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RESEARCH ARTICLE

PHYSICOCHEMICAL CHARACTERIZATION OF CONTROLLED AND POLLUTED AGRICULTURAL SOILS OF DRAVYAWATI RIVER IN SANGANER REGION, JAIPUR

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ABSTRACT

The soil of Sanganer region is adversely affected with industrial effluents that are directly dumped in the Dravyawati river water stream. In this study the control and polluted soils were analyzed for analyzing different physicochemical characteristics including pH, Color, Water Holding Capacity (%), Electrical Conductivity (m Mhos/cm), Total Dissolved Solids(mg/l), Total Organic Carbon(%), Total Organic matter (%), Heavy metals Zinc, Iron, Cadmium Chromium, Copper, Lead, Nickel. Soil was alkaline (7.45 – 8.51) throughout the study areas. Control soils had light brown color while the color of Polluted soils was dark brown- black. The water holding capacity was found decreased in the soils of polluted sites (57.5% - 55%) in the comparison to the control-soils (70%- 75%). The pH of polluted sites was higher as compared to control soils while EC of polluted sites were decreased as compared to control sites. Similarly the average value of EC was found decreased in the soils of polluted sites as compared to controlled soils. EC in all samples varied between 272.95 m Mhos to 329.2 m Mhos. Maximum average values of TDS were found in control soils as compared to the pol1uted soils. The Total organic carbon in all samples was varied from 0.0544 % to 0.1455 %. The TOC was found decreased more than two times in polluted soils .The TDS, TOC and Organic matter in polluted Sites were lower as compared to Control Sites. Higher concentration of heavy metals was assessed in polluted soil samples as compared to the control soil samples. Thus physicochemical characteristics reveal higher pollution level and toxicity in nearby agricultural fields.

Key words: Industrial effluents, Soil samples, Heavy metals, Concentration

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INTRODUCTION

Soil is a dynamic system because of the presence of microorganisms and their biochemical activities liberating a lot of enzymes in soil, which become stabilized in soil by binding to soil components (Alexander, 1985). Influence of irrigation with pulp and paper mill effluent on soil chemical and microbiological properties were studied by Kannan and Oblisami (1990). Irrigation of sugarcane crops with combined pulp and paper mill effluent increased soil pH, organic C, N, P and K. Results also showed that over a period of 15 years effluent application increased exchangeable Na by 4.5-fold compared with control soil (well water irrigated), which ultimately elevated the Na adsorption ratio of the soils. The combined effluent irrigation increased the soil populations of bacteria, actinomycetes, fungi, rhizobia and yeasts. Seema (1997) analyzed the physicochemical and microbiological characteristics of agricultural soils irrigated with petroleum refinery effluents. Irrigation with such water quality rendered detrimental soil quality. Results revealed on alkaline shift in pH, increase in soil total organic carbon, total nitrogen and sodium contents along with substantial accumulation of oil, grease and asphalt; and significant increase in total bacterial and fungal count as compared to control soils. Pati and Sahu (1998) investigated the effects of fluoride on amylase and protease activity in soil. A significant decrease in amylase activity was noticed after 15 days at or above 50 mg/kg level of fluoride. The decrease was more pronounced during later days of incubation. Physico-chemical and biological properties, heavy metal accumulation and enzyme production in the soils of industrial estate of Warangal, Andhra Pradesh, India were studied during 1995-1996 by Kumari and Charya (1999). Maximum levels of alkalinity, hardness, chlorides, sodium and potassium were present in polluted soils. Heavy metals showed maximum accumulation in winter months and poor in rainy season. The soil enzymes showed a remarkable biological significance in polluted and unpolluted soils. Krishna and Govil (2004) conducted a study on heavy metal contamination of soil around Pali industrial area, Rajasthan. The result - indicated heavy metals (lead, chromium, copper, zinc) levels were significantly higher than their normal distribution in soil. Krishna and Govil (2005) investigated heavy metal distribution

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and contamination in soils of Thane-belapur industrial development area, Mumbai. The results indicated that the soils enriched with Cu, Cr, Co, Ni and Zn. Sudha *et al.* (2006) investigated the levels of trace metals in industrially polluted soils of Ranipet industrial town, Vellore district, Tamil Nadu. The analysis revealed that villages located near this industrial area whose main occupation is agriculture are adversely affected due to these industries. The levels of some metals were found to be exorbitantly high. Aiello et al. (2007) investigated the effects of reclaimed wastewater irrigation on soil and tomato fruits. A disturbed layer of soil was observed characterized by reduced soil porosity and a consequent decrease in water retention and hydraulic conductivity. Sharma *et al.,* (2007) conducted a study to find heavy metal contamination of soil resulting from wastewater irrigation in the suburban areas of Varanasi, India. Heavy metals in irrigation water were below the internationally recommended (WHO) maximum permissible limits set for agricultural use for all heavy metals except Cd. The study also points to the fact that adherence to Indian standards for heavy metal contamination of soil and irrigation water does not ensure safe food.

Oluyemi *et al.*, (2008) investigated the seasonal variations in concentrations of the heavy metals - As, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb and Zn - in soil and crops from a farm near the refuse dump site of Obafemi Awolowo University, Ile-Ife, Nigeria. This was done to assess the pollution status of the farm and hence the safety levels of the crops produced. Maldonado *et al.* (2008) determined heavy metal concentrations in different soils of Chihuahua City, Mexico. They concluded that some metals were present in the soils due to anthropogenic activities but others are present in natural forms. Zeng *et al.*, (2008) investigated heavy metal contamination in Chinese vegetable plantation soils .They investigated heavy metal content in vegetable land soils systematically through objective to promote the development of vegetable production with high quality and efficiency. However, comparatively serious contamination was found in industrial/sewage irrigation and suburb vegetable land soils. Yang *et al.*, (2009) conducted Cd accumulation in different vegetable species using agronomic technologies. Six vegetable species (Chinese leek, pakchoi, carrot, radish, tomato and cucumber) were grown in pot and field experiments to study the accumulation of Cd under different conditions. It is concluded that the vegetable species differed markedly in the Cd accumulation and species performed consistently under different growth conditions.

Khan *et al.*, (2010) conducted a study to investigate the concentrations of heavy metals in soil and vegetables, and human health risks through ingestion of contaminated vegetables. Soil and vegetable samples were collected from different locations in Gilgit, northern Pakistan, and analyzed for Cd, Cu, Ni, Pb and Zn and concluded that ingestion of vegetables was of great concern in the study area. Chung *et al.*, (2011) conducted pot experiment study in a plastic film house to evaluate the translocation and uptake of heavy metals (Pb, Cd, Cu, and Zn) into brown rice (Oryza sativa L.) and the heavy metals residues in soils which had previously been irrigated with domestic wastewater. Lente *et al.*, (2012) investigated heavy-metal contamination and its related health risks in urban vegetable farming in Accra. Samples of irrigation water, soil and five different kinds of vegetable were collected and analyzed for copper, zinc, lead, cadmium, chromium, nickel and cobalt. All water, soil and vegetable samples contained detectable concentrations of each of the seven heavy metals except for irrigation water which had no detectable chromium, cadmium and cobalt. They concluded that the risk from heavy metals was less significant than that from pathogen contamination. Chibuike *et al.*, (2014) studied Soils polluted with heavy metals and showed a reduction in growth, performance, and yield. Bioremediation is an effective method of treating heavy metal polluted soils. Microorganisms and plants employ different mechanisms for the bioremediation of polluted soils.

Singh and Mishra (1987) studied the effects of fertilizer factory effluent on soil and crop productivity. The effluents was highly alkaline and contained high amounts of Na, Ca^{2+}, Na^{+}, Cl^{-}, CO_3^{-}, HCO_3^{-} and suspended and dissolved solids, BOD was also high. Navarro *et al.* (1993) studied the effect of industrial pollution (paper mill) on mercury levels in water, soil and sludge in the coastal area of Motril, Southeast Spain, An increase in Hg concentration was observed in the fresh water, wastewater soil, and sludge samples passing dose to the factory.

Zhao *et al.* (2010) conducted a study to determine heavy metals in soil-rice system in Zhejiang province, China, which is one of the well-known electronic and electric waste recycling centers. The results indicated some studied areas had potential contaminations by heavy metals, especially by Cd. The spatial distribution of Cd, Cu, Pb and Zn illustrated that the highest concentrations were located in the northwest areas and the accumulation of these metals may be due to the industrialization, agricultural chemicals and other human activities.

MATERIALS AND METHODS

Studies of soil analysis in some agricultural fields were conducted during the period of May 2009 to May 2012. Soil samples were collected from control sites [(Department of Botany (Site-I) and Shikarpura, Sanganer (Site-II)] as well as polluted sites [Govindpura (Jotadawala), Sanganer (Site-III)] and near Shikarpura Flyover, Sanganer (Site IV)] of Amanishahnalla. During the sampling soil was being collected up to desired depth (upper surface layer and deeper layers) after scraping of the surface litter, if any. The soil was quickly air dried in shade at room temperature and put in polythene bags with identification (Ghosh *et al.,* 1983).

1. pH (Potential Hydrogenii)

pH is the negative $\log^{-10}$ of the Hydrogen ion concentration in solution. pH of soil samples were analyzed by digital pH meter (Model No. 161E).

2. Electrical Conductivity (EC)

EC of the soil sample was determined by digital conductivity meter model no 161E.

3. Total Dissolved Solids (TDS)

Total Dissolved Solids (TDS) were determined by same soil digital meter model no 161E and the reading was taken directly from the display unit in mg/l.

4. Water Holding Capacity (WHC)

Method prescribed by U.S. Salinity Laboratory Staff (1954) was adopted for determination of WHC. The water holding capacity or storage capacity of soil or field capacity is the extent to which it can hold capillary water.

$$\text{WHC (\%)} = \frac{\text{Total Volume of Water - Volume of Pereolated Water} \times 100}{\text{Total Volume of Water}}$$

5. Total Organic Carbon (TOC)

The organic matter present in the soil is digested with excess of potassium dichromate and sulphuric acid and the residual unutilized dichromate is then titrated with ferrous ammonium sulphate. Walkely and black rapid titration method was used for determination of TOC and Total organic matter.

$$\%C = \frac{3.951\ (1\text{-}T/S)}{g}$$

Where,

% Organic Matter - % C × 1.724

G = Weight of Sample in gm
S = ml Ferrous Solution with Blank Titration
T= mlofFerrous Solution with Sample Titration

6. Heavy metal analysis in soil samples

Heavy metals viz. zinc, iron, cadmium, copper, chromium and lead were detern1ined by atomic absorption spectrophotometer.

$$\text{Element } (\mu g/l) = \frac{C \times V \times d.f}{W}$$

Where,

C = absorbance
V = final volume (after makeup)
d.f. = dilution factor

RESULTS AND DISCUSSION

Indian soil is being uncontrollably exposed to a variety of agro-chemicals in order to increase crop yield and soil fertility, decrease crop infections and infestation etc. for good economy (Deshpande, 1996). On the other hand, any entry of foreign particle or polluting agent (sewage and wastewater etc.) in the soil system results in alternation to the soil quality. The qualitative changes of soil start from the physico-chemical changes and further changes may be biological, physiological, biochemical etc. (Kumbharkar and Dubey, 2003). pH is a measure of acidity and alkalinity of soil-water suspension and provides a good identification of soil chemical nature. Soil was alkaline throughout the study areas (7.45-8.51). Higher pH was assessed in Site - IV as compared to other sites. Increased pH may be attributed to hydroxides of calcium [Ca $(OH)_2$] and aluminum [Al $(OH)_3$] formed during hydration process (Czaja, 1962). Similar results were obtained by Kannan and Oblisami (1990). They also observed that irrigation of sugarcane crops with combined pulp and paper mill effluent increased soil pH. Seema (1997) also reported and alkaline shift in pH in agricultural soils irrigated with petroleum refinery effluents. Kumari and Charya (1999) studied the physico-chemical analysis in the soils of industrial estate of Warangal. Their results revealed that maximum levels of alkalinity were present in polluted soils. Maximum water holding capacity (75%) was observed in the soil of Site II. The water holding capacity of Site I, Site II, Site III and Site IV were70%, 75%, 57.50% and 55% respectively. The water holding capacity was found decreased in the soils of polluted

Fig.1 Different Soil Samples

sites in the comparison to the control soils. Aiello *et al.* (2007) investigated the effects of reclaimed wastewater irrigation on soil. Polluted soil was observed characterized by reduced soil porosity and consequent decrease in water retention and hydraulic conductivity. In the present investigation Electrical Conductivity of control Sites I and II was found 326 m Mhos/cm and 329.2mMhos/cm respectively. EC of Site III and Site IV were found 318 m Mhos/cm and 272.595mmhos/cm respectively. The average value of EC was found decreased in the soils of Polluted sites as compared to controlled soils. The decreased EC value indicates the presence of good quality of ions and salts present in the polluted soils. Acidic soil showed a definite tendency towards high EC, increased Ca. Mg, Fe and Mn contents and decreased levels of organic Carbon (Gupta, 1999). The TDS of control Sites I and II was found 2090 mg/l and 2029 mg/l respectively. TDS of polluted Sites III and IV were found 1960mg/l and 1962.5 mg/l respectively. Maximum average values were found in control soils as compared to the polluted soils. Reddy (1988) reported that restricted drainage of water in the high ground water tale or low permeability is one of the major factors contributing towards salinity in western Maharashtra and brining such soil under cultivation, is one of the major issues of concern. Kumari and Charya (1999) also found maximum levels of hardness, salts, chlorides; sodium and potassium were present in polluted soils.

The Total organic carbon was found in higher percentage in control site – II (0.1455%) than the control site-I (0.1327%). The TOC was found decreased more than two times in polluted Sites III and IV i.e. 0.0643 % and 0.0544% respectively in the comparison to control soils. Similar results were obtained by Moore and Russell (1972). They reported higher organic carbon content in control soil as compared to polluted soils.

Table 1: Physico-chemical analysis of Control and Polluted Soil of Dravyawati River

	Parameters	Control		Polluted	
		Site-I	Site-II	Site-III	Site-IV
1.	pH	7.480	7.450	7.965	8.510
2.	Color	Light Brown	Light Brown	Dark brown	Brown black
3.	Water Holding Capacity (%)	70	75	57.50	55
4.	Electrical Conductivity (m Mhos/cm)	326	329.200	318	272.595
5.	Total Dissolved Solids(mg/l)	2090.0	2029.0	1960.0	1962.5
6.	Total Organic Carbon (%)	0.1327	0.1455	0.0643	0.0554
7.	Total Organic matter (%)	0.2995	0.2446	0.09485	0.08145
8.	Zinc (ppm)	15.53	22.34	50.95	50.98
9.	Iron (ppm)	956.65	1090.00	8666.25	7538.00
10.	Cadmium (ppm)	0.0	0.0	2.475	1.615
11.	Chromium (ppm)	0.0	0.0	16.375	14.425
12.	Copper (ppm)	14.730	17.670	77.450	80.175
13.	Lead (ppm)	0.0	1.980	8.960	8.055
14.	Nickel (ppm)	0.0	0.0	0.0	0.0

Kannan and Oblisami (1990) also observed that irrigation of sugarcane crops with combined pulp and paper mill effluent increased organic Carbon. Organic matter (%) found in Site I and II was 0.2995% and 0.2446 % respectively while in Site III and IV 0.09485% and 0.08145 % respectively. Seema (1997) analyzed the physicochemical characteristics of agricultural soils irrigated with petroleum refinery effluents and found increase in soil total organic carbon, organic matter, total nitrogen and sodium contents along with substantial accumulation of oil, grease and asphalt; and significant increase in total bacterial and fungal count as compared to control soils.

Heavy metal accumulation in control soils showed remarkable variation. Iron and copper was found in higher amounts in all the soil samples. Cadmium, Lead and Chromium was not traceable in the soil of control sites. Nickel was not traceable in the soils of control and polluted sites. Higher concentration of Iron, Cadmium and Chromium was found in polluted Sites as compared to the control Sites. Whereas soils of polluted Sites contained higher amount of Zinc, Copper and Lead as compared to control sites. The findings of the present study are in accordance with results reported by following workers. The possible relationship between soil and vegetable contents of environmental cadmium, lead and nickel contamination was studied by Algeria *et al.* (1991), in their analysis soils seems to be the main contributor to nickel content of plants (leaves-stems). Kumari and Charya (1999) studied the heavy metal accumulation in the soils of industrial estate of Warangal and found maximum accumulation of heavy metals in polluted soils. The soil enzymes also showed a remarkable biological significance in polluted and unpolluted soils. Krishna and Govil (2004) conducted a study on heavy metal contamination of soil around Pali industrial area, Rajasthan. The result indicated heavy metals (lead chromium, copper, zinc) levels were significantly higher than their normal distribution in soil. Krishna and Govil (2005) also investigated heavy metal distribution and contamination in soils of Thane-Belapur industrial development area, Mumbai. The results indicated the soils enriched with Cu, Cr, Co, Ni and Zn. Sudha *et al.* (2006) investigated the levels of trace metals in industrially polluted soils of Ranipet industrial town of Vellore district (Tamil Nadu). They found that villages adjoining this town are adversely affected due to these industries. The levels of some metals were found to be exorbitantly high. The above said findings revealed that the sewage and industrial wastewater of Nalla deteriorated the quality of soil which adversely affected the crops grown in that area. A similar finding was observed by Kannan and Oblisami (1990). They studied the influence of irrigation with pulp and paper mill effluent on soil chemical and microbiological properties and results showed increased soil pH, organic C, N, P and K. Results suggested that over a period of 15 years effluent application increased exchangeable Na by 4.5-fold as compared with control soil (well water irrigated), which ultimately elevated the Na adsorption ratio of the soils. Seema (1997) analyzed the physicochemical and microbiological characteristics of agricultural soils irrigated with petroleum refinery effluents and concluded that irrigation water quality rendered detrimental effect on soil quality. Sharma et al., 2007 conducted a study to find heavy metal contamination of soil resulting from wastewater irrigation is a cause of serious concern due to the potential health impacts of consuming contaminated produce. In this study an assessment is made of the impact of wastewater irrigation on heavy metal contamination of Beta vulgaris (palak). Khan *et al.,* 2010 conducted a study to investigate the concentrations of heavy metals in soil and vegetables, and human health risks through ingestion of contaminated vegetables. Lente *et al.,* 2012 investigated heavy-metal contamination and its related health risks in urban vegetable farming in Accra. Chibuike and Obiora 2014 studied the polluted soils with heavy metals that have become common across the globe due to increase in geologic and anthropogenic activities. Plants growing on these soils show a reduction in growth, performance, and yield. Bioremediation is an effective method of treating heavy metal polluted soils. All the results are mentioned in Table 1 and soil samples are shown in Fig.1.

Conclusion

Soil was alkaline (7.45 – 8.51) throughout the study areas. The pH of polluted sites was higher as compared to control soils while EC of polluted sites showed the reverse order. The water holding capacity was lesser in the soils of polluted sites (57.5% - 55%) in the comparison to the soils of control sites (70%-75%). Values of TDS were higher in control soils as compared to the pol1uted soils. The Total organic carbon in all samples varied from 0.0544 % to 0.1455 %. The TOC was found decreased more than two times in polluted soils. The TDS, TOC and Organic matter in polluted sites were lower as compared to control sites. Higher concentration of heavy metals was recorded in polluted soil samples as compared to the control ones. Fe and Cu were found in higher amounts in all the polluted soil samples. Cd and Cr were not traceable in the soils of control sites. In all samples variable concentration of Fe (956.65 mg/l to 8666.25 mg/l), Cd (1.615 mg/l to 2.475 mg/l) and Cr (14.425 mg/l to 16.375 mg/l) were observed. Polluted soils samples contained higher amount of Zn, Cu and Pb as compared to control ones.

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