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The Physico-Chemical Characteristics of Soil Parameters from Multan Industrial Area, Pakistan

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Abstract: An experiment was conducted to verify the soil physical and chemical contamination nearby Multan Industrial Estate (MIE). Six parameters consisting of pH, Organic Matter (OM%), Zn, Cu, Cd and Pb were taken as representatives for the study from five sites out of which the farthest two sites were chosen as control. Physico-chemical parameters were determined by using standard techniques of Atomic Absorption Spectrophotometer (AAS). The results showed significant relationship among parameters at ($P<0.05$, $P<0.01$ and $P<0.001$). First two sites near industrial area expressed high level of contamination of metals. The distribution of trace metals was observed in order of Zn> Pb> Cu> Cd which explains that out of four elements, Zn and Pb contributed prominent level of absorption in the soil. It is suggested such practices should be ceased at the earliest that increased the level of soil pollution.

Key words: Soil physico-chemical properties · Contamination · Multan Industrial Estate

INTRODUCTION

Trace metal contamination of soil due to anthropogenic activities especially industrialization [1, 2] is of major concern now-a-days [3]. This blemish of soil depends upon the soil types and the way by which soil is being used [4, 5]. Metal contamination not only affects soil but also water resources including river [6] and lakes [7]. The principal outcome of this soil contamination leads to influence on growth metabolism, development and reproduction to plants [8, 9] and the people whom are exposed [10, 11]. Many studies highlight the importance of contamination of most of agricultural soils of Pakistan including Multan [12], Lahore [13], Peshawar [14], Karachi [15] and some studies in northern region [16, 17]. So here we projected an experiment where we collected soil of five sites that is to say S1, S2, S3, S4 and S5 from Multan Industrial Estate (MIE). (A picture of map of MIE can be seen in Fig. 1).

MATERIALS AND METHODS

MuItan Industrial Estate (MIE) is located at a distance of about 15 km south west of Multan city. It has total area of 667 acres with industrial plots of 426 acres and infrastructure of 241 acres (Fig. 1). Types of industries working here are chemical, textile, flour mills, animal feed, paper, leather and engineering [18]. The area of this region is even, alluvial plain and is also used for agriculture purpose [12, 19]. The five sites (S1, S2, S3, S4 and S5) were at a distance of 3, 5, 7, 9 and 15 km respectively out of which sites S4 and S5 were taken as control. A total of 36 soil samples were collected from MIE and nutrients were determined by Atomic Absorption Spectrophotometer (AAS) (Schimadzu, AA-670) and data was obtained in mg/kg. Calibration curve was prepared using working standards for each element [20, 21]. The numerical data created from AAS were then subjected to statistical procedures including basic statistics (mean, standard deviation, standard error and quartiles test) and correlation matrix by using software [22].

RESULTS AND DISCUSSION

The descriptive statistics of soil physico-chemical properties are presented in the Table 1. The mean, standard deviation (S.D.) and quartiles (Q) of 36 samples are discussed. The mean pH of all samples was 6.67 with maximum 8.3 and minimum 5.2. It means most of the samples attained a slight alkaline pH. Among four heavy

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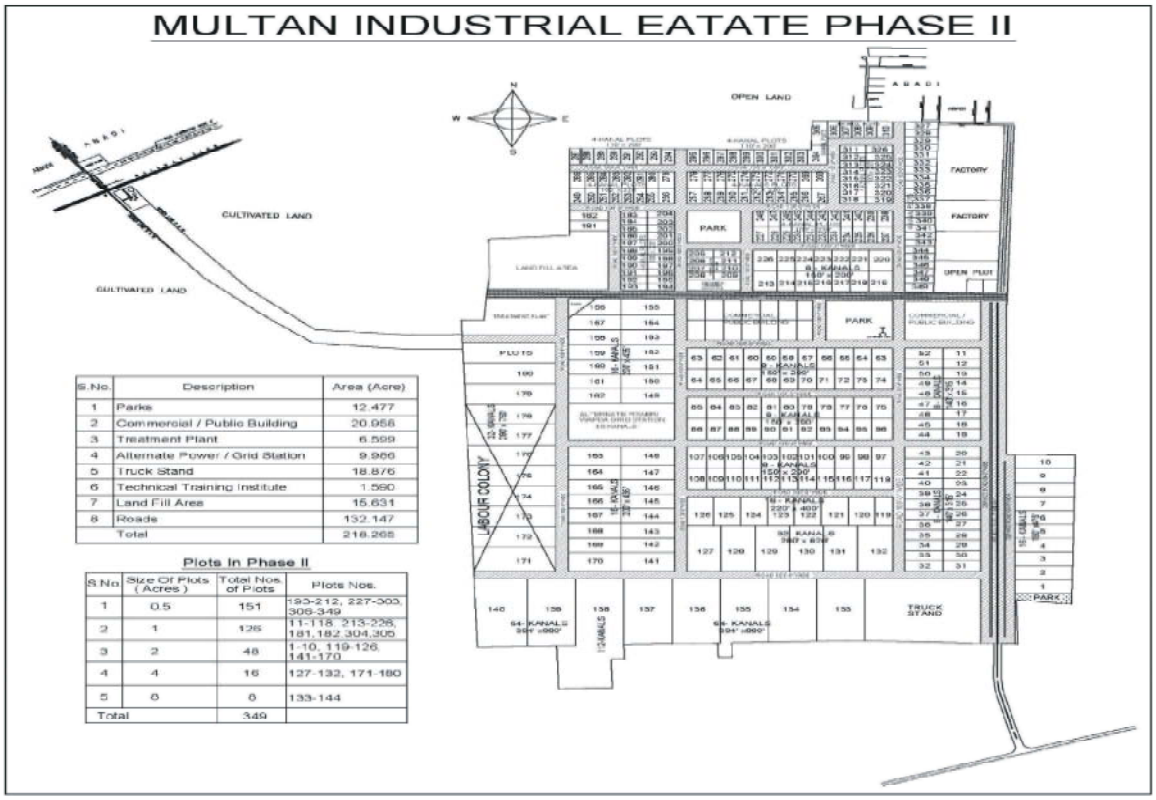

Fig. 1: A detail map of Multan Industrial Estate (MIE) taken from Punjab Industrial Estate (www.pie.com.pk) official website. The data is owned by Development and Management Company Government of Punjab, Pakistan

Table 1: Descriptive statistics of soil physical and chemical properties of 36 samples from five sites

Variable	Mean	Median	St. Dev.	S.E	Min	Max	Q1	Q3
pH	6.675	6.65	0.834	0.139	5.2	8.3	6	7.3
OM%	21.09	17.15	13.54	2.26	4.7	65.2	10.6	26.82
Zn	1366	524	1392	232	140	4890	222	2570
Cu	82.9	31.5	104.2	17.4	9	560	22	114.7
Cd	23.14	5.5	27.77	4.63	1	98	2	39.75
Pb	625	106	1145	191	10	4620	36	848

Where St. Dev. = Standard Deviation, S.E. = Standard Error, Min = minimum, Max = maximum, Q1 = Quartile 1, Q3 = Quartile 3

Table 2: The Pearson Correlation matrix of six variables (physical and chemical parameters) of 36 samples collected from MIE

	pH	OM	Zn	Cu	Cd
OM	-0.49				
Zn	-0.513	0.629			
Cu	-0.43	0.561	0.665		
Cd	-0.117	-0.032	0.357	0.173	
Pb	-0.259	0.518	0.564	0.398	0.352

metals i.e., Zn, Cu, Cd and Pb, the two metals Zn and Pb have higher values with the mean 1366 and 625, respectively. Also these metals explained elevated standard deviation as compared to other heavy metals. Hence it is observed that the values of Zn and Pb explained vast discrepancy in their values (as we can see the minimum and maximum values of Zn (140 and 4890 and S.D. = ±1392) and Pb (10 and 4620 and S.D. = ±1145) respectively). The lower values were pragmatic in case of organic matter, Cu and Cd with the small S.D. i.e., ±13.54, ±104.2 and ±27.7 respectively reported in other studies [23].

We checked relationship of all six parameters taken from 36 samples by using the Pearson correlation matrix (Table 2). The level of significance for critical values of r' (the Pearson correlation coefficient) are significant at

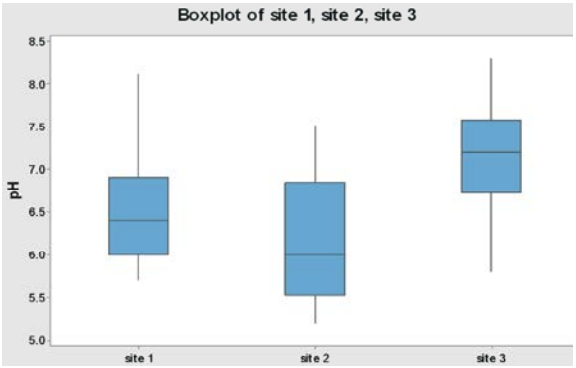

Fig. 2a: Box and Whisker Plot of pH of three sites (S1, S2, S3)

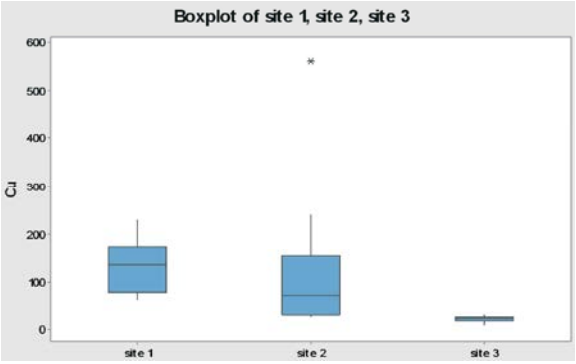

Fig. 2d: Box and Whisker Plot of Cu of three sites (S1, S2, S3)

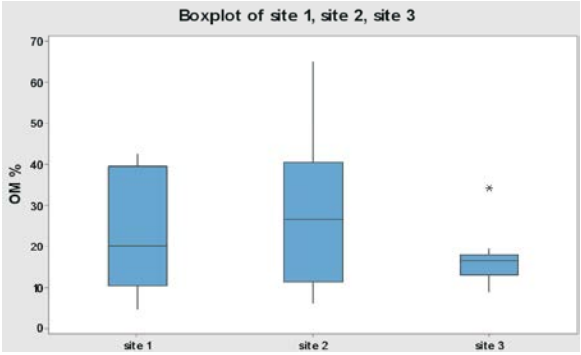

Fig. 2b: Box and Whisker Plot of OM% of three sites (S1, S2, S3)

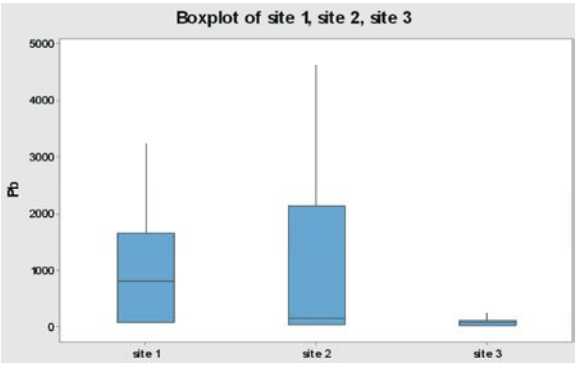

Fig. 2e: Box and Whisker Plot of Pb of three sites (S1, S2, S3)

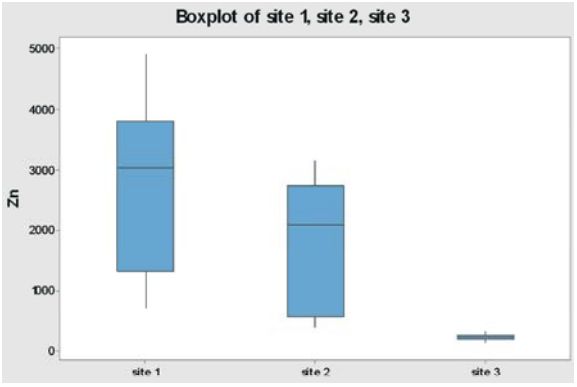

Fig. 2c: Box and Whisker Plot of Zn of three sites (S1, S2, S3)

0.349, 0.449 and 0.554 as (P<0.05), (P<0.01) and (P<0.001) respectively. The matrix (Table 2) shows nine positive and six negative values in which most of the values (i.e., 12 values) are significant at (P<0.05, P<0.01, P<0.001). The pH established negative relationship with all parameters. This negative relationship explains that decrease in pH will ultimately accountable for the increase in concentration of all parameters. Organic Matter (OM%) showed significant relationship with Zn, Cu and Pb. Individual Zn explained a strong positive association with all parameters at (P<0.01). This strong positive relationship shows that rise in Zn increase other metal concentration. Pb showed strong correlation with other parameters too at considerable level.

We adopted approach where we used three sites for box and whisker analysis as the data from other sites (S4 and S5) are small. The box plots of site 1, site 2 and site 3 for all six parameters are shown in the Figs. (2a, 2b, 2c, 2d, 2e, 2f). The pH showed mean values of all three sites in the range of 6.0 to 7.0. The lowest pH was observed from site 2 whereas the highest pH was seen in site 3 touching the values up to 8.4. The Organic Matter (OM%) from three sites (Fig. 2b) offered the higher values from Site 1 and Site 2 whereas site 3 represented the least values of organic matter. Two outliers were apparent in the box plot in case of organic matter and Cu. These outliers represent that the values of these two samples were scattered from the mean value. The next four box plots represent metal concentration of soil (i.e., Figs. 2c, 2d, 2e, 2f respectively). The common thing observed in these plots is that site 3 explained the lowest values of Cu, Zn, Cd and Pb. First site of Zn, Cu and Cd showed the

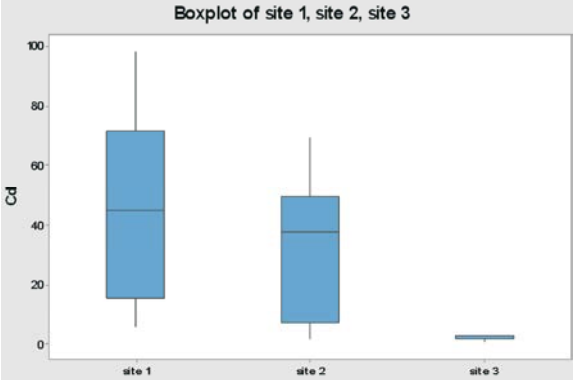

Fig. 2f: Box and Whisker Plot of Cd of three sites (S1, S2, S3)

highest values whereas Pb showed the highest values in case of site 2. The overall summary of the above results states that all metals including OM are strongly correlated with one another. Besides this, OM, Zn, Cu, Cd and Pb represented lowest values in case of site 3. A continuing decrease occurred in last five parameters with respect to sites.

A high elevated concentration of metals was seen in S1 and S2 and is in agreement with the result proposed by some other studies in the area or away from the city [12-14]. The high mean concentration of elements were 4890 mg/kg for Zn, 230 mg/kg for Cu, 98 mg/kg for Cd and 3225 mg/kg for Pb at site S1 and similar values of 3130 mg/kg for Zn, 560 mg/kg for Cu, 69 mg/kg for Cd and 4620 mg/kg for Pb at S2 was observed. These values in comparison with S3, S4 and S5 (which explained mean concentration for these elements of S3, (310 mg/kg for Zn, 31 mg/kg for Cu, 3 mg/kg for Cd and 240 mg/kg for Pb) respectively, demonstrate the augmentation of metal contents at site 1 (S1) and site 2 (S2) with respect to Zn, Cd and Pb concentration. These values are increased at the level of 18, 30 and 40 times in comparison with the sites farther from industrial Area. At Site 3, one sample showed the high concentration of Cu, Pb and was representative of contamination reported by site 1 and site 2. It indicates that emission from industries may cause influence in soil characteristics over 7 Km from the source. The S4 site showed a greater mean concentration of Zn i.e., 234 mg/kg as compared to S3 (223.4 mg/kg) and S5 (186.6 mg/kg) but concentration in S3 hit the highest point. The maximum mean (21 mg/kg) and peak concentration (26 mg/kg) of Cu from S3 away from industrial area was recorded from S3 with respect to S4 which contain mean concentration of 20.6 mg/kg but less than S5 mg/kg Cu respectively. The S4 site having an average of Cd (3 mg/kg) concentration including one sample with concentration 4 mg/kg and it is above the limit value for Cd in sewage sludge. The average concentration of this element (Cd) in S3 and S5 were found 2.5 and 2.3 respectively.

As the site S3 (7 km away from Industrial State), S4 (9 km away) and S5 (15 km away), the author believes that these should not be influenced by industrial State but only by diffused sources of pollution. The high Cd concentration at S5 as compared to S3 shows that there were some other sources which were potentially influencing this site. Similar elevated total metal concentration was observed from agricultural soil sample adjacent to S1, S2 and S3.

The pH of the soil was experiential different not only between the sites but also within the sites. The pH range at S1 and S2 was pH 5.7 – pH 8.1 with an average of pH 6.56 and pH 5.2 – pH 7.5 (average pH 6.18), respectively. These are neutral array of soil pH but these are found to be more acidic than S3, pH 5.8 – pH 8.3 (average pH = 7.15) and S5, pH 7.1 – pH 8.1 (average pH 7.7). Soil of S4 site were in the range of pH 5.8 – pH 6.5 (average pH 6.1). The elevated acidity of the soils at S1 and S2 is due to the actuality of increased metal concentration of the soil [24, 25]. According to Speir [26], cation Pb^{+2} hydrolyze in solution and immersed strongly in the soil which results in greater concentration of H^{+} ions. These greater concentrations of pH encourage acidic pH. The pH of the soil sample from S1, S2 and S3 were in the variety of pH 7 – 8 which are the acceptable range for agricultural soil.

Like pH, the organic matter (OM %) produced different results not only between sites but also within the sites. The sites S1 and S2 showed higher contents of organic matter (OM%) with the values 10.6 % to 42.6% (23.2% average) and 6.5% to 65.2% (28.02% average) respectively as compared to S4, 7.91% to 8.78% (8.5% average), S3, 9.1% to 34.5% (17.14% average) and S5, 12.5% to 22.2% (16.8% average). The eminent organic matter of soil proposed that elevated metal contamination in S1 and S2 may badly affect the organic matter breakdown [23, 27]. The two sites away from Industrial Area of Multan (i.e., S3 and S5) present approximately identical values of organic matter contents and are within the tolerable limits of soil organic matter also reported in some other studies [28, 29].

The summary shows, first two sites S1 and S2 exposed high level of contamination. Among the selected metals, the first two sites (having a distance of 3 and 5 km correspondingly from Industrial state) exposed towering

concentration of Zn, Cu, Cd and Pb. If we compare the distribution of metals between site S1 and site S2, site S1 presented a higher level of contamination. It means as we go farther than Multan Industrial area, the level of contamination become reduced and this similar results was also reported by Davis [30] in his study. The rise of these metals including Zn, Cu, Cd and Pb are contributing factors to the soil contamination (although there are some other elements which are also causal factor of soil contamination as discussed in studies of Tariq [12] or in nearby Multan region [14, 31]. Besides this, the allocation of trace metals was observed in order of Zn> Pb> Cu> Cd. This apportionment explains that out of four elements, Zn and Pb contributed elevated level of absorption in the soil.

CONCLUSION

As a final point, it is concluded that soil investigation from Multan Industrial Estate (MIE) shaped some handful results in the determination of contamination of agricultural soil close to the industrial area. The soil pH explicated negative relationship with other parameters ($P<0.05$; $P<0.01$ and $P<0.001$) and is in argue that augmentation of these metals increase the soil acidity. All parameters (pH, OM, Zn, Cu, Cd and Pb) showed considerably significant results. These parameters are accountable for the contamination of soil which is deliberately produced by some industries of the area. Hence it is suggested that such activities of industries nearby the industrial area should be ceased at instant basis to evade the contamination of the agricultural soil.

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