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ORIGINAL ARTICLE

Studies on Soil Characteristics Irrigated By Industrial Effluents in Grassland of Agra District

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ABSTRACT

Water relations of plants bring about in them many physiological changes by affecting transpiration, respiration translocation, photosynthesis, seed germination, uptake of nutrients, growth and some biochemical processes. The concentration and composition of dissolved and suspended constituents in water determine its quality for use of plants. The dissolved salts in water can change the physico-chemical properties of soil by affecting the chemical composition and concentration of the soil solution and subsequently that may affect the cations present in the soil water exchange complex. Effluent from industries are normally considered as the main pollutants as they contain various colours, tastes, odour, organic and inorganic compounds, acids, alkalies and other materials in dissolved and suspended forms. When these effluents are discharged into the environment, they disrupt the ecological niches of living organism. Keeping these points in view present article highlights the contamination of soil by industrial effluents which in turn affect the grasslands in Agra district.
Key words: *Soil, Irrigation, Industrial Grassland*

INTRODUCTION

Soil is the basic and most important life support component of biosphere. The process of soil formation involves addition and admixture of organic matter and mechanical and chemical eluviations by translocation of certain constituents. Excessive concentration of organic and inorganic materials in soil adversely affects its physico-chemical characteristics and may induce abnormalities in plant growth and development (Agrawal, *et al.,* 1964). Therefore, the eventual soil is a chemically, physically and biologically complex dynamic system. Its constituents are constantly undergoing changes, the rate of which is influenced by a number of factors of the environment. Most physiological and biochemical reactions of plants are influenced or controlled by nutrients. Deficiencies of mineral nutrients or toxicities are inherent to the morphology and chemical composition of the soil creating a serious constraint for crop production and land development. Uptake of cations by plants depends upon the cation exchange capacity and other adsorption properties of the soil in relation to the labile concentration of the specific ions. Thus the availability of one cation to plants is always affected by the availabilities of others.

The growth of plants depends not only on absolute concentration of different essential elements above the critical limits but also on the suitable ionic balance among them. The elemental ratios at initial stage of plant growth have their impact on the ultimate yields. Soil has the great capacity for receiving and decomposing wastes and pollutants of different kinds. Soil is then efficient purifying media. Suspended matter is filtered out by the soil particles and its organic matter is decomposed by the soil microflora. Nutrients are utilized by the soil as its constituents. However, if the input of the pollutants is higher than the purifying capacity of the soil then the population of microorganisms decreases considerably, thus the physico-chemical and biological properties of the soil gets adversely affected. The industrial effluents can affect the physical and chemical properties of soil and also the availabilities of certain nutrients there from. The effect on ecologically related physical and chemical properties of soil is important in determining convenience of agricultural utilization of effluents. Around Nunhai Industrial Area, Agra, selected for this study, a large area receives huge amount of effluents as a result of overflow from the drainage channels. This study demonstrates utilization of certain standard techniques for determining the influence of industrial effluents on soil composition and changes in physico-chemical properties of effluent affected soil in the field of wasteland areas.

MATERIALS AND METHODS

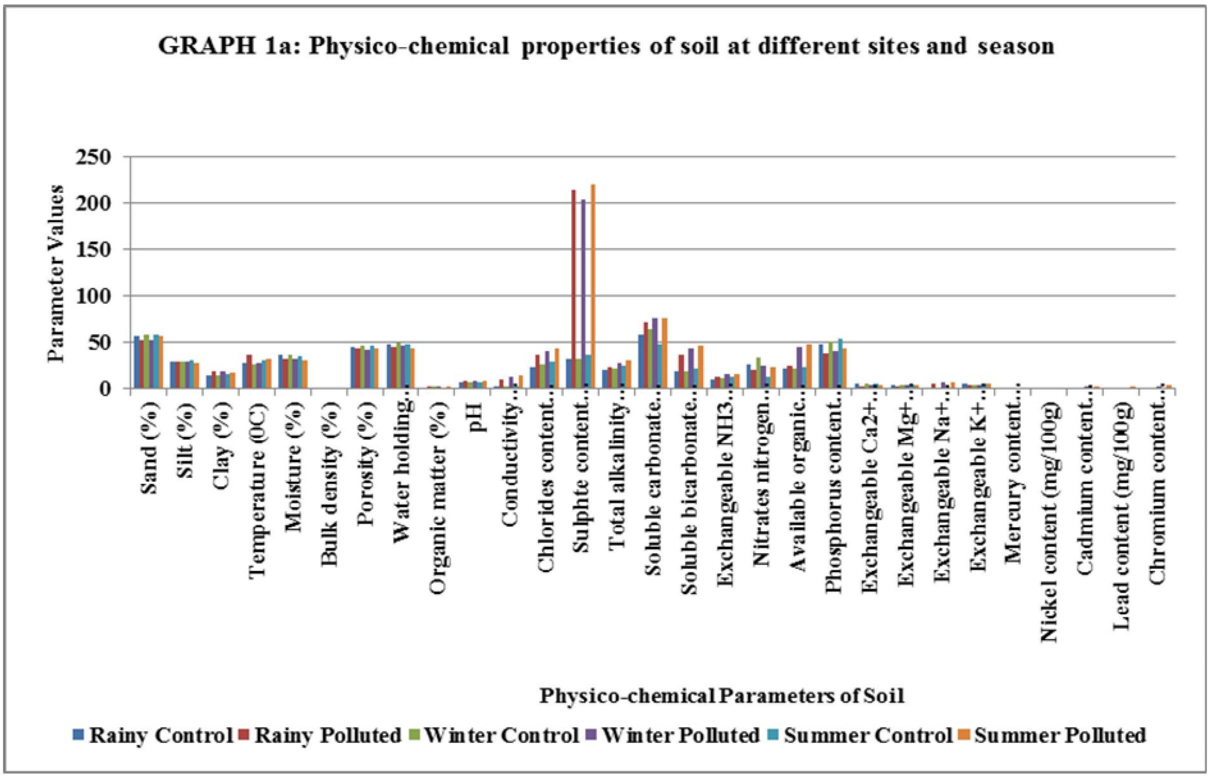
Five replicates each of one litre of the effluents (Polluted) and tap water (Control) were collected periodically in three seasons, i.e., rainy, winter and summer in new plastic sampling bottles. During the collection of effluents and water, samples were analysed for the physical properties-temperature, colour, odour and pH value at the time of sampling. The collected samples were stored in a cool, dark and dry place till analysis. Care was taken to see that no contamination of the collection sample took place during transportation and storage. Necessary sampling precautions and specialized sampling equipments were used whenever needed (Michael, 1984). The study would be under taken to examine the physico-chemical and biological characterization of the industrial effluents discharged into the nearby grassland soils affected.

Table 1: Physico-chemical properties of soil at different sites and season

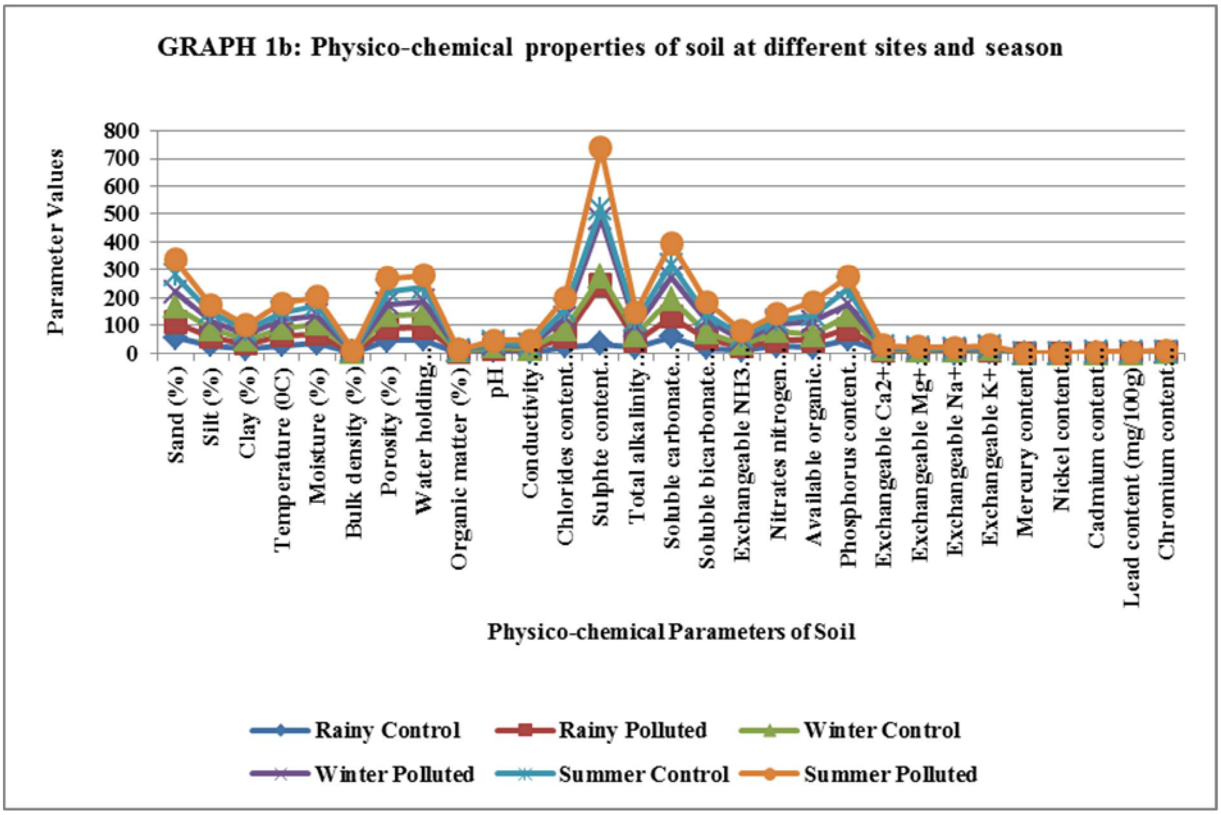
Parameter	*Season*					
	Rainy		*Winter*		*Summer*	
	Site					
	Control	*Polluted*	*Control*	*Polluted*	*Control*	*Polluted*
Soil texture:						
Sand (%)	56.916 ± 0.044	52.563 ± 0.226	58.163 ± 0.052	52.843 ± 0.109	58.380 ± 0.453	57.076 ± 0.050
Silt (%)	28.833 ± 0.142	29.383 ± 0.094	28.340 ± 0.083	29.113 ± 0.127	29.983 ± 0.078	27.040 ± 0.041
Clay (%)	14.413 ± 0.081	18.640 ± 0.166	14.496 ± 0.089	18.686 ± 0.157	15.853 ± 0.083	17.046 ± 0.040
Depth in 0-30 cm						
Colour	Yellow	Black	Brown	Black	Brown	Black
Odor	Odorless	Stinking	Odorless	Stinking	Odorless	Stinking
Temperature (^{0}C)	27.483 ± 0.044	36.283 ± 0.116	26.276 ± 0.514	27.073 ± 0.074	30.096 ± 0.117	32.230 ± 0.127
Moisture (%)	35.986 ± 0.081	32.073 ± 0.037	36.906 ± 0.106	32.173 ± 0.126	34.770 ± 0.217	30.220 ± 0.121
Bulk density (%)	1.370 ± 0.015	1.536 ± 0.018	1.536 ± 0.018	1.720 ± 0.015	1.470 ± 0.015	1.733 ± 0.060
Porosity (%)	45.766 ± 0.185	43.226 ± 0.118	46.126 ± 0.048	42.966 ± 0.088	46.196 ± 0.148	44.353 ± 0.133
Water holding capacity (%)	47.593 ± 0.294	45.050 ± 0.028	49.050 ± 0.028	46.233 ± 0.145	47.670 ± 0.176	43.973 ± 0.078
Organic matter (%)	1.743 ± 0.047	2.452 ± 0.029	1.900 ± 0.028	2.576 ± 0.049	1.710 ± 0.015	2.483 ± 0.210
p^H	7.050 ± 0.028	8.143 ± 0.097	7.216 ± 0.060	8.550 ± 0.028	7.326 ± 0.014	8.780 ± 0.121
Conductivity (m.mhos/cm)	2.100 ± 0.057	10.213 ± 0.063	2.333 ± 0.057	12.393 ± 0.082	3.083 ± 0.044	14.473 ± 0.107
Cl^- content (mg/100g)	23.110 ± 0.066	36.083 ± 0.044	26.116 ± 0.066	40.130 ± 0.049	28.336 ± 0.129	43.723 ± 0.203
SO_4 content (mg/100g)	32.556 ± 0.254	213.64 ± 1.734	32.326 ± 0.066	203.763 ± 2.839	35.733 ± 0.145	220.663 ± 0.770
Total alkalinity (mg/100g)	20.146 ± 0.093	23.180 ± 0.124	22.190 ± 0.134	28.260 ± 0.130	24.300 ± 0.251	31.050 ± 0.246
Soluble CO_3 (mg/100g)	58.593 ± 0.214	71.266 ± 0.159	64.926 ± 0.063	76.27 ± 0.137	48.376 ± 0.313	76.540 ± 0.254
Soluble Na_2CO_3 (mg/100g)	18.180 ± 0.094	36.326 ± 0.161	19.200 ± 0.078	43.306 ± 0.115	22.200 ± 0.124	46.366 ± 0.252
Exchangeable NH_3 me/100g)	10.056 ± 0.031	12.676 ± 0.387	11.30 ± 0.076	15.296 ± 0.160	12.423 ± 0.245	16.413 ± 0.285
NO_3-N (mg/100g)	25.916 ± 0.044	20.350 ± 0.301	32.966 ± 0.072	24.936 ± 0.044	30.356 ± 0.254	23.703 ± 0.160
Available organic P mg/100g)	21.056 ± 0.034	24.11 ± 0.072	22.103 ± 0.072	45.476 ± 0.342	23.483 ± 0.360	48.420 ± 0.312
PO_4 content (mg/100g)	47.793 ± 0.121	38.173 ± 0.118	50.653 ± 0.189	41.306 ± 0.096	54.550 ± 0.242	43.513 ± 0.311
Exchangeable Ca^{2+} (me/100g)	4.996 ± 0.027	3.256 ± 0.092	5.203 ± 0.130	3.750 ± 0.134	5.233 ± 0.064	4.243 ± 0.029
Exchangeable Mg^+ me/100g)	3.326 ± 0.043	3.166 ± 0.024	3.896 ± 0.123	3.810 ± 0.101	3.780 ± 0.113	3.780 ± 0.015
Exchangeable Na^+ (me/100g)	0.343 ± 0.023	5.713 ± 0.092	0.403 ± 0.008	6.93 ± 0.047	1.203 ± 0.012	6.570 ± 0.172
Exchangeable K^+ (me/100g)	4.803 ± 0.031	4.116 ± 0.026	4.483 ± 0.245	4.556 ± 0.047	5.570 ± 0.176	4.940 ± 0.050
Hg content (mg/100g)	0.000 ± 0.000	0.013 ± 0.003	0.000 ± 0.000	0.036 ± 0.003	0.000 ± 0.000	0.060 ± 0.005
Ni content (mg/100g)	0.000 ± 0.000	0.036 ± 0.003	0.000 ± 0.000	0.076 ± 0.018	0.000 ± 0.000	0.110 ± 0.005
Cd content (mg/100g)	0.000 ± 0.000	0.510 ± 0.045	0.000 ± 0.000	2.396 ± 0.037	0.000 ± 0.000	2.840 ± 0.023
Pb content (mg/100g)	0.000 ± 0.000	0.210 ± 0.005	0.000 ± 0.000	1.616 ± 0.008	0.000 ± 0.000	1.876 ± 0.049
Cr content (mg/100g)	0.000 ± 0.000	1.346 ± 0.008	0.000 ± 0.000	3.120 ± 0.011	0.000 ± 0.000	4.220 ± 0.127

Since water pollution is essentially a biological phenomenon, the degree of pollution can be estimated either from physical and chemical properties or from biological characteristics of water. The present study includes physico-chemical and biological analysis of industrial effluents discharged into grassland at selected site. Physico-Chemical and Biological Analysis of the Industrial Effluents from Selected Area will be carried out following, NEERI (1979), Grob (1983), APHA (1992, 1995), APHA-AWWA-WPCF (1995).

Physico-Chemical and Biological Analysis of Soils Irrigated with Industrial Effluents before and after treatment will be carried out using the methods recommended by Piper (1950), Black (1965), Jackson (1973), Groot *et al.*, (1982). The parameters are Color, Odor, Temperature, Moisture, pH, Conductivity, Chlorides, Sulphate, Total Alkalinity, Soluble carbonates and bicarbonates, Exchangeable NH_3, Nitrates, Total Organic Matter, Available Organic Phosphorus, Total Phosphorus, Exchangeable Ca^{2+} and Mg^{+}, Exchangeable Na^{+} and K+.



Graph 1a: Physico-chemical properties of soil at different sites and season



Graph 1b: Physico-chemical properties of soil at different sites and season

RESULTS AND DISCUSSION

Samples of liquid discharge from industrial areas were collected from time to time. Five replicates of each sample were analysed by the methods described above. The results obtained are discussed below as given in Table 1; Graphs 1a, 1b.

Soil Texture: Polluted and control sites showed slight variation in soil texture both with regard to the study sites and also with regards to the seasons. The percentage of sand, silt and clay particles were found to be 52.3, 29.20 and 18.50 percent during rainy season, 52.90, 28.90 and 18.20 percent during winter season and 53.20, 28.90 and 17.90 percent during summer season at polluted site, respectively. The percent of sand, silt and clay were found to be 56.8, 28.70 and 14.50 percent during rainy, 57.4, 28.4 and 14.20 percent during winter and 57.70, 28.20 and 14.10 percent during summer season at control site, respectively. At control site sand percentage was always higher than polluted site but clay percentage was less than polluted site.

SOIL TEXTURE

SAND: The percentage of sand in the soil on polluted site was found to be in the order of:

Rainy season– 52.563%; winter– 52.843% and in summer season– 57.076% showing higher content during summer season. On the other hand, the control site showed sand percentage in the order of:

Rainy season– 56.916%; winter– 58.163% and in summer season– 58.380% showing highest content during summer season. Thus, control site showed higher sand content in all the three seasons than at the polluted site.

SILT: The percentage of silt in the soil on polluted site was found to be in the order of:

Rainy season– 29.383%; winter– 29.113% and in summer season– 27.040% showing higher content during summer season. On the other hand, the control site showed sand percentage in the order of:

Rainy season– 28.833%; winter– 28.340% and in summer season– 29.983% showing highest content during summer season. Thus, control site showed higher sand content in all the three seasons than at the polluted site.

CLAY: The percentage of clay in the soil on polluted site was found to be in the order of:

Rainy season– 18.640%; winter– 18.686% and in summer season– 17.046% showing higher content during summer season. On the other hand, the control site showed sand percentage in the order of:

Rainy season– 14.413%; winter– 14.496% and in summer season– 15.853% showing highest content during summer season. Thus, control site showed higher sand content in all the three seasons than at the polluted site.

Colour: The colour of soil was slightly different at polluted site than control site. Soil at polluted site showed black colour during the three seasons. On the other hand, in the rainy season it was yellow where as in the winter and summer seasons it happened to be brown in colour.

Odour: Odour at the polluted site showed stinking smell in the three seasons whereas it was odourless in the three seasons at control site.

Temperature: The average temperature (^{0}C) of the effluent and water was recorded at the control .and polluted sites. The average temperature of effluent at polluted site was recorded 36.283^{0}C, 27.073^{0}C and 32.230^{0}C in rainy, winter and summer seasons respectively. The temperature of control water was always lower i.e., 27.843^{0}C (rainy), 26.276^{0}C (winter) and 30.096^{0}C (summer) in comparison to polluted site.

Moisture Percentage: Moisture percentage also varied from polluted to control sites). The data indicated that moisture percentage of soil at control site was always higher than the polluted site during all seasons. Percentage value of soil moisture was 32.073% and 35.986% at polluted and control sites respectively during rainy season. Moisture percentage recorded was slightly higher during winter than that in rainy season at polluted and control sites, i.e., 32.173% and 36.906% at polluted and control sites respectively. During summer season, the value of moisture percentage was always less than rainy and winter season that is 30.220% at polluted and 34.770% in control.

Bulk Density: The bulk densities of soil showed slight variation at polluted and control sites. The maximum value of bulk density was found at polluted site and it was found to be 1.536, 1.720 and 1.733 percent during rainy, winter and summer seasons respectively. At control site the value of bulk density was always lower, i.e., 1.370 (rainy), 1.536 (winter) and 1.470 percent (summer season) as compared to polluted site.

Porosity: it is evident that percentage porosity of soil of different fields varied from polluted to control site. The data indicate that the percentage of soil porosity at polluted site was lower than that of control site during all the three seasons, i.e. rainy, winter and summer. The value of soil porosity was recorded 43.226 (polluted site) and 45.766 percent (control site) during rainy season. The percent of porosity was less in winter in comparison to rainy at polluted site (42.966), and higher at control site (46.126). The porosity percentage in summer season was recorded 44.353 (polluted site) and 46.196 (control site).

Water Holding Capacity (WHC): Remarkable variation in the water holding capacity of the effluent affected polluted soils was recorded over that of the control field. It reduced from 47.593, 49.050 and 47.670 percent during rainy, winter and summer seasons at control site respectively. At polluted site the percentage of water holding capacity was recorded to have lower values as compared to control site i.e., 45.050, 46.233 and 43.973 during rainy, winter and summer seasons respectively.

Organic Matter: The soil organic matter content was maximum during winter season, i.e. 2.576 and 1.900 percent at polluted and control sites, respectively. Percentage of organic matter was relatively less during rainy season, i.e., 2.452 and 1.743 at polluted and control sites. The values recorded during summer season, i.e., 2.483 and 1.710 percent at polluted and control site respectively.

Soil pH: It has an increasing trend in rainy to summer seasons at polluted and control sites. Maximum pH values were recorded at polluted site, i.e., 8.143, 8.550 and 8.786 during rainy, winter and summer season respectively. Minimum values were observed at control site, i.e., 7.050, 7.216 and 7.326 during rainy, winter and summer season respectively. These observed values were always less than those for polluted site.

Electrical Conductance: The electrical conductivity was observed maximum at polluted site, i.e., 10.213, 12.393 and 14.473 dsm^{-1}during rainy, winter and summer seasons respectively, whereas it was significantly less at control site as compared to the polluted site, i.e., 2.100, 2.333 and 38364 dsm^{-1} during rainy, winter and summer season respectively.

Chloride: The chloride content of the soil varied greatly at polluted and control sites. It indicate that chloride content was always higher at polluted site during all seasons as compared to the control, i.e., 36.083, 40.130 and 43.723 mg/100 g during rainy, winter and summer seasons respectively. The chloride content was significantly less at control site than polluted site, i.e., 23.110, 26.116 and 28.336 mg/l00 g during rainy, winter and summer seasons respectively.

Sulphate: The sulphate content in the soil always varied at polluted and control sites. The data indicated that sulphate of the soil at polluted site was more than the control sites. Maximum sulphate was recorded during summer season, i.e., 220.663 and 35.773 mg/100 g at polluted and control site respectively. Minimum value of sulphate was noted during winter, i.e., 203.763, and 32.326 mg/100 g at polluted and control sites respectively. In rainy season it was 32.556 and 213.640 at control and polluted sites respectively. Sulphate content was about 6 times higher in polluted site as compared to control site.

Total Alkalinity: Total alkalinity was fond to be in the range of 23.180; 28.260 and 31.050 during rainy, winter and summer seasons at the polluted site. On the other hand it was 20.146; 22.190 and 24.300 during rainy, winter and summer seasons respectively which was always lower than the polluted site.

Carbonate: The carbonate content of soils varied greatly at polluted and control sites. Maximum carbonate content was recorded during summer season, i.e. 76.540 mg/100 g at polluted site and at control site it was maximum during winter season. The carbonate was relatively less during summer season in the control site i.e., 48.376 and 71.266 mg/100 g at polluted site during rainy season.

Sodium Bicarbonate: The soluble sodium bicarbonate content varied greatly at polluted and control sites. Maximum bicarbonate content was recorded during summer season, i.e. 46.366 mg/100 g at polluted site and at control site it was also maximum during summer season, that is, 22.200 mg/100 g. The bicarbonate was relatively less during winter season at the polluted site

(43.306 mg/100 g) and at control site (19.200 mg/100 g) while it happened to be 36.326 mg/100 g at polluted site and 18.180 mg/100 g at control site during rainy season.

Exhangeable NH_3: The maximum value of ammonium was recorded to be 16.413, 15.926 and 12.676 mg/l00 g at polluted site during summer, winter and rainy seasons respectively. The ammonium content at control site was significantly low as compared to polluted sites, i.e., 12.432, 11.300 and 10.056 mg/100 g during summer, winter and rainy seasons respectively.

Nitrate Nitrogen: The maximum value of nitrate-nitrogen of soil was recorded in winter season, i.e., 24.936 and 32.966 mg/100 g at polluted and control sites respectively. During summer season the nitrate content of soil was relatively less; i.e., 23.703 and 30.356 mg/l00 g at polluted and control sites respectively. During rainy season the nitrate content was always low as compared to other two seasons, i.e., 20.350 and 25.916 mg/l00 g at polluted and control sites respectively.

Available Organic Phosphorus: The organic phosphorus content of the soil varied greatly from polluted to control sites. The data indicate that phosphorus content was always higher at polluted site during all the seasons. The phosphorus content at polluted site was 24.11, 45.476 and 48.420 mg/l00 g during rainy, winter and summer seasons respectively while values of organic phosphorus content of soil was noted at control site, i.e., 21.056, 22.103 and 23.483 mg/l00 g during rainy, winter and summer seasons respectively.

Phosphorus Content: The phosphorus content of the soil varied greatly from polluted to control sites. The data indicate that phosphorus content was always higher at control site during all the seasons. The phosphorus content at polluted site was 38.173, 41.306 and 43.513 mg/l00 g during rainy, winter and summer seasons respectively while values of phosphorus content of soil was noted at control site, i.e., 47.793, 50.653 and 54.550 mg/l00 g during rainy, winter and summer seasons respectively.

Exchangeable Calcium: The exchangeable calcium of soil varied from polluted to control sites. The data indicate that value of calcium at polluted site was always lower than control site. Maximum values of exchangeable calcium were recorded during summer season, i.e., 4.243 and 5.233 me/l00 g at polluted and control sites respectively. The values of calcium were relatively less during winter season, i.e., 3.750 and 5.203 me/100 g at polluted and control sites respectively. During rainy season the soil exchangeable calcium was always lower than the other seasons, i.e., 3.256 and 4.996 me/100 g at polluted and control sites respectively.

Exchangeable Magnesium: The values of exchangeable magnesium were recorded at polluted site, i.e., 3.166, 3.810 and 3.780 me/l00 g during rainy, winter and summer seasons respectively. The value of magnesium at control site was recorded relatively higher, i.e., 3.326, 3.896 and 3.780 me/l00 g during rainy, winter and summer seasons respectively.

Exchangeable Sodium: The exchangeable sodium content of soil varied from polluted to control sites. The data indicated that the soil exchangeable sodium of effluent affected fields was always higher at polluted site during all seasons. The maximum exchangeable sodium was recorded at polluted site i.e., 5.713, 6.93 and 6.570 me/100 g during rainy, winter and summer seasons respectively. The exchangeable sodium at control site was much lower as compared to polluted site. It was recorded 0.343, 0.403 and 1.203 me/100 g during rainy, winter and summer seasons respectively.

Exchangeable Potassium: The soil exchangeable potassium values were recorded in three different seasons (i.e., rainy, winter and summer). The exchangeable potassium of soil at polluted site was found always lower, i.e., 4.116, 4.556 and 4.940 me/100 g during rainy, winter and summer seasons respectively. The exchangeable potassium at control site was recorded as 4.803, 4.483 and 5.570 me/l00 g.

Mercury: The amount of Hg at polluted site was recorded 0.013, 0.036 and 0.060 mg/l during rainy, winter and summer seasons respectively. The control site was always free from Hg content.

Nickel: The amount of Ni at polluted site was recorded 0.036, 0.076 and 0.110 mg/l during rainy, winter and summer seasons respectively. The control site was always free from Ni content.

Cadmium: The amount of Cd at polluted site was recorded 0.510, 2.396 and 1.876 mg/l during rainy, winter and summer seasons, respectively. The control site was always free from Cd content.

Lead: The amount of Pb at polluted site was recorded 1.210, 1.610 and 1.876 mg/l during rainy, winter and summer seasons, respectively. The control site was always free from Pb content.

Chromium Content: The amount of Cr at polluted site was recorded 1.346, 3.120 and 4.220 mg/l during rainy, winter and summer seasons, respectively. The control site was always free from Cr content.

The results presented above indicated a deleterious effect of effluent on the physico-chemical properties of the soil on polluted site. The cations anions of soil were recorded comparatively higher on polluted than control site. The change in colour of the soil may be' due to excess amount of caustic soda, bleaching powder and other chemicals which are used as dye and in washing purposes. The mechanical composition of soils at both the sites was more or less similar and ideal for the fertile sandy loam soil, 'suitable for excellent growth of different plants. Various salts, chemicals and solids contained m effluent have contributed to an increase in bulk density. The increase in bulk density of soil had resulted in the reduced percent porosity of the soils. The percent porosity of soil was observed maximum during summer season while minimum during rainy season. An increasing trend in bulk density is associated with decrease in percent porosity and thereby the water holding 'capacity of the effluent stressed soils.

The water holding capacity and the soil moisture percentage in polluted soil have lower values than control. The change in soil porosity is, directly related to the amount of salts, chemicals and total solids added to the soil by the effluents. Among the chemicals, sodium, insoluble calcium, sulphate, soapanified dirts and dyes, etc. direct negative impact on the porosity. In presence of excess sodium the clay particles defloculate, causing a further decrease in porosity of the soil. These elements in significant quantity might also have increased the rigidness in the soil particle compaction. This is the main factor in decreasing the permeability and gaseous exchange essential for the optimal growth of the plants. It had been observed that the high sodium content adversely affects physical properties, of the soil by decreasing the porosity and permeability of the soil (Tripathi, 1975). The water holding capacity is a measure of the water retention capacity. Industrial effluents had a marked influence over the water holding capacity of the soils on polluted site as compared to the control site. The soil of polluted site showed significant decrease in water holding capacity. In contrast to soil porosity and water holding capacity, the pH of the study sites during this course of investigation had increased from control to polluted site. The increase in pH is found to be associated with increasing concentration of carbonate and sodium in the soil. The high pH of effluents has also resulted into an increase of pH at polluted site. The salts of sodium and potassium in soap and detergents and excess of sodium in washing soda present in effluent are responsible for the excess accumulation of sodium in soil and increased salt activity. High sodium on tent in soil has also been reported by Sharma and Parashar (2009).

The exchangeable potassium and calcium contents of the effluent affected polluted soil were lower as compared to the control soil. The mineralization of the organic matter might be responsible for lower concentration of potassium and calcium in effluent affected soil (Billore 1973). The presence of chromium in polluted soil is directly associated with the chromium content of effluents. The range of chromium content is much above the toxic range of the plants also reported by Eleiwa *et al*. 1997. Chromium content was undetectable from the control site. In contrast to the exchangeable potassium and calcium, the carbonate, chloride and sulphate content in soil of effluent affected site was much higher than the control site. Thus, the irrigation of the land with factory effluent may enrich sulphate, chloride and sodium levels in the recipient soil. These may be regarded harmful for the soil composition and plant productivity (Massey, *et al*. 2013).

A gradual decrease in nitrate content of soil was observed at polluted than the control site during all seasons i.e. rainy, winter and summer. This might be due to negative effects of effluents In the process of nitrification. High soil ammonium content at polluted site in comparison to control site was closely related to that of their irrigation waters. It was directly related to ammonium content of the effluent. The decrease in total soil nitrogen of effluent at study sites was due to change in physiological properties resulting into great ionic imbalance in soil.

In the end it can be summarized that the discharge from causes spectacular changes in the composition of soil. Such changes included decrease in porosity, nitrogen, phosphorus, potassium, calcium and organic matter content accompanied by an increase in bulk density, pH, chloride, carbonate and sodium content of the soil. The concentration of heavy metal chromium in effluent affected soil is alarmingly high and deserves in depth study of these effluents on growth of plants.

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