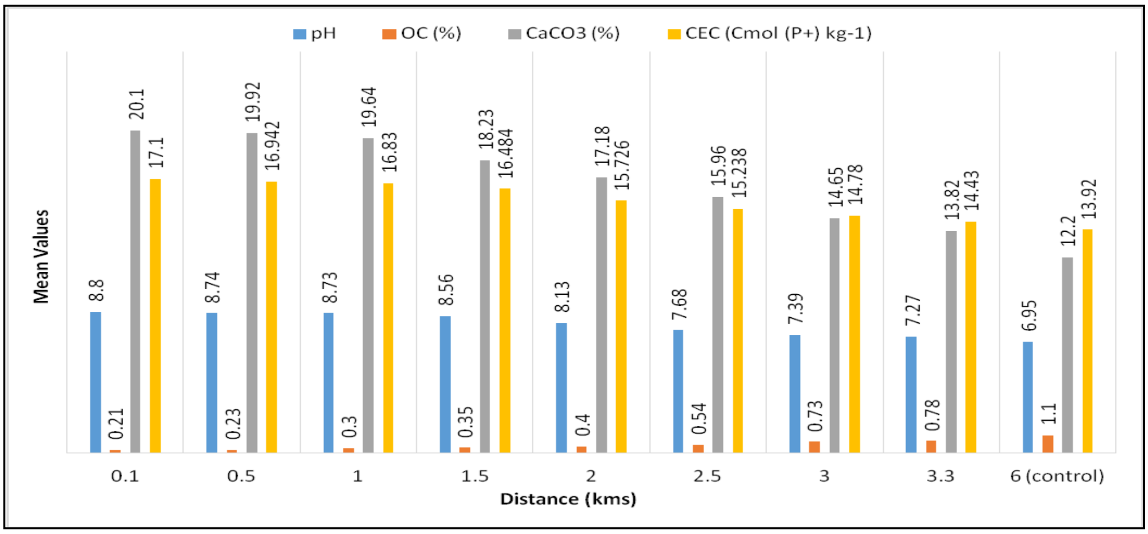

Fig. 1c: Physico-chemical characteristics of soils around JK Cement Industry, Khrew

The per cent organic carbon (OC) content of soils around Max cement industry ranged from 0.22 to 1.22 with average value of 0.50, around Arco cement plant. It varied from 0.23-1.14 per cent with average value of 0.50 per cent, and at JK cement plant OC content ranged from 0.21-1.10 per cent with average value of 0.47 per cent. The organic carbon content was low up to 2.2 km, medium up to 2.9 km and high beyond 3 km distance from the cement plants. Amount of organic carbon content depend on the accumulation and decomposition of organic matter in to the soil. Similar results were observed by Pandey *et al.* (2011), Khamparia *et al.* (2012), Solanki and Parihar (2017) and Oludoye and Ogunyebi (2017). The $CaCO_3$ content of soils around Max, Arco and JK cement industries varied from 12.16-20.00, 12.16-19.96 and 12.20-20.10%, with average values of 17.11, 17.17 and 17.20%, respectively. The cement dust showed a positive effect on $CaCO_3$ content of soils, as an increasing trend was observed, when one moved towards the cement plants. It could be attributed to the fact that the dust coming out from the cement factory contains particulates of calcite, a dominant mineral of cement. Ade-Ademilua *et al.* (2008) and Al-omran *et al.* (2011) have also reported higher $CaCO_3$ content in the soils around cement polluted areas. The data revealed that CEC of soils ranged from 13.88-17.00, 13.83-17.00 and 13.92-17.10 Cmol (P^+) kg^{-1}, with mean values of 15.74, 15.78 and 15.84 around Max, Arco and JK cement factories, respectively. The CEC showed an increasing trend towards the polluted sites and was highest at 0.1 km distance from the cement plants, and decreased when one moved away from the industries. Cation exchange capacity being a measure of the quantity of readily exchangeable cations in the soil showed positive impact to dust pollution. The dust polluted soil witnessed a sharp rise in exchangeable cations like Ca^{2+}, Mg^{2+} and K^+ that might have increased the cation exchange capacity of the soil. Similar results have also been reported by Zerrouqi *et al.* (2008), Bilen (2010) and Oludoye and Ogunyebi (2017).

CONCLUSION

The soil pH showed in increasing trend towards the cement polluted sites and were slightly to moderately alkaline in nature. Cement dust had a positive effect on soil EC, as the electrical conductivity increased with proximity to the cement plants. The organic carbon content was lower towards the more polluted sites i.e. closer to cement plants. The organic carbon content was low up to 2.2 km, medium up to 2.9 km and high beyond 3 km distance from the cement plants. The cement dust showed a positive effect on $CaCO_3$ content and CEC of soils, as an increasing trend was observed, when one moved towards the cement plants. It is seen that the cement dust adversely affect the physico-chemical properties and nutrient status of soil. Hence it is recommended that well established agro-forestry systems such as alley cropping should be established in the degraded lands.

CONFLIT OF INTEREST

All the authors affirm that there is no conflict of interest among them. All research activities comply with relevant legal, institutional and ethical standards.

AUTHOR CONTRIBUTION

All the authors contributed equally in the present study.

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