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PHYSICO-CHEMICAL CHARACTERISTICS OF SOIL OF PANCHANGANGA RIVER BASIN

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ABSTRACT

Continuous urbanization and industrialization have greatly increased the amount of waste generated through human activities. Most of the industries dispose the soild and liquid wastes into streams or on adjacent land. At the disposal sites the wastes interact with the soil through direct contact when the effluent is disposed on ground, and after transport and deposition when released into the water medium. Whether the soils retain or transmit the undesirable element of the effluents to the surrounding environment generally depends mostly on the characteristics of soil. Fifteen representative soil samples analyzed for physico-chemical, heavy metals and indicated that soils of the Panchanganga river basin are lateritic, deep black and coarse shallow soil in texture. Lateritic soils are acidic in nature and black cotton soils are saline in nature. The concentration of metals is according to the sequence Fe >Mn> Zn > Cu >Pb> Ni > Co > Cd. A comparison of these heavy metal concentrations with those in Global Shales suggests that the soils under study are unpolluted.

KEY WORDS : Panchaganga river basin, Physico-chemical characteristics, Heavy metals.

Review of Literature

Large amount of literature is available on this subject. However, in this chapter an attempt has been made to review only the most significant contributions.

The USDA (1953) classified the soil into three major groups based on pH, electrical conductivity and exchangeable sodium percentage (ESP) and this classification is given in Table 1.

Agrarwal and Yadav (1956) studied the relationship between pH, and ESP values and concluded that $pH_2 > 9.2$ corresponds to ESP values greater than 15. Seth (1967) classified soils into four groups on the basis of electrical conductivity of 1.2 soil water suspension as follows:

EC (mmho's/cm)		Group :
<1.0	-	Normal
1.0 to 2.0	-	Tending to salin
2.0 to 3.0	-	Saline
> 3.0	-	Highly saline

Badrapur and Rao (1977) observed that the electrical conductivity and total concentration of ion decreased with depth. The quality of groundwater governs the salinity of surface soils. Bhumba (1977) studied the chemical composition of irrigation water and its effect on the crop growth and soil properties. A similar study was done by Sharma *et al.* (1981) and found that irrigating the crop with saline water reduced 50% crop yield at EC 16 mmho's/cm for wheat and at 6 mmho's/cm for maize, over a period of three to four years.

Rangaswamy and Krishnamurthy (1976) studied the influence of absorbed cations on plasticity, heat of wetting, specific surface and soil strength. The soils rich in calcium and magnesium are found to be very hard, with sodium rich soils moderately strong and the potassium –rich soils highly friable. The soils rich in steatite group of clay minerals become exceptionally hard when saturated with magnesium and become highly friable when saturated with potassium. Sharma and Gupta (1986) classified soils as normal (pH_s<7.5 or pH_2<8.0), saline (pH_s7.5 to 8.5 of pH_2 8.0 to 9.0) and alkali (pH_s 8.2 to 10 or pH_2 9 to 10.8). The industrial waste from numerous sources

Table 1. Classification of Soil (USDA, 1953)

Parameter	Saline	Saline – Alkaline	Non-saline- Alkaline
pH	<8.5	8.5	8.5 to 10.0
EC at 25^0 CMmho's/cm	>4	> 4	< 4
ESP	<15	>15	> 15

their way to soil, but only a few of these are advertently introduced into the soil in significant amounts. The interaction between the industrial effluent and soil is evident by the change in certain soil properties such as soil pH, soil texture and structure, ion exchange characteristics, oxidation reduction status of the soils, and soil compaction : including types of phyllosilicates , nature and amounts of oxides, hydroxide and hydrous oxides of Al, Fe, and Mn, organic matter and soil microorganism (Ausafur Rahman, 1982). Narender Sivaswamy (1990) studied the effect of pollution on the nutrient status of field soils. Chauhan *et al.* (1990) studied the impact of groundwater on the soil characteristics and observed that salinity buildup in soil depends only upon EC_w of water, and that SAR_w and RSC of water did not contribute significantly to the soil salinity. Many scientists have documented adverse effects of different industrial effluents on the growth of plants dye waste water has also been found toxic to several crop plants (Reddy and Baghel, 2011, 2012).

The heavy metal constituents of soil and water has been studied by several researchers, the contribution being those by Warren (1981); Mohammad Ajmal *et al.* (1987); Subramanian (1990); Bird (1987) John (1988); Pawar *et al.* (1985); Kumar (1989); Kuldeep Singh *et al.* (1990), Bhosale and Shahu (1991) and others.

Study area : The study area of the Panchanganga river basin selected is bonded between latitude 16^0 18′ 00"N to 16^0 50′00" N and longitude 73^0 50′ 00" E to 74^0 16′ 6.42" E . The river basin has been carved out in basalt flows of the Deccan Volcanic Province. These rocks now form the valley side, hills and ridges within the basin. At higher altitudes they have been converted into laterites that contain pockets of bauxites. The soils derived from these rocks form a thin veneer on the valley floor. Because of the intensive weathering of parent rock and their transportation downstream, well developed alluvial deposits are formed on the banks of rivers. The thickness of the alluvial soil varies from 5 to 10m in the valley portions of the Panchanganga river basin. As shown in Fig. 1. within the river basin, three types of soils can be demarcated. Black cotton soil is well developed in the north and north-western part of the basin and all along the bank of the river Bhogawati. Reddish brown lateritic soil is well developed on the plateau in the western and central part of the basin. In the southern part of the Kolhapur city a thin layer of coarse soil is developed on weathered basalts. There are four sugar factories with distilleries namely Bhogawati S.S.K-Parete, Datta S.S.K Asurle-Porle (A unit of Dalmia Bharat Sugars and Industries Ltd.), Kumbhi-Kasari S.S.K, Kuditre and Kolhapur Sugar Mill, Kasaba Bawada, Kolhapur.

Soil sampling : Representative soil samples were collected from cropland, from a depth of 10-15 cm. About 1.5 kg.of sample was collected in a polythene bag and dried in the laboratory before grinding and sieving. The samples were collected only once during the course of work. The location of these soil samples are shown in Fig.1.

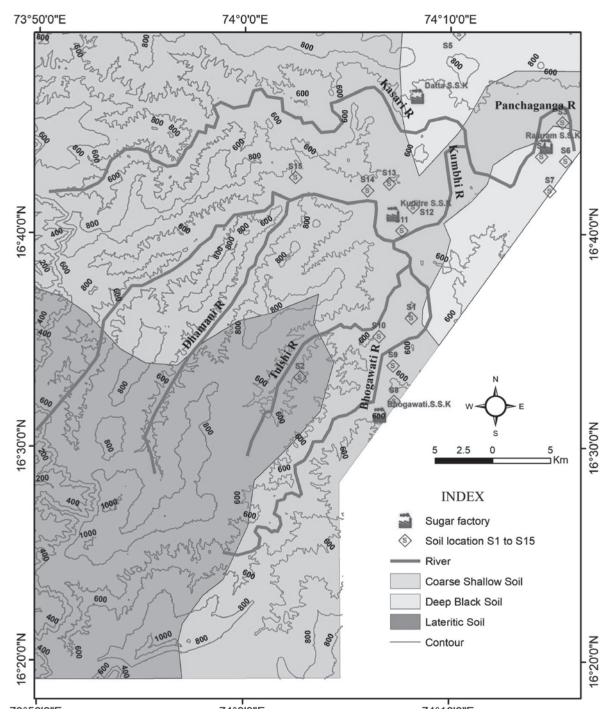

Fig. 1. Location of soil samples in Panchanganga River Basin

Methodology : Standard method of analysis was followed as given in Trivedi and Goel, 1986)

RESULTS AND DISCUSSION

Fifteen representative soil samples were analyzed for their physico-chemical characteristics and the results are presented in Table 1.0 and correlation coefficient of different variables is given in Table 2.

pH: pH also changes soil permeability which results in polluting underground resource of water [9]. The pH of the saturated paste extract varied between 6.4 to 8.2. The pH of the lateritic soil or reddish soil was in the acidic range (6.4 to 6.6, Sample No. S_1, S_2, S8, S9, S10 and S_{15}). However, the black cotton soils showed a comparatively higher pH range of 6.8 to 8.2. the soil samples which are contaminated by Sugar Factory effluents and where the water table has almost reached the surface level showed higher pH values (Sample No. S_4, S_7, S_{11}& S_{14}). Based on the classification of Sharma and Gupta (1986), the soils of the study area can be classified as normal to saline.

The pH of the soil has significant impact on the soil microorganisms and nutrient availability. When the base saturation is less than 100 percent an increase in pH is associated with an increase in the amount of calcium, magnesium, nitrogen and sulphate in soil and a decrease in the micronutrients Fe, Mn, Al, Cu, Zn which are of vital importance to plant growth (Henry, 1951). Sugar cane yield has decreased to 40 tonnes/ Acre from 75 tonnes/acre around the sugar factories. Therefore, the decrease in the yield of sugarcane in the study area can be attributed to the increasing pH of soil. pH showed significant positive correlation with EC, CEC, Na^+ and K^+ (> 0.57).

Electrical Conductivity (EC): The EC of the saturation paste is recommended as a general method of appraising soil salinity in relation to plant growth. EC is more suitable for salinity measurements because it increases with salt contents. The results expressed in specific conductance or conductivity makes determination independent of the size and shape of the sample.

In the present study, the electrical conductivity of the saturation paste was found to vary between 1.96 to 3.13 mmho's/cm. The average value was 2.38 mmho's/cm.

The use of the conductivity of the saturation extract as an index of soil salinity was introduced by Rubidooux Laboratory in 1939 and later on the conductivity scale was modified by U.S. Salinity Laboratory Staff (1953) to assess the salinity in relation to plant growth as follows:

0 – 2 mmho's/cm	:	Salinity effects mostly negligible
2 – 4 mmho's/cm	:	Yields of very sensitive crops may be restricted.
4 – 8 mmho's/cm	:	Yields of many crops restricted
8 – 16 mmho's/cm	:	Only tolerant crops yield satisfactorily
16 – 20 mmho's/cm	:	Only a few very tolerant crops yield satisfactorily

According to the above classification crop yield will be restricted in case of sensitive crops in the Panchaganga basin. According to Seth's (1967) classification, the soil samples of the area generally fall under saline group (EC = 2 to 3 mmho's/cm). Three samples (Nos S_3, S_4, S_7) fall under high saline groups (EC > 3.0 mmho's/cm). According to Muhr (1963), most soil samples are critical for growth of salt sensitive crops and three samples (Nos S_3, S_4, S_7) are injurious to the crops. This was confirmed in the field, where the development of white crust of salt on soil surface hampered the growth of cucumber . The EC has shown significant positive correlation with all the parameters (Table 2).

Exchange Cations : When a sample of soil is placed in a solution of a salt such as ammonium acetate, ammonium ions are adsorbed by the soil and all equivalent amounts of cations are displaced from the soil into the solution. This reaction is termed as "Cation Exchange" and the cation displaced from the soil are referred to as "exchangeable". The total amount of exchangeable cation that a soil can retain is designed as cation exchange capacity and is usually expressed in milli equivalents per 100 gm of soil. It is often convenient to express relative amount of various exchangeable cations present in a soil as percentage of the CEC. The ESP is equal to 100 times the exchangeable sodium content divided by the CEC, both expressed in the same units. In the present study exchangeable Ca^{++}, Mg^{++}, Na^+ and K^+ were estimated from the soil samples.

Calcium (Ca^{++}) : The maximum exchangeable calcium concentration was 17.75 meq/100 g of soil and the minimum was 7.4 meq/100 g of soil with an average of an value of 12.95 meq/100 g of soil. The Samples Nos. S_1, S_2 and S_{15} from the upper reaches of the basin showed the calcium concentration of 10.48

meq/100 g which is below the average value shown by the downstream samples.

Magnesium (Mg^{++}) : The maximum concentration detected was 10.8 meq/100 g of soil (Sample No. S_7) and minimum was 4.8 meq/100 g of soil (Sample No. S_1). The average value of exchangeable magnesium was 6.77 meq/100 g of soil. The concentration of Mg^{++} was less than that of Ca^{++} in almost all the samples except one (Sample No. S_4), which implies abnormal soil because reclamation of Mg rich soil is most difficult. This could be due to the direct impact of spent wash of the distillery on the soil characteristics.

Sodium (Na^+) : The sodium concentration varied between 2.8 to 4.97 meq/100 g of soil. The average concentration was 3.786 meq/100 g of soil. The concentration of sodium was less than that of calcium and magnesium.

Potassium (K^+) : The maximum concentration of K^+ was 1.29 meq/100 g of soil (No. S_4) and minimum was 0.12 meq/100 g of soil (No. S_{11}). The average value was 0.44 meq/100 g of soil. The black cotton soils showed higher concentration of potassium (0.53 meq/100 g of soil) as compared to the brownish coloured soils (0.20 meq/100 g of soil). The concentration of potassium was less than sodium in all the samples.

The analysis of exchangeable cations Ca^{++}, Mg^{++}, Na^+ and K^+ revealed that calcium was the most dominant cation. The dominance of cations were in the order $Ca^{++} > Mg^{++} > Na^+ > K^+$in almost all the sample except one (Sample No. S_4) which showed the sequence of $Mg^{++} > Ca^{++} > Na^+ > K^+$.

Cation Exchange Capacity (CEC) of Soils : The colloidal fraction carries a positive as well as negative charge. The negative charge, however, is of much greater magnitude and of greater significance for plant growth in most soils. The CEC is an expression of number of cations adsorption sites per unit weight of the soil. The CEC of pure clay such as montmorillonite is 100 meq/100 g of soil, of illite 30

Table 1. Physico-chemical characteristics from Panchanganga River Basin

Sample no.	pH	EC (mmho's/ cm	Ca^{++} (meq/ 100 g)	Mg^{++} (meq/ 100 g)	Na^+ (meq/ 100 g)	K^+ (meq/ 100 g)	ESP	CEC (meq/ 100 g)
S1	6.4	1.96	11.12	4,80	2.95	0.25	14.04	21.00
S2	6.5	1.96	9.60	5.20	3.00	0.14	15.00	20.00
S3	7.5	3.12	17.75	7.00	4.22	0.81	12.00	35.00
S4	7.7	3.02	7.40	9.20	4.54	1.29	18.91	24.00
S5	7.00	2.47	14.30	6.20	4.97	1.28	17.75	28.00
S6	7.8	2.11	11.60	6.80	3.50	0.20	14.58	24.00
S7	8.2	3.13	14.75	10.80	4.63	0.55	13.22	35.00
S8	6.8	2.44	14.20	6.60	3.60	0.31	12.85	28.00
S9	6.6	2.46	13.90	6.20	3.75	0.41	13.39	28.00
S10	6.5	2.19	12.25	7.00	3.00	0.21	12.00	25.00
S11	7.6	1.95	10.30	6.40	2.80	0.12	12.72	22.00
S12	7.5	2.40	14.20	5.60	3.75	0.50	13.39	28.00
S13	7.4	2.60	15.50	6.50	4.00	0.13	13.33	30.00
S14	7.8	2.83	16.80	7.40	4.73	0.20	15.15	32.00
S15	6.6	2.09	10.65	5.90	3.35	0.21	14.56	23.00

Table 2. Correlation coefficient of different variables

pH	EC	Ca^{++}	Mg^{++}	Na^+	K^+	ESP	CEC
1.00	0.63	0.27	0.70	0.57	0.24	0.11	0.55
	1.00	0.50	0.75	0.83	0.57	0.14	0.82
		1.00	0.08	0.47	0.01	0.43	0.87
			1.00	0.58	0.37	0.15	0.51
				1.00	0.68	0.48	0.70
					1.00	0.64	0.21
						1.00	0.25
							1.00

meq/100 g of soil, and of kaolinite 8 meq/100 g of soil. In temperate zones the CEC of the clay fraction as a whole may in the vicinity of 500 meq/100 g of soil, because clay fraction is a mixture of clay minerals. The fertility of the soil depends upon the CEC of the soil. Higher the CEC, higher is the fertility because such soils can provide more nutrients to the plant.

In the present study, the CEC of the soil varied between 20.00 to 35.00 meq/100 g of soil. The black soils showed comparatively higher CEC ranging 22.00 to 35.00 meq/100 g of soil, whereas lateritic soils showed in the range of 22.00 to 23.00 meq/100 g of soil. The CEC of the soil sample indicates that the clay fraction is composed of large number of clay minerals. The higher values of CEC of black soils indicate that these soils have got higher capacity of intaking the pollutants due to their 2:1 layer arrangement.

Exchangeable Sodium Percentage (ESP) : Most of the soil sample showed ESP values in the range of 12 to 18.91 with an average of 14.19 and electrical conductivity less than 4 mmho's/cm. According to USDA (1953), such soils can be classified as non-saline and non-alkaline. However, according to Seth (1967), most soils show a tendency towards salinity which is identified in the field by the development of white crust of salts on the soil surface. This is particularly so around the sugar factories.

From the analysis of physico-chemical characteristics of the soil samples it is evident that the soils of the Panchaganga basin are normal to saline in nature. This indicates that the reduction in the yield of sugarcane (personal communication with the farmers) could be due to the rise of water table in the vicinity of sugar factory (which reduces the aeration in the soil) and the change in soil structure due to the effect of effluents on the fine textured soil and deposition of fine carbon particulate from factory might also reduce the photosynthesis of the plant and this hamper the growth of plants and ultimately the crop yield.

The soils in the study area are irrigated by the groundwater's C_1S_3, C_1S_4 and C_2S_3 types. These are low to medium in sodium content and moderately high saline. This reflects that groundwater quality contributes significantly towards the salinity of soil. The irrigation waters belonging to high sodium water (No. S_5) and very high sodium water (No. S_{14}) are generally harmful. However, the soils in the present study area are rich in calcium, which contributes about 50% of the total exchangeable cations and therefore, the irrigation waters belonging to C_1S_3, C_1S_4 and C_2S_4 fields can dissolve sufficient calcium and can decrease sodium hazard appreciably. The addition of gypsum to the soil is essential for further reducing the salinity of the soil.

Heavy metals in the soil sediments

Due to the large scale industrialisation and agriculturalisation of the area under study, the concentration of heavy metals is rapidly increasing in water and soil. The mechanism of accumulation of metals in the sediments is mainly controlled by the nature the substrata and the physic-chemical environment. The use of excess of chemical

Table 3. Heavy metals in the soil sediments of the Panchanganga river basin (in ppm)

Sample No.	Fe	Mn	Cu	Zn	Cd	Pb	Ni	Co
S1	10920.00	138.00	24.00	38.00	0.22	5.12	4.64	4.16
S2	6180.00	154.00	26.00	17.00	0.21	5.16	4.06	3.76
S3	6280.00	135.00	14.00	34.00	0.19	5.26	3.66	3.12
S4	15460.00	136.00	20.00	26.00	0.22	5.90	5.99	3.59
S5	9080.00	139.00	16.00	19.00	0.20	4.80	4.85	3.66
S6	17560.00	198.00	31.00	39.00	0.22	4.94	5.24	4.18
S7	11840.00	155.00	16.00	17.00	0.21	5.20	6.63	3.92
S8	8060.00	429.00	22.00	84.00	0.19	4.98	3.96	3.42
S9	15400.00	195.00	31.00	19.00	0.23	5.22	5.33	4.47
S10	5400.00	131.00	23.00	25.00	0.21	4.92	3.98	3.64
S11	14860.00	100.00	26.00	30.00	0.19	4.12	4.05	3.33
S12	15920.00	187.00	29.00	44.00	0.22	5.14	5.23	4.64
S13	13800.00	287.00	27.00	36.00	0.22	5.08	5.32	4.17
S14	8960.00	239.00	32.00	70.00	0.23	5.20	5.01	3.87
S15	16280.00	410.00	42.00	42.00	0.23	5.40	7.29	5.93
Shale	46700.00	850.00	45.00	95.00	0.30	20.00	68.00	19.00

fertilizers also leads to the contribution of heavy metals in the soil sediments. The sources of Cd and Zn in the soils are mainly commercial fertilizers (Stenstrom and Vahter, 1974). Essential heavy metals such as Mn, Fe, Ni and Zn are needed by living organisms for their growth, development and physiological functions, while non-essential heavy metals such as Cd, Pb, Hg, and As are not needed by living organisms for any physiological functions (Gohre *et al.,* 2006). The heavy metals accumulate in the plant material grown in these soils, which will ultimately go to human body through food chain directly or indirectly causing a number of physicomental problems (Sharma *et al.,* 2008). The presence heavy metal pollutants serves as great threat to soil and plants growing on such soil, with consumption of such plants by animals and human being due to their entry into food chain through biomagnifications and bio accumulation leading severe detrimental effects (Saidi, 2010). It is reported that intake of toxic metals in vegetables and corn products accumulates in the kidney, leading to dysfunction. Some reports have linked skeletal damage (osteoporosis) in human to heavy metals, such as high level selenium (Abdullahi, 2013).

The results of the heavy metal analysis from different soil analysis are presented in Table 3. The heavy metal concentration was compared with Global Shale (Table 4) of Turekian and Wedepohl (1969).

From Table 3, it is observed that heavy metal concentration in the soil sediments ranged as follows:

Fe : 5400 – 17560 ppm, Mn : 100 – 429 ppm, Cu : 14 – 42 ppm, Zn : 17 – 84 ppm, Cd : 0.19 – 0.23 ppm, Pb : 4.12 – 5.9 ppm, Ni : 3.66 – 7.29 ppm, Co : 3.12 – 5.93 ppm.

Iron was most dominant amongst other metal concentration in the soil sediments. The lateritic or medium dark soil showed an average of 10,672.5 ppm around city area whereas other samples from upper reaches of the basin showed an average concentration of 12,945.7 ppm. The main source of iron in the area is the leaching through basaltic rocks rich in iron content.

The soil samples from the barren areas showed lower concentration of zinc and cadmium, the background value being 3.00 and 0.19 ppm, respectively. However, higher concentration of zinc and cadmium as high as 84 ppm and 0.23 ppm respectively, can be attributed to chemical fertilizers such as urea, phosphates and superphosphates. The analysis of fertilizer samples showed that concentration of Cd and Zn ranged between 1.2 and 79 mg kg^1 and 17 and 3070 mg kg^1, respectively (Naseem *et al.*, 1981).

The average concentration of lead shown by soil sediments around Kolhapur city (Sample Nos. S_3, S_4, S_5& S_7) was 5.16 ppm, whereas average concentration shown by rest of the samples was 4.99 ppm. This clearly indicates that there is an increasing trend in the concentration of this metal towards the city area, due to the increase in the automobile traffic.

Nickel, cobalt and copper showed smaller variation and do not depict any particular trend. However, copper showed highest concentration of 42 ppm in soil sample No. $S_{15.}$ The following

Table 4. Ratios of heavy metal concentration to the World Shale background

Sample No.	Fe	Mn	Cu	Zn	Cd	Pb	Ni	Co
S1	0.233	0.162	0.533	0.400	0.733	0.256	0.068	0.218
S2	0.132	0.181	0.577	0.178	0.700	0.258	0.059	0.197
S3	0.134	0.158	0.311	0.357	0.633	0.263	0.053	0.164
S4	0.331	0.160	0.444	0.273	0733	0.295	0.088	0.188
S5	0.194	0.163	0.355	0.200	0.666	0.240	0.071	0.192
S6	0.376	0.232	0.688	0.412	0.733	0.247	0.077	0.220
S7	0.253	0.182	0.355	0.178	0.700	0.260	0.097	0.206
S8	0.172	0.504	0.488	0.884	0.633	0.249	0.058	0.180
S9	0.329	0.229	0.688	0.200	0.766	0.261	0.078	0.235
S10	0.115	0.154	0.511	0.263	0.700	0.246	0.058	0.191
S11	0.318	0.110	0.557	0.030	0.633	0.206	0.059	0.175
S12	0.340	0.220	0.644	0.463	0.733	0.257	0.076	0.244
S13	0.295	0.337	0.600	0.378	0.733	0.254	0.076	0.219
S14	0.191	0.281	0.711	0.736	0.766	0.260	0.073	0.203
S15	0.360	0.482	1.200	0.442	0.766	0.270	0.107	0.312

sequences of decreasing concentration of metals was observed in the soil samples :

Fe >Mn> Zn > Cu >Pb> Ni > Co > Cd.

The pollution due to heavy metals in waters is difficult to determine due the lower concentration. However, many researchers have found that the degree of heavy metal pollution in soil sediment is conveniently expressed as the ratio with respect to the average concentration of Global Shale (Forstner and Wittmann, 1979).

In the present study, the metal ratio was calculated with respect to Global Shale (Table 4) and it is observed that all most all the elements showed a ratio less than one, indicating that the soil sediments of the Panchanganga basin are not polluted with respect to the heavy metals.

CONCLUSION

1. Within the river basin, three types of soils can be demarcated. Black cotton soil is in the north and north-western part of the basin and all along the bank of the river Bhogawati. Reddish brown lateritic soil is well developed on the plateau in the western and central part of the basin. In the southern part of the Kolhapur city a thin layer of coarse soil is developed on weathered basalts.
2. The pH of lateritic or semi-lateritic soil was in acidic range. The soils of the study area can be classified as normal to saline. pH showed significant positive correlation with EC, CEC, Na^+ and K^+ (> 0.57).
3. Based on Electricity conductivity most of the soil samples fall under the category of saline which restrict yields of very sensitive crops.
4. The exchangeable cations such as Ca^{++}, Mg^{++}, Na^+ and K^+ showed an average concentration of 12.95, 6.77, 4.14 and 0.44 meq/100 g of soil, respectively.
5. The CEC of soil varied between 20.00 to 35.00 meq/100 g of soil. The black cotton soils showed higher values as compared to those of lateritic and semi-lateritic soils.
6. Based on ESP values, the soils are classified as non-saline and non-alkaline. However, based on electrical conductivity values, some of the samples classify as saline.
7. The concentration of metals is according to the sequence Fe >Mn> Zn > Cu >Pb> Ni > Co > Cd. A comparison of these heavy metal concentrations with those in Global Shales suggests that the soils under study are unpolluted.
8. The physico-chemical analysis of soils revealed that in the immediate vicinity of the sugar factories the groundwater are mainly C_1S_3, C_1S_4 and C_2S_4 types. Continued irrigation by these types of water has made the soils saline in some places. Rising water table due to excess irrigation, and use of chemical fertilizers have contributed to salinisation of soils. Consequently the sugarcane yield has been reduced due to insufficiency of air in the root zone of crop.

REFERENCES

Abdullahi, M.S. 2013. Toxic effects of metals in humans: an over view. *Global Advanced Journal of Environmental Science and Toxicology*. 2 (6) : 157-162.

Agarwal, R. R. and Yadav, J.S.P. 1956. Diagnostic techniques for the saline and alkali soils of the Indian Gangetic alluvium in U.P., *J. Soil Sci.* 7 : 109-121.

Ausafur Rahman, 1982. Soil characteristics and soil waste interactions at solid-waste disposal sites in urban communities of developing countries. *Internation symposium on soil, geology and land forms - impact on landuse planning in developing countries, Bangkok, Thailand*, A14.1 - A14.10.

Bhadrapur, R.G. and Rao, T.S. 1977. Effect of seepage and water logging on the development of saline and sodic soils in Tungabhadra project area of Karnataka. *J. Indian Soil Soc.* 27 : 408-513.

Bhosale, U. and Sahu, K.C. 1991. Heavy metal pollution around island city of Bombay, India. Part II: Distribution of heavy metals between water, suspended particles and sediments in a polluted aquatic regime, *Chemical Geology*. 90 : 285-305.

Bhumba, D.R. 1977. Reclamation and utilisation of salt affected soils. *J. Can. Fmg.* 22 (5) : 151-154.

Bird, S.C. 1987. The effect of hydrological factors on the trace metal contamination in the river Tawe, South Wales. *Environmental Pollution*. 45 : 87-124

Chauhan, R.P.S., Bhudayal, Chauhan, C.P.S. and Vishnoi, R.K. 1990. Quality assessment of groundwaters of semi-arid tract and their impact on soil. *J. Indian Soc. Soil Sci.* 38 : 516-519.

Forstner, U. and Wittmann, G.T. 1979. *Metal Pollution in Aquatic Environment*. 136, Berlin Springer.

Gohre, V. and Paszkowski, U. 2006. Contribution arbuscular mycorrhizalsymbiosis to heavy metalsphytoremidation. *Planta*. 223 : 1115-1122.

John, M. Hellawell, 1988. Toxic substances in river and streams. *Envt. Pollution*. 50 : 61-85.

Kuldeep Singh, Goyal, V.P. and Mahendra Singh, 1990. Distribution of micronutrient cations in semi-arid alluvial profiles. *J. Indian Soc. Soil Sci.* 38 : 736-737.