[Shakha*, 5(2): February, 2016]

ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

ASSESSMENT OF SOIL QUALITY IN PARTS OF LUDHIANA DISTRICT, PUNJAB, INDIA IN ORDER TO ATTAIN AGRICULTURAL SUSTAINABILITY

Sharda Shakha*, Kaur Gurmeet and Rishi Madhuri

*Department of Environment Studies, Panjab University, Chandigarh.

Department of Geology (CAS), Panjab University, Chandigarh.

Department of Environment Studies, Panjab University, Chandigarh.

ABSTRACT

Industrial agriculture which is in vogue in the present times advocates the use of synthetic, chemical fertilizers and monocrop agriculture practices. Unmindful use of synthetic fertilizers has polluted the atmosphere, soils and waterways. The monocrop agriculture practices have further added to the woes of the soil. In the past two to three decades, intensive agricultural practices have put a tremendous pressure on the soils, declining its fertility both in terms of its macro and micronutrients. Maintenance of soil fertility is important for sustainable agricultural production. Soil quality (micro and macro nutrients and heavy metals) of the study area has been carried out using standard methods.The soil of the study area had pH between 6.5 to 8.7 i.e. under normal category which is optimum for the crops. EC is below 0.8dS/cm and is also optimum for the crops. The organic carbon content in the soil is low to medium. The content of macronutrients like: nitrogen, phosphorus and potassium is generally low to medium in the study area. The content of micronutrient like: zinc and copper are deficient but iron and manganese are in sufficient amount. The content of chloride is also low in the study area. The content of heavy metal like cadmium is high at 15cm depth but is low at 30cm depth. The concentration of lead in the soil is low. The SAR value of the soil varies from0.62 meq/l to 1.90 meq/l which is good for the crops. Correlation analysis shows that there is a strong positive correlation between pH and the soil parameters which shows that soil is suitable for many crops. There is weak correlation between OC and soil parameters because of minimum amount of organic content in the soil. There is a positive correlation between the heavy metal as they are insusceptible to leaching and cause soil contamination. Thus, it is evident from the above parameters that the soil is good for agricultural purposes in the study area but proper soil management is urgently required to reduce the soil contamination due to heavy metals.

KEYWORDS: Monocrop, macro-nutrients, sustainable agriculture, SAR (Sodium Absorption Ratio), soil management, soil management.

INTRODUCTION

Soil is the backbone of agriculture and it is very essential to keep soil vigorous for production of crops. Soil is composed of very fine mineral particles, water, air and organic nutrients as shown in Fig.1which have the capacity to support vegetation.Soil contains about 25 elements out of which 16 elements are essential for plant growth and are further divided into two groups: nine macronutrients which include C, H, O, N, P, S, Ca, K and Mg and seven micronutrients: comprising Fe, Mn, B, Mo, Cu, Zn andCl (Randhawa, 2012).

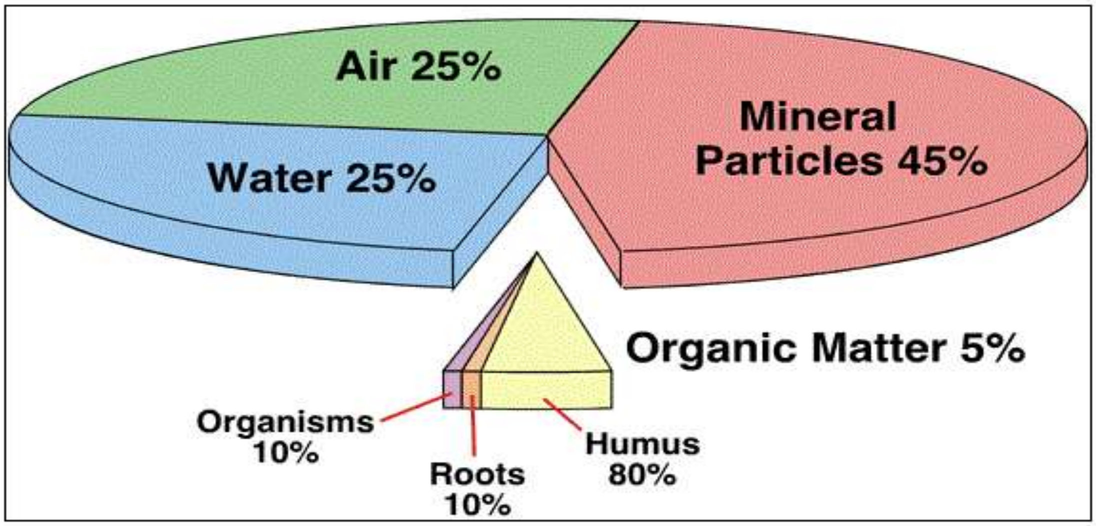

Fig.1 Components of soil

Unfortunately, the population explosion and ever increasing demand for food has put tremendous pressure on soil and has resulted in over exploitation of soil by cutting of forests and excessive ploughing and tillage leading to rampant soil erosion. Excessive usage of fertilizers and pesticides which enhance the crop production temporarily, leave behind the degraded, impoverished soil in terms of its natural nutrients, and, even at times making the soils barren, posing another major threat to sustainable agriculture.

Two nutrient pollutants i.e. nitrogen (N) and phosphorus (P) which are released to water and soil systems as a result of excessive use of synthetic fertilizers for agriculture have become a threat to living systems. The high nitrogen and phosphorous contents in water and soil has led to many diseases in human beings and animals. Double cropping of both rice and wheat sequence results in the depletion of the nutrient contents because of their high nutrient requirements (Benbi et al. 2006).Maintenance of soil fertility is as essential component to sustain agricultural production.

Location

Geographically, Ludhiana district lies between North Latitude 30^{o}-34' and 31^{o}-01' and East longitude 75^{o}-18' and 76^{o}-20'. It is the most centrally located district of Punjab and is bounded on the north by the River Sutlej which separates it from Jalandhar district. The district shares common boundaries with Roopnagar district in the East, Moga district in the West and Sangrur, Fatehgarh Sahib and Patiala districts in the South and South-east (Fig.2). It is the largest city in Punjab, both in terms of area (3860 sq km) and population (approximately 34, 87,882 as per 2011 census). Ludhiana is the first metropolitan city, popularly known as “Manchester of India.” located on National Highway-I, has emerged as the most vibrant and important business center of Punjab.

Topography

The district constitutes a typical alluvial plain. It owes its origin to the augmentation of the Sutlej River. The alluvium deposited by the river was reworked by aeolian activities to give rise to a number of small dunes and sand mounds. The District can be divided into the flood plains of the Sutlej and the upland plains.

ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

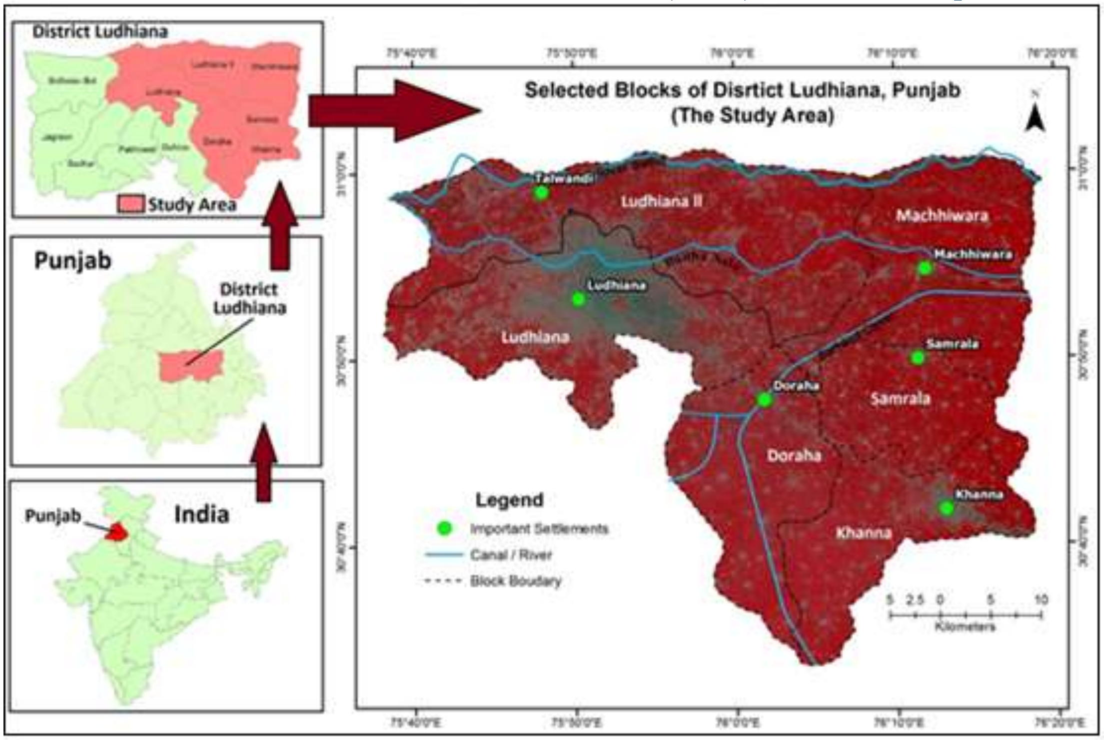

Fig.2 Location map of the study area

Climate

The climate of the district is characterized as tropical steppe (hot and semi-arid) except a brief spell of monsoon season in a very hot summer and a bracing winter. The summer season extends from April to the end of June, hot and scorching dust laden winds blow during the summer season. July, August and half of September experience the south west of monsoon, the period of mid-September to about the middle of November as post monsoon or transitional period. The winter season is from middle of November to the early part of March. June is generally the hottest month; December and January are the coldest months. The mean daily temperature varies in the range of 5.8 ^{o}C to 41.2 ^{o}C.

Temperature

Variation in the minimum temperature in Ludhiana district of Punjab was found to be lowest during January, February and December and highest has been noticed in June, July and August. There has been a consistent increase in the average minimum and maximum temperature in Ludhiana District due to climate change.

Agriculture is the main occupation of the people of the study area.It is therefore, essential to understand soil characteristics, determine the potential of soil in the area and identify the impacts of intensive agriculture on soil quality and thus device an effective approach to attain the agricultural sustainability. Accordingly, a study of assessment of the soil quality has been carried out.

METHODOLOGY

A scientific, well-tested and technically sound methodology including both field and laboratory investigations were followed to carry out the present study.The procedures discussed below have been followed for the sample collection in the field and chemical analysis of major elements in laboratory for the present study.

Field investigations and sample collection

- A random sampling was done to collect the soil samples from the area selected.

- Total 44 soil samples from different locations were collected to assess the soil quality of the area under investigation.
- At each location soil samples were collected at two different depths i.e. 15 cm and 30 cm below the surface and homogenized.
- The samples were collected and transferred to laboratory in a good quality, air tight and clean plastic bags for the analysis.

Laboratory Investigation and determination of soil quality

- All characteristics of collected soil samples were analyzed in the geochemical laboratory of the Department of Geology, Panjab University, Chandigarh, according to the standard methodology given by American Public Health Association (1998), Trivedy and Goel (1986) and Central Pollution Control Board, New Delhi (2001).
- The soil samples collected from different blocks in the field were sieved, shade dried and stored for analysis. The soil samples were analyzed for various parameters like pH, EC, OC, macro-nutrients like: (N, P, and K), micro-nutrients like :(Zn, Fe, Cu, Mn andCl) and heavy metals like: (Cd and Pb). The Ca^{2+}, Mg^{2+} and Na^{+} were also calculated to determine the SAR value of the soil.

Preparation of Soil Solutions

Before the preparation of the solution, the soil samples were air dried and then pulverized to 200 meshes. The mortar was washed and dried after each run. The powder was thoroughly mixed through coning and quartering techniques. Powdered samples were kept in glass bottles for drying in oven at 110 ºC overnight. Solutions were prepared from these oven dried samples.

Methods used for Soil Analysis

Following methods were used for the determination of soil quality of the study area:

- The pH values of the soil were measured with the help of pH meter.
- The EC of the soil was measured in Electrical Conductivity meter.
- The method given by Walkley and Black (1934) Rapid Titration method was used for the determination of organic carbon.
- The method given by Subbiah and Asija (1965) was used to determine the available nitrogen in the soil.
- The method given by (Olsen et al.1954) was used to determine available phosphorus, sodium, calcium and magnesium in the soil.
- The method given by Merwin and Peech (1950)was used to determine the available potassium in the soil.
- Fe, Zn, Cu, Mn and Cl were extracted with a DTPA solution for determination of available micro-nutrients and the concentration of the micronutrients was determined by atomic absorption spectrophtometry.
- The concentration of Cd and Pb was estimated by I-CAP (Inductive- Couple Argon Plasma method).
  The locations of soil samples are shown in Fig. 3. Table 1 shows the soil parameters like: pH, EC and TDS at depth of 15and 30 centimeters, respectively.

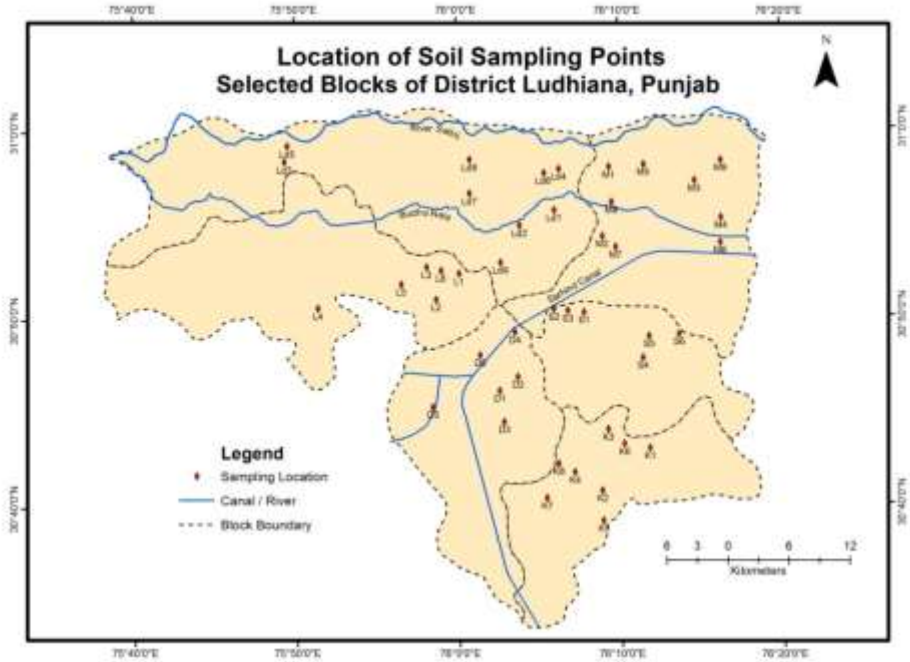

Fig.3Location map of soil sampling sites of the study area

Table: 1 Soil parameters (pH, EC and OC) of the study area

S. No.	Sampling Locations	Block	Name of the village	pH (depth)		EC (dS/cm) (depth)		OC (%) (depth)	
				15 cm	30 cm	15 cm	30 cm	15 cm	30 cm
1	L1	Ludhiana I	Kohara	7.56	7.58	0.45	0.43	0.45	0.51
2	L2		Sahnewal	7.8	7.62	0.45	0.45	0.42	0.38
3	L3		Ramgarh	8	8.05	0.47	0.48	0.87	0.45
4	L4		Gill	8.01	7.98	0.63	0.49	0.675	0.315
5	L5		Gobindgarh	7.96	8.04	0.57	0.53	0.975	0.795
6	L6		Jandiali	7.96	7.94	0.46	0.45	0.36	0.295
7	Ld1	Ludhiana II	Sherian	7.92	7.98	0.56	0.48	0.84	0.705
8	Ld2		KumKalan	7.96	8	0.49	0.48	0.46	0.435
9	Ld3		Kadian	8.16	8.2	0.47	0.47	0.54	0.48
10	Ld4		Johnewal	7.15	7.23	0.58	0.51	0.47	0.36
11	Ld5		FatehgarhGujran	7.83	7.48	0.45	0.47	0.63	0.52
12	Ld6		Balliawal	8.04	8.01	0.61	0.59	0.59	0.38
13	Ld7		BonkarGujran	7.43	7.53	0.54	0.49	0.42	0.35
14	Ld8		MachianKalan	7.15	7.26	0.5	0.47	0.57	0.41
15	Ld9		Rayian	7.26	7.15	0.49	0.42	0.65	0.49
16	M1	Machhiwara	Udhowalkalan	7.13	6.98	0.55	0.53	0.72	0.62
17	M2		Iraq	7.05	6.15	0.6	0.59	0.83	0.71
18	M3		Hambowal	6.93	6.65	0.53	0.45	0.67	0.53
19	M4		Kaunkd	6.12	7.09	0.62	0.56	0.59	0.48
20	M5		Jasowal	7.23	7.13	0.49	0.4	0.45	0.39
21	M6		Powat	7.11	6.23	0.36	0.37	0.62	0.57

22	M7		Bhattian	6.19	6.05	0.53	0.51	0.57	0.51
23	M8		Manewal	6.78	6.53	0.47	0.43	0.82	0.71
24	M9		RajewalJattan	6.93	6.26	0.55	0.54	0.57	0.49
25	S1	Samrala	Ghulal	7.11	7.08	0.43	0.39	0.54	0.46
26	S2		NeelonKhurd	6.15	6.45	0.55	0.51	0.63	0.59
27	S3		Bijlipur	6.59	6.15	0.61	0.58	0.71	0.68
28	S4		Rajewal	7.03	6.37	0.48	0.47	0.63	0.54
29	S5		Utalan	6.15	6.28	0.39	0.32	0.54	0.46
30	S6		Dialpur	6.83	6.76	0.45	0.43	0.49	0.38
31	D1	Doraha	Kaddon	6.14	6.13	0.31	0.32	0.53	0.51
32	D2		Mahlipur	6.56	6.42	0.35	0.34	0.48	0.42
33	D3		KotlaAfgana	6.14	6.15	0.43	0.39	0.35	0.31
34	D4		Katana Sahib	7.03	6.98	0.51	0.45	0.53	0.43
35	D5		Bilaspur	6.15	6.21	0.38	0.37	0.42	0.38
36	D6		Rajgarh	6.23	6.15	0.42	0.39	0.39	0.32
37	K1	Khanna	Kauri	6.48	6.13	0.39	0.26	0.43	0.39
38	K2		Kotla Duck	6.53	7.08	0.43	0.35	0.37	0.32
39	K3		Daheru	6.11	6.23	0.53	0.51	0.42	0.37
40	K4		BirKishan Singh	7.03	6.91	0.37	0.42	0.36	0.32
41	K5		RajewalRohnon	6.18	6.15	0.36	0.41	0.41	0.38
42	K6		Libra	6.23	6.03	0.41	0.36	0.32	0.29
43	K7		Chima	6.11	6.04	0.38	0.32	0.35	0.31
44	K8		Payal	6.21	6.08	0.42	0.39	0.38	0.35
			Minimum	**6.11**	**6.03**	**0.31**	**0.26**	**0.32**	**0.29**
			Maximum	**8.16**	**8.2**	**0.63**	**0.59**	**0.975**	**0.795**
			Average	**6.96**	**6.88**	**0.47**	**0.44**	**0.54**	**0.45**
			Standarddeviation	**0.68**	**0.72**	**0.08**	**0.07**	**0.15**	**0.12**

DETERMINATION OF SOIL PARAMETERS

Determination of soil pH

The acid/alkali balance is very important in maintaining optimum availability of applied nutrients. At very low pH values, soluble aluminium becomes toxic, phosphate is unavailable and calcium levels can be low (Smith and Doran, 1996). At high pH, iron and other trace elements are rendered unavailable because they are locked up as hydroxides and carbonates. At low pH, solubility of micro nutrients is high while at high pH the solubility of micro nutrients decreases (Brady and Weil, 2002). Figs. 4a and b shows distribution of pH in the soils of the study area. Average soil pH of the samples falls in the range of normal category and is optimum for the majority of crops. The pH of the soil is animportantphysico-chemical characteristic, as it influences:

- the suitability of a crop for production.
- the availability of nutrients insoil.
- the microbial activity insoil.
- the lime and gypsum requirement.
- the soil physical properties like structure, permeability etc.
- to predict soil fertility.

Interpretation according to Bates(1954)and Jackson (1967) is given in Table 2.

 ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

Table: 2Classification of soil based on pH Values

S.No	pH	Category	No. of Samples	Recommendation
1	<6.5	Acidic	Nil	Requires liming for reclamation
2	6.5-8.7	Normal	44 (100%)	Optimum for most crops
3	8.7-9.3	Alkaline	Nil	Requires application of organic manures
4	*>9.3*	*Alkali (Sodic)*	*Nil*	*Requires gypsum for amelioration*

(Source:Bates(1954)and Jackson (1967))

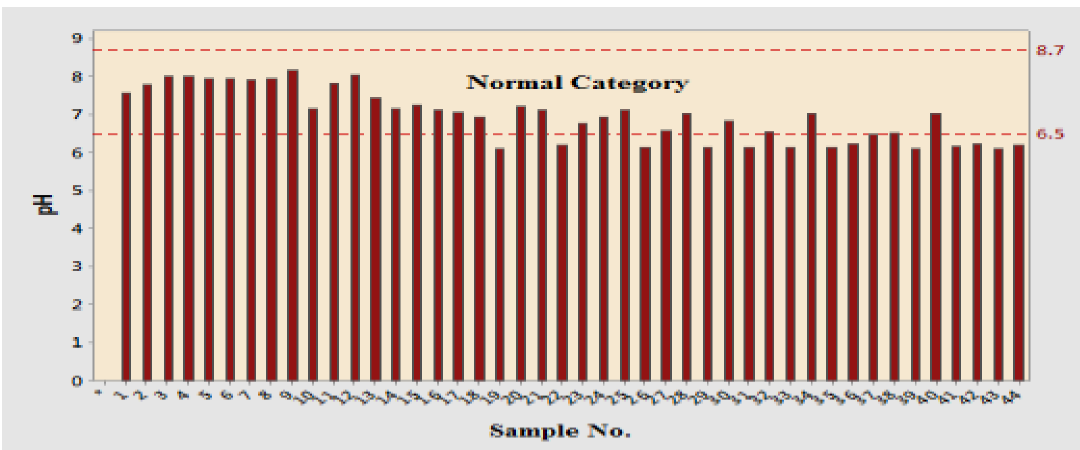

Fig.4 aSoil pH at 15 cm depth in the sampled locations

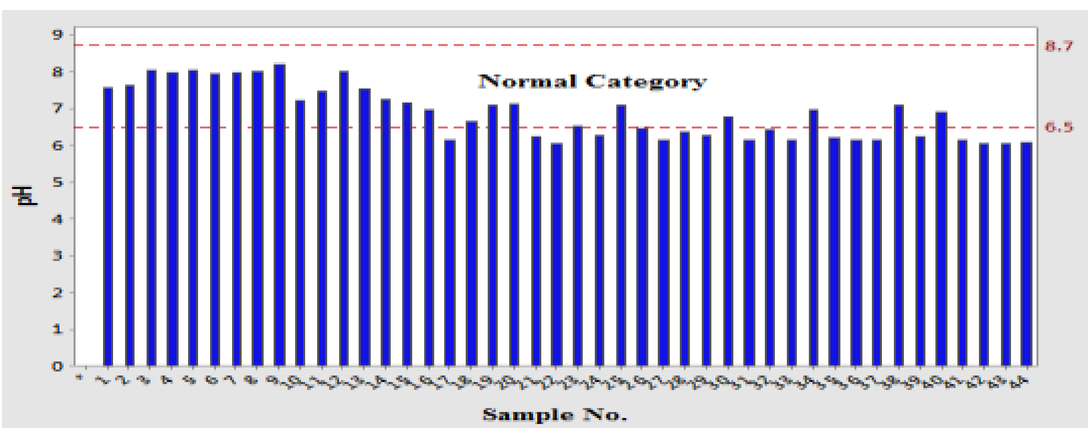

Fig.4 bSoil pH at 30 cm depth in the sampled locations

Electrical Conductivity (EC)

EC and TDS both are significant from agricultural point of view. High electrical conductivity of the soil indicates more dissolved substances. The increase in soil salinity speeds up soil erosion and retard the plant growth (Szabolcs, 1989). Sources of soluble salts in the soil include weathering of primary minerals and native rocks, atmospheric deposition, saline irrigational water, addition of inorganic and organic fertilizers (Sparks, 2003).

Allfertile soilshave atleast small amounts of soluble salts in them. When a soil contains as excess soluble salts, it is termed as saline soil. The soluble salt content of soil can be estimated from an electrical conductivity measurement of soil in water (Smith and Doran, 1996). A better estimate of soluble salts can be obtained from the conductivity of a water extract of soil.Tables 2and 3 show the list of crops according to salt tolerance and interpretation of EC at different values.

Table: 2 List of crops according to salt tolerance

High salt - tolerant crops	Medium salt - tolerant crops	Low salt - tolerant crops
Barley (grain), Sugarbeet, Rape, Cotton, Kale, Spinach Date Palm	Rye (grain), Wheat, Oats, Rice, Sorghum, Corn, Flax, Sunflower, Castorbeans, Tomato, Cabbage, Grape, Cauliflower, Pomegranate	Field beans, Raddish, Pea, Green beans, Apple, OrangeGrape fruit

(Source: After Soil Science Laboratory Manual, 1997)

Table: 3Classification of soil based on EC

EC in mmhos/cm or dS/cm	Soil Category
Below 0.8	Normal-suitable for all crops
0.8-1.6	Criticalfor salt-sensitive crops
1.6-2.5	Critical for salt-tolerant crops
Above 2.5	Injurious toall crops

(Source: After Jackson (1967) and Richards (1954)

- The EC value of soil samples of the study area ranged from 0.31mmhos/cm to 0.63mmhos/cm with the mean value of 0.47 mmhos/cm at 15cm depth and 0.26mmhos/cmto 0.59 mmhos/cmwith the mean value of 0.44mmhos/cm at 30cm depth.
- All the soil samplesfall in the normal category which is suitable for all crops. The distribution of EC in the soil samples are shown in Figs. 5a and b.

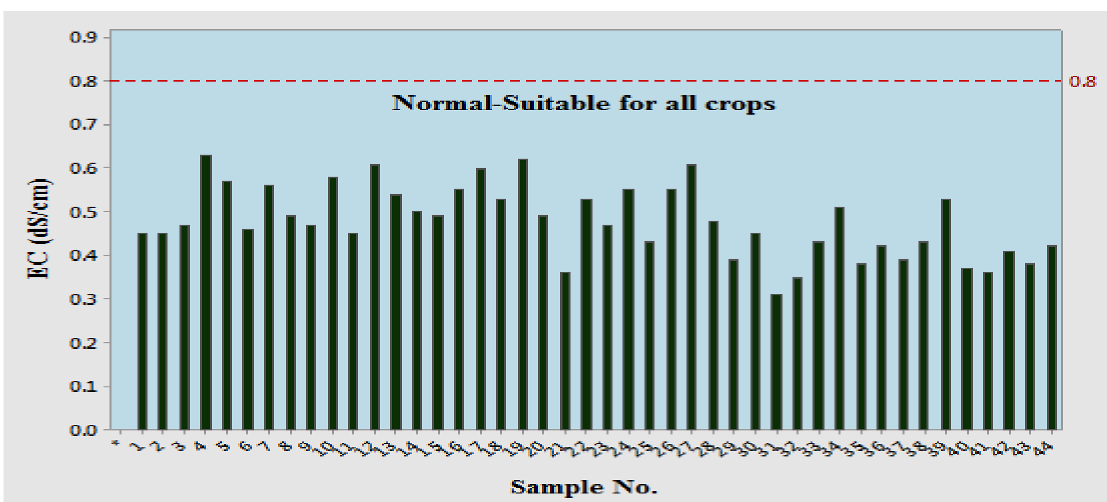

Fig.5 aSoil EC at 15 cm depth in the sampled locations

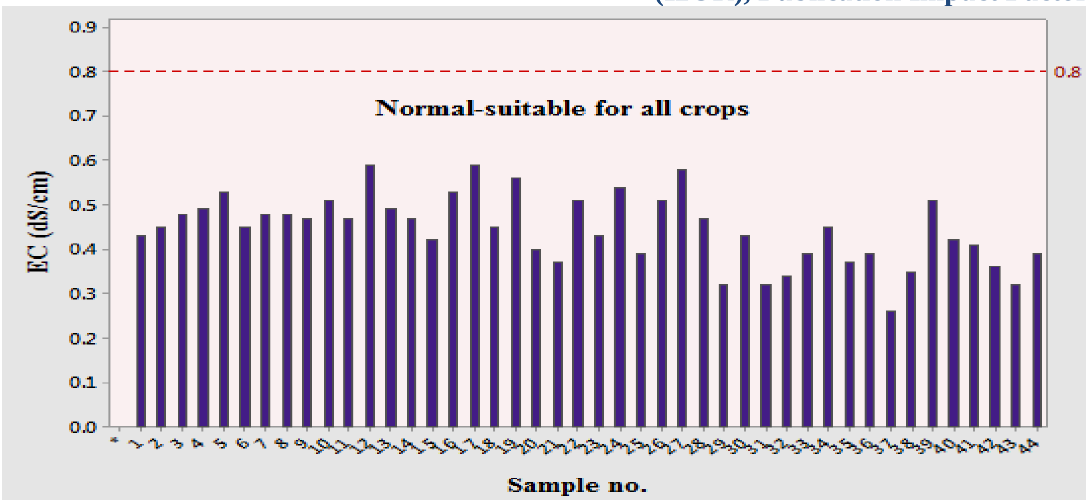

Fig.5 bSoil EC at 30 cm depth in the sampled locations

Soil Organic Carbon

Carbonis the chief constituent of soil organic matter and the estimation of organic matter is based on organic carbon. Values for the organic carbon content of soils maybe expressed as total organic matter by multiplying the figure for organic carbon by a factor of 1.724 (Van Bemmlen factor), which is based on the assumption that organic matter, on an average, contains 58% organic carbon (Soil Science laboratory Manual, 1997).

Soil organic matter, which refers to the remains of plants, animals and microbes in different stages of decomposition, isof vital importance it reflects the following functions:

- It act as storehouse of nutrients-nitrogen, phosphorus, sulphur, boron etc.
- It accounts for at least half the cation exchange capacity of soils.
- It releases carbon dioxide.
- It supplies energy and body building constituents for microbes, which are responsible for various biochemical changes in the soils.
- It isresponsiblefor the stability of soil structure and thus influences moisture retention and aeration.

The organicmatter is used as an index of nitrogen supplying capacity of a soil as it contains, on an average, approximately 5% nitrogen. Thecontent of organic matter in soils is considered as anindex of soil fertility and their interpretation is given in Table 4.

Table: 4Classification of soil based on Organic Carbon (%)

Organic Carbon (%)	Rating	No. of Soil Samples/ (%)	
		15 cm (depth)	30cm (depth)
Below 0.40	Low	08/(18.18)%	19 / (43.18)%
0.40-0.75	Medium	31 / (70.45)%	24 / (54.54)%
Above0.75	High	05 /(11.36)%	01 / (2.27)%

(Source: After Black (1965) and Jackson (1967)

- ➢ The soil organic carbon of the study area ranged from 0.32 to 0.97 (%) with the average value of 0.54 (%) at 15cm depth and 0.29to0.79 (%) with an average value of 0.45 (%) at 30cm depth.
- ➢ Soil organic carbon is generally low to medium because of the low or limited applications of organic manure and non-recycling of crop residues. The distribution of OC is shown in Figs. 6a and b.

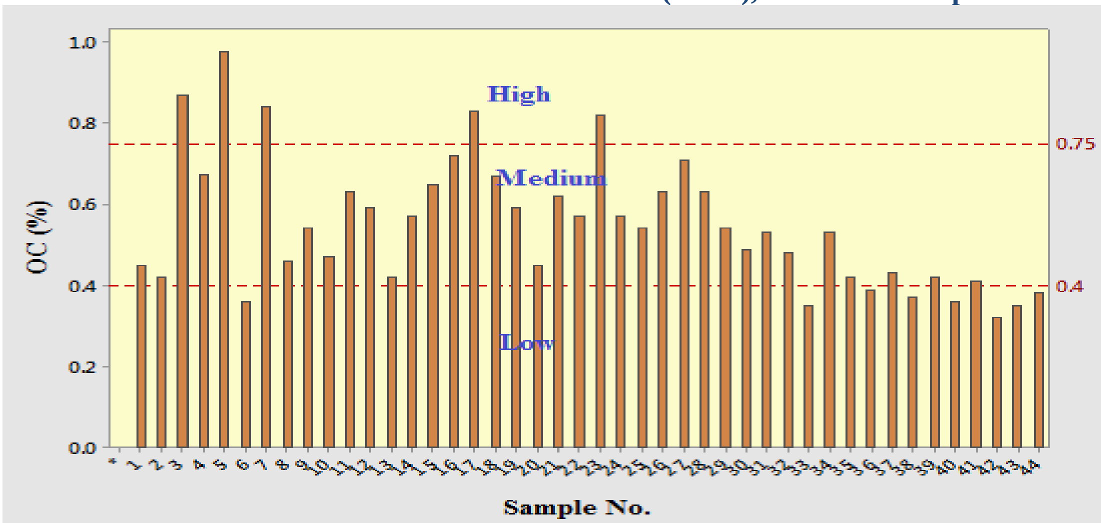

Fig.6 aSoil OC (%) at 15 cm depth in the sampled locations

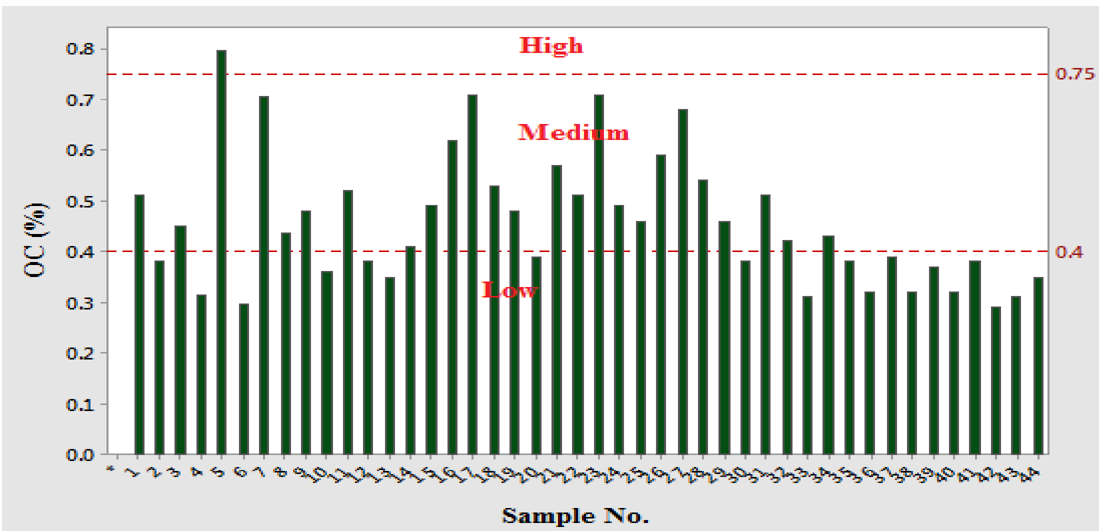

Fig. 6bSoil OC (%) at 30 cm depth in the sampled locations

STATUS OF MACRO-NUTRIENTS

The status of macro-nutrients in the soil at 15cm depth and at 30 cmdepth is shown in Table 5.

Determination of available nitrogen in soil

The quantity of nitrogen in soils is associated with the amount of organic matter of which nitrogen makes up approximately 5 per cent. Thenitratesand exchangeable ammonium which are the forms available for plant nutrition usually make less than 1per cent of the total soil nitrogen content. But the totalamount of nitrogen that is available to plants is more than that, due to the release of nitrogen, from organicto inorganic forms. This amount of nitrogen, in soil, which is susceptible to absorption by plants, istermed as "available nitrogen". The interpretation of nitrogen in soil is shown in Table 6.

ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

Table:6Classification of soil based on available nitrogen

N in kg/ha	Rating	No. of soil samples Depth	
		15cm	30 cm
<271	Low	44	44
271-543	Medium	Nil	Nil
>543	High	NIl	Nil

(Source: After Subbiah and Asija (1965)

Table: 5 Status of macro nutrients of the soil of the study area

S. No	Sampling Locations	Block	Name of the village	N (kg/ha) depth		P (kg/ha) depth		K (kg/ha) depth	
				15 cm	30 cm	15 cm	30 cm	15 cm	30 cm
1	L1	Ludhiana I	Kohara	175	164	17.8	14.2	213	198
2	L2		Sahnewal	167	148	14.2	11.9	197	189
3	L3		Ramgarh	123	112	13.9	10.7	186	176
4	L4		Gill	132	119	15.1	12.3	205	191
5	L5		Gobindgarh	165	142	16.3	13.1	193	174
6	L6		Jandiali	153	139	16.03	13.6	199	183
7	Ld1	Ludhiana II	Sherian	161	157	18.1	14.01	210	195
8	Ld2		KumKalan	172	160	14.98	12.4	183	177
9	Ld3		Kadian	157	149	13.05	11.8	189	181
10	Ld4		Johnewal	163	157	14.09	11.05	176	172
11	Ld5		FatehgarhGujran	149	123	15.1	12.09	193	185
12	Ld6		Balliawal	129	113	16.03	13.01	199	193
13	Ld7		BonkarGujran	137	126	13.9	11.8	201	189
14	Ld8		MachianKalan	145	138	12.6	10.9	199	180
15	Ld9		Rayian	153	141	16.2	14.05	183	173
16	M1	Machhiwara	Udhowalkalan	110	93	11.03	9.8	175	162
17	M2		Iraq	98	89	9.98	8.2	169	159
18	M3		Hambowal	113	105	10.1	8.9	153	142
19	M4		Kaunkd	105	90	9.6	7.2	167	151
20	M5		Jasowal	92	83	10.1	8.1	159	148
21	M6		Powat	109	97	12.3	9.3	173	163
22	M7		Bhattian	101	92	10.3	7.5	164	157
23	M8		Manewal	97	89	9.6	6.2	156	143
24	M9		RajewalJattan	120	115	10.5	7.3	170	155
25	S1	Samrala	Ghulal	133	121	11.28	8.6	149	132
26	S2		NeelonKhurd	118	109	9.03	7.9	133	128
27	S3		Bijlipur	110	93	12.01	9.2	158	142
28	S4		Rajewal	123	105	13.3	10.1	147	139
29	S5		Utalan	108	95	12.26	9.7	139	126
30	S6		Dialpur	95	87	11.84	8.6	143	133
31	D1	Doraha	Kaddon	89	81	11.01	9.1	159	143
32	D2		Mahlipur	87	79	10.86	7.3	147	132
33	D3		KotlaAfgana	72	63	11.84	8.1	139	129
34	D4		Katana Sahib	81	75	14.3	10.3	145	136
35	D5		Bilaspur	93	85	10.9	8.4	153	141

36	D6		Rajgarh	78	63	15.1	9.03	162	156
37	K1	Khanna	Kauri	69	59	10.7	7.86	149	137
38	K2		Kotla Duck	61	55	11.4	8.4	137	128
39	K3		Daheru	57	49	15.3	7.9	129	121
40	K4		BirKishan Singh	88	74	11.2	6.3	142	136
41	K5		RajewalRohnon	91	83	8.6	5.98	139	120
42	K6		Libra	69	57	7.9	5.16	128	119
43	K7		Chima	76	65	9.9	6.86	139	125
44	K8		Payal	81	67	10.01	7.01	130	115
			Minimum	**57**	**49**	**7.9**	**5.16**	**128**	**115**
			Maximum	**175**	**164**	**18.1**	**14.2**	**213**	**198**
			Average	**113.75**	**102.40**	**12.49**	**9.57**	**165.43**	**153.95**
			Standard deviation	**33.18**	**32.187**	**2.56**	**2.43**	**24.94**	**24.75**

- The available nitrogen in the soil at 15 cm depth ranged from 57kg/ha to 175kg/ha with the mean value of 113.75 kg/ha.
- The available nitrogen in the soil at 30 cm depth ranged from 49kg/ha to 164kg/ha with the mean value of 102.40 kg/ha.
- The nitrogen available in the soil is generally low in the study area. Theirdistribution is shown in Figs. 7a and b.

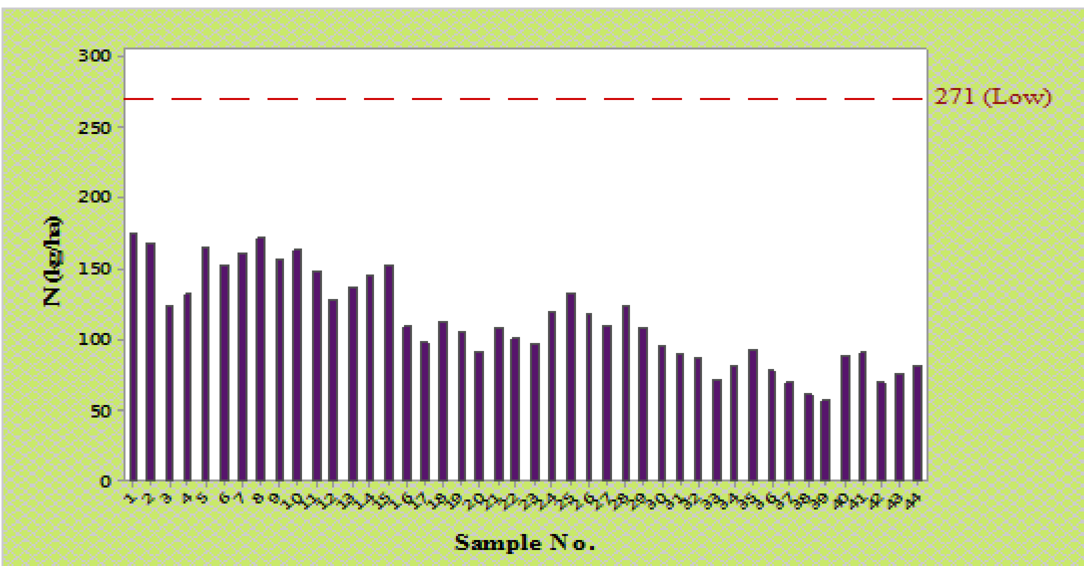

Fig.7 a Soil N at 15 cm depth in the sampled locations

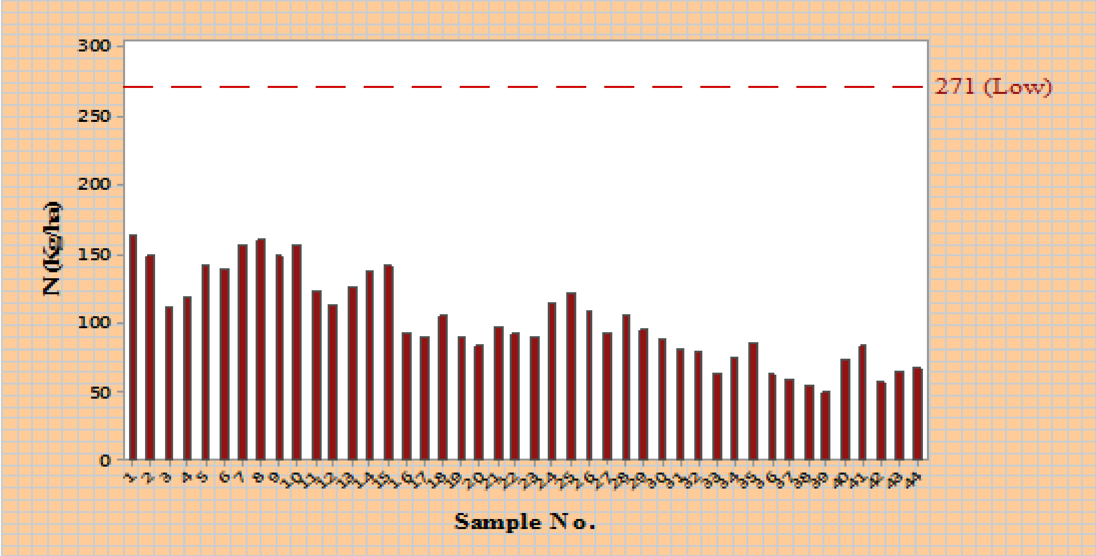

Fig.7 b Soil N at 30 cm depth in the sampled locations

Determination of Phosphorus in the soil

Phosphorus is one of the three major elements essential for plant growth. Phosphorus content in the soils of the study area varies from low to medium category. The decline in the phosphorus content may be due to the area under rice-wheat system and their interpretation is given in Table 7.

Table: 7Classification of soil based on available phosphorus

Amount of available phosphorus in kg/ha	Rating	No. of soil samples /%	
		15cm (depth)	30 cm (depth)
12	Low	19 / (43.18)%	35 / (79.54)%
12-22	Medium	25 / (56.81)%	09 / (20.45)%
>22	High	Nil	Nil

(Source: After Black (1965) and Jackson (1967)

- The available phosphorus in the soil at 15 cm depth ranged from 7.9kg/ha to 18.1kg/ha with the mean value of 12.49kg/ha.
- The available phosphorus in the soil at 30 cm depthranged from 5.16kg/ha to 14.2kg/ha with the mean value of 9.57kg/ha.
- The phosphorus content in soil of the study area varies from low-medium and their distribution is shown in Figs. 8aand b.

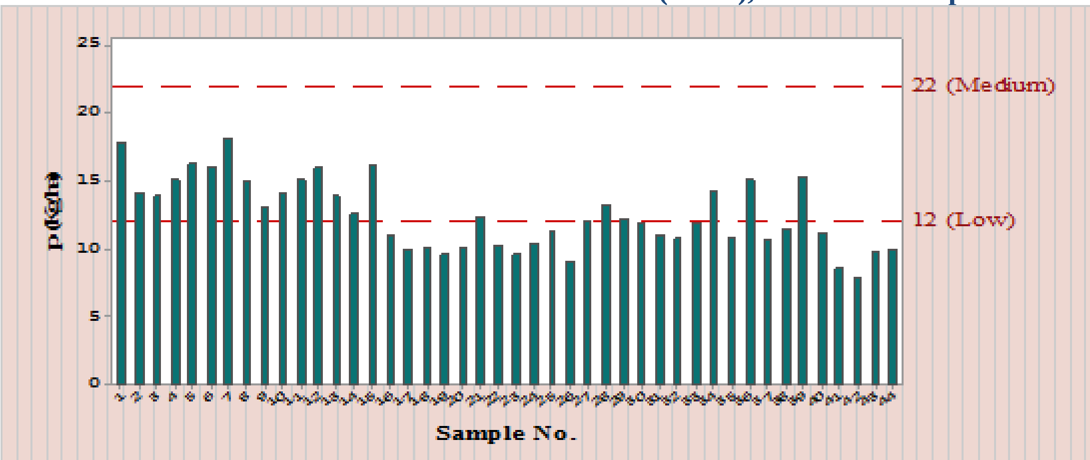

Fig.8 aSoil P at 15cmdepth in the sampled locations

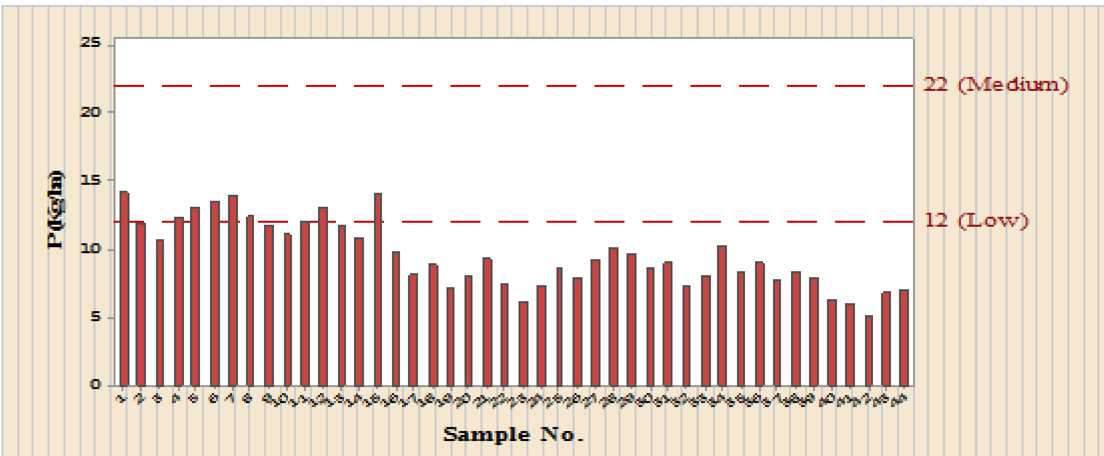

Fig.8 bSoil P at 30 cm depth in the sampled locations

Determination of Potassium in soil

Potassiumafter nitrogen and phosphorus is the 3rd most used element in fertilizers (Bohn, *et al.*, 2001).In plants K remains in ionic form having different functions e.g., synthesis of protein, chlorophyll and carbohydrate, transformation of nitrogen from nitrates, helps in the root absorption, translocation and storage of carbohydrates (Hausenbuiller, 1972). Symptoms of K deficiency are chlorosis and necrosis of leaves and stunted plant growth (Jain, 2006).

The available potassium is the sum of exchangeable and water-soluble potassium. Both of these forms of potassium are in equilibrium with the non-exchangeable potassium. Their interpretation is givenin Table 8.

Table: 8Classification of soil based on available potassium

Amount of available K (kg/ha)	**Rating**	**No. ofsoil samples/ (%)**	
		15cm (depth)	**30cm (depth)**
<136	Low	04/(9.09)%	12 / (27.27)%
136-333	Medium	40/(90.90)%	32 / (72.72)%
>333	High	Nil	Nil

(Source: Black (1965) and Jackson (1967)

- The available potassium in the soil at 15 cm depth ranged from 128kg/ha to 213kg/ha with the mean value of 165.43kg/ha.

ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

- The available potassium in the soil at 30 cm depth ranged from 115kg/ha to 198kg/ha with the mean value of 153.95kg/ha.
- The potassium content in the soil of the study area is generally low to medium and their distribution in shown in Fig. 9a and b.

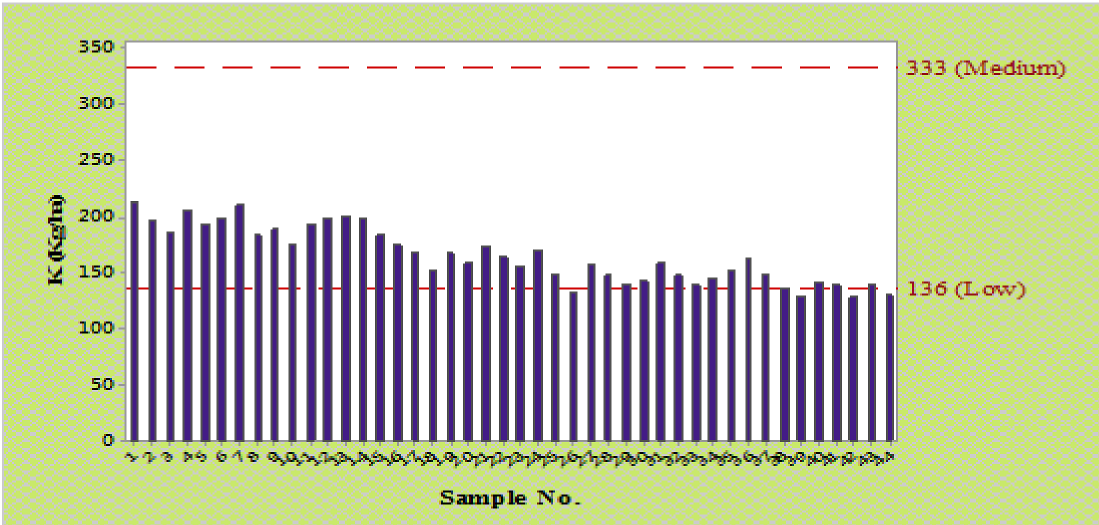

Fig.9 aSoil K at 15 cm depth in the sampled locations

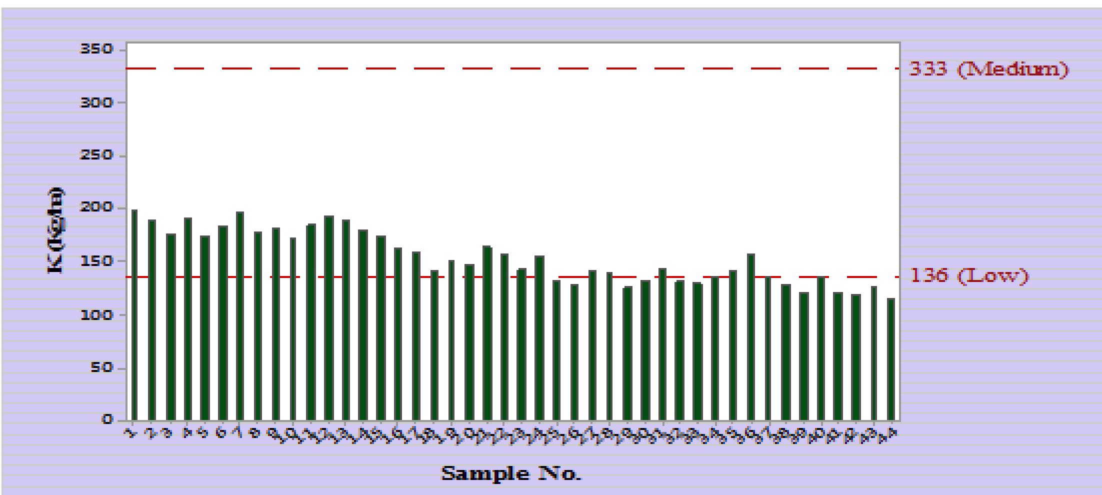

Fig.9 b Soil K at 30 cm depth in the sampled locations

STATUS OF MICRO-NUTRIENTS

Micronutrients, comprising iron (Fe), zinc (Zn), copper (Cu), manganese (Mn) and chloride (Cl) though required in much smaller amounts are essential for the plants as are the major nutrients. Table 9 shows the status of micronutrients in the soil of the study area.

Table:9Micro-nutrients status in the soil of the study area

S.No.	Sampling Locations	Name of the village	Zn (mg/kg) (depth)		Fe (mg/kg) (depth)		Cu (mg/kg) (depth)		Mn (mg/kg) (depth)		Cl (mg/kg) (depth)	
			15cm	30 cm	15 cm	30 cm	15 cm	30 cm	15 cm	30cm	15 cm	30 cm
1	L1	Kohara	0.98	0.78	12.2	9.8	0.9	0.18	5.98	4.48	1.21	0.8
2	L2	Sahnewal	0.81	0.63	10.3	8.6	0.76	0.17	4.12	3.6	1.01	0.6
3	L3	Ramgarh	0.53	0.42	9.1	8.2	0.81	0.15	4.03	3.01	0.93	0.51
4	L4	Gill	0.62	0.59	10.5	9.7	0.9	0.14	3.15	2.9	0.89	0.23
5	L5	Gobindgarh	0.7	0.61	11.2	9.6	0.62	0.16	5.09	4.3	0.73	0.17
6	L6	Jandiali	0.81	0.73	9.6	8.1	0.71	0.18	4.18	3.5	0.65	0.53
7	Ld1	Sherian	0.75	0.7	8.9	7.9	0.89	0.18	5.23	4.01	0.59	0.41
8	Ld2	KumKalan	0.74	0.69	8.3	6.3	0.75	0.13	4.16	3.6	0.45	0.38
9	Ld3	Kadian	0.63	0.56	9.2	7.2	0.63	0.15	3.19	2.9	0.23	0.17
10	Ld4	Johnewal	0.5	0.43	8.1	6.9	0.57	0.17	3.28	2.7	0.39	0.27
11	Ld5	FatehgarhGujran	0.45	0.39	6.3	5.8	0.49	0.16	4.04	3.2	0.63	0.51
12	Ld6	Balliawal	0.57	0.51	9.7	8.1	0.32	0.14	5.19	4.15	0.43	0.34
13	Ld7	BonkarGujran	0.76	0.71	8.6	6.7	0.69	0.13	4.23	3.7	0.59	0.42
14	Ld8	MachianKalan	0.75	0.67	6.3	5.9	0.57	0.12	5.04	4.03	0.62	0.57
15	Ld9	Rayian	0.63	0.55	11.3	9.3	0.75	0.11	3.18	2.7	0.71	0.62
16	M1	Udhowalkalan	0.52	0.49	9.7	8.6	0.83	0.12	3.72	2.1	0.59	0.48
17	M2	Iraq	0.57	0.42	8.9	7.9	0.89	0.13	4.01	3.2	0.45	0.37
18	M3	Hambowal	0.61	0.51	12.05	9	0.76	0.14	5.23	4.05	0.29	0.29
19	M4	Kaunkd	0.74	0.63	9.8	8.5	0.59	0.16	5.19	4.16	0.35	0.23
20	M5	Jasowal	0.83	0.71	8.3	7.3	0.47	0.15	4.26	3.21	0.49	0.46
21	M6	Powat	0.79	0.69	7.2	6.7	0.63	0.13	3.96	2.76	0.38	0.31
22	M7	Bhattian	0.63	0.55	6.1	5.8	0.45	0.14	4.04	2.03	0.61	0.52
23	M8	Manewal	0.67	0.57	5.9	5.7	0.36	0.12	5.01	3.05	0.56	0.46
24	M9	RajewalJattan	0.59	0.42	6.9	6.2	0.33	0.11	4.19	3.78	0.47	0.31
25	S1	Ghulal	0.47	0.39	7.4	7.4	0.41	0.13	3.86	2.13	0.52	0.41
												Contd………. ……….
S.No.	Sampling Locations	Name of the village	Zn (mg/kg) (depth)		Fe (mg/kg) (depth)		Cu (mg/kg) (depth)		Mn (mg/kg) (depth)		Cl (mg/kg) (depth)	
			15 cm	30 cm	15 cm	30 cm	15 cm	30 cm	15 cm	30 cm	15 cm	30 cm
26	S2	NeelonKhurd	0.49	0.37	10.3	8.1	0.37	0.14	4.04	3.15	0.41	0.23
27	S3	Bijlipur	0.39	0.28	8.1	6.3	0.29	0.11	4.19	3.09	0.28	0.16
28	S4	Rajewal	0.51	0.46	9.4	7.5	0.35	0.15	3.03	2.98	0.2	0.11
29	S5	Utalan	0.42	0.35	11.5	8.6	0.41	0.11	3.86	2.04	0.29	0.14
30	S6	Dialpur	0.39	0.3	8.6	6.1	0.5	0.1	3.24	2.16	0.31	0.23
31	D1	Kaddon	0.45	0.31	7.2	5.9	0.46	0.11	4.18	3.01	0.46	0.2
32	D2	Mahlipur	0.37	0.26	8.1	6.3	0.31	0.13	3.15	2.86	0.32	0.19
33	D3	KotlaAfgana	0.49	0.38	7.9	5.7	0.49	0.09	3.91	2.12	0.29	0.15
34	D4	Katana Sahib	0.37	0.21	8.5	4.2	0.32	0.13	4.05	2.11	0.31	0.23
35	D5	Bilaspur	0.43	0.36	7.3	4.9	0.28	0.12	2.86	1.98	0.39	0.24
36	D6	Rajgarh	0.39	0.29	8.18	6.01	0.21	0.08	3.19	2.01	0.28	0.15
37	K1	Kauri	0.27	0.18	7.4	5.3	0.31	0.11	4.01	2.15	0.31	0.19
38	K2	Kotla Duck	0.35	0.26	6.3	5.6	0.29	0.06	3.86	1.79	0.25	0.17
39	K3	Daheru	0.43	0.3	7.8	4.9	0.35	0.05	2.98	1.63	0.2	0.13
40	K4	BirKishan Singh	0.36	0.29	5.2	3.6	0.2	0.09	3.95	2.05	0.18	0.12
41	K5	RajewalRohnon	0.45	0.27	7.46	4.1	0.19	0.1	3.15	1.83	0.11	0.1
42	K6	Libra	0.38	0.19	8.01	5.05	0.36	0.06	4.01	2.15	0.2	0.15
43	K7	Chima	0.31	0.25	6.98	4.11	0.21	0.05	3.16	2.23	0.23	0.18
44	K8	Payal	0.37	0.24	7.04	3.9	0.25	0.08	4.05	2.54	0.19	0.21
		Minimum	**0.27**	**0.18**	**5.2**	**3.6**	**0.19**	**0.05**	**2.86**	**1.63**	**0.11**	**0.1**
		Maximum	**0.98**	**0.78**	**12.2**	**9.8**	**0.9**	**0.18**	**5.98**	**4.48**	**1.21**	**0.8**
		Average	**0.55**	**0.45**	**8.48**	**6.75**	**0.50**	**0.12**	**4.00**	**2.88**	**0.45**	**0.31**
		Standard deviation	**0.16**	**0.17**	**1.69**	**1.68**	**0.21**	**0.03**	**0.72**	**0.79**	**0.24**	**0.16**

Where, * L = Ludhiana Block, *Ld = Ludhiana II Block, *M = Machhiwara Block,
* S = Samrala Block, * D = Doraha Block and * K = Khanna Block

Determination ofiron in soil

Iron content provides base in the classification of soil types.Iron is a plant micronutrient and its deficiency leads to severe impacts on growth and yield (Marschner, 1995).Iron has important part in nitrate and sulphate reduction, chlorophyll formation, metabolism and catalytic functions (Pendias and Pendias, 1992).Permissible limit ofFe for normal agricultural soils given by Lindsay and Norvell(1978) and Chaudhari et al. (2012) is 4.5 mg/kg.

- The concentration of iron in the soil at 15 cm depth ranged from 5.2mg/kg to 12.2mg/kg with the mean value of 8.48mg/kg.
- The concentration of iron in the soil at 30 cm depth ranged from 3.6mg/kg to 9.8mg/kg with the mean value of 6.75mg/kg.
- Hence, the present soil in the study area has enough Fe content as shown in Figs. 10a and b.
- All the soil samples are above critical limit at 15 cm depthand 88.63% of soil samples are above critical limit at 30 cm depth.

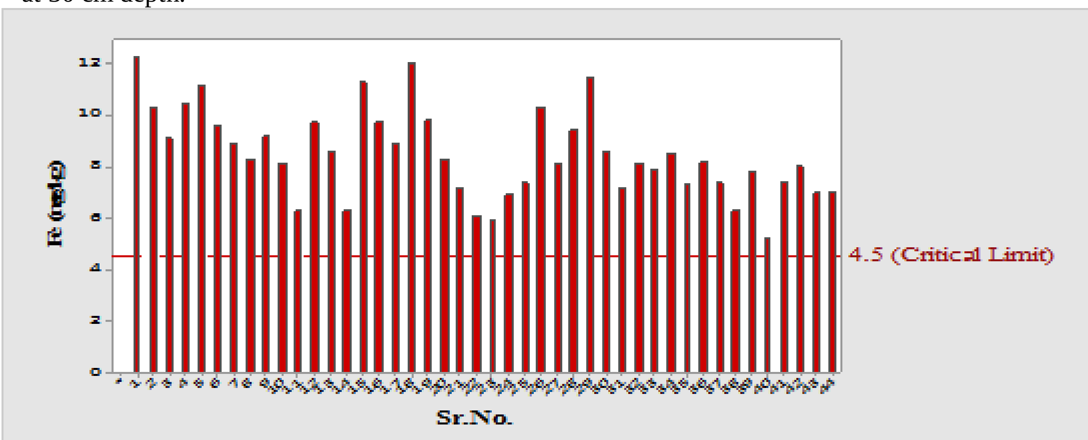

Fig.10 aSoil Fe at 15 cm depth in the sampled locations

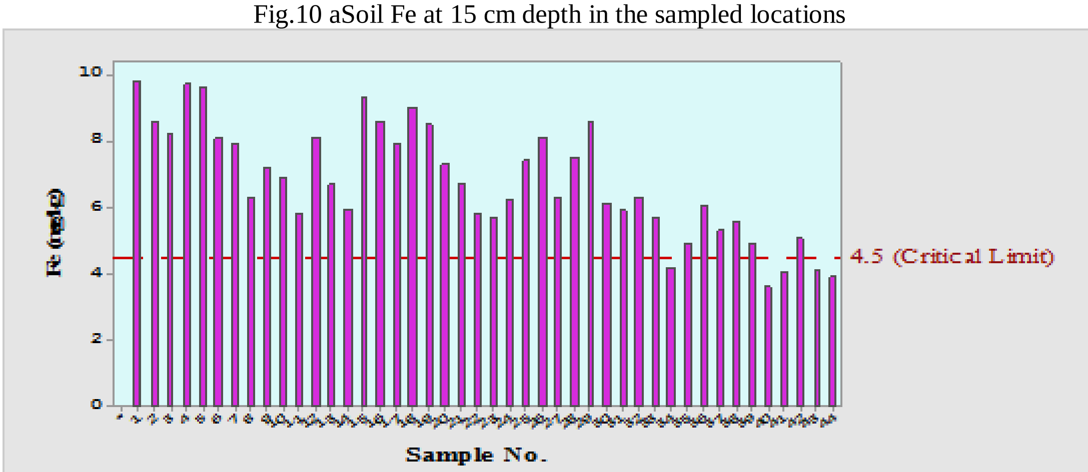

Fig.10 bSoil Fe at 30 cm depth in the sampled locations

5.2 Determination of zinc in soil

The zinc is an important component of various enzymes that are responsible for driving many metabolic reactions in all crops. The critical limitfor zinc is 0.5 to 1.0 mg/kg (Chaudhari et al., 2012).

- The concentration of zinc in the soil at 15 cm depth ranged from 0.27mg/kg to 0.98mg/kg with the mean value of 0.55mg/kg.
- The concentration of zinc in the soil at 30 cm depth ranged from 0.18mg/kg to 0.78mg/kg with the mean value of 0.45mg/kg.
- 54.54% of soil samples are above critical limit at 15 cm depth and 40.90% of soil samples are above critical limit at 30cm depth.
- Hence, the present soil in the study area is deficient in zinc content as shown in Figs. 11aand b.

ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

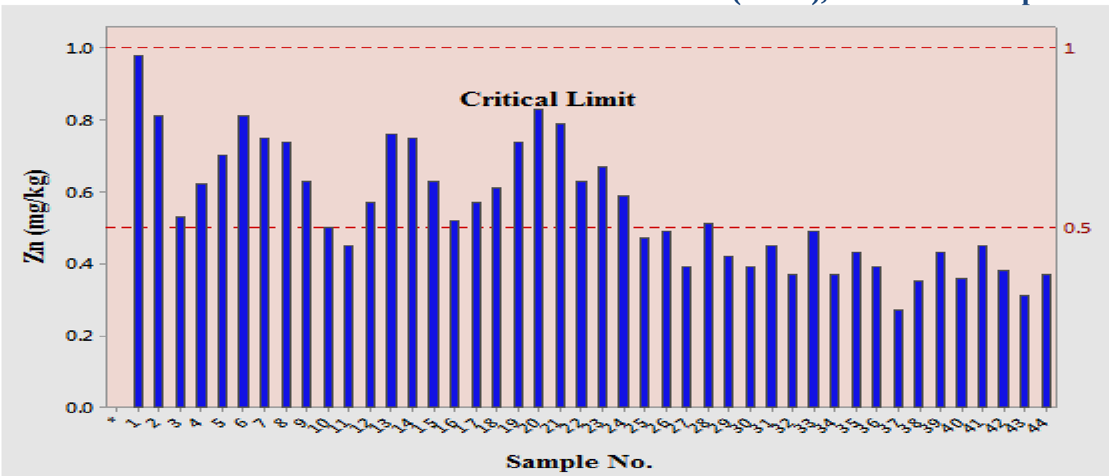

Fig.11 aSoil Zn at 15 cm depth in the sampled locations

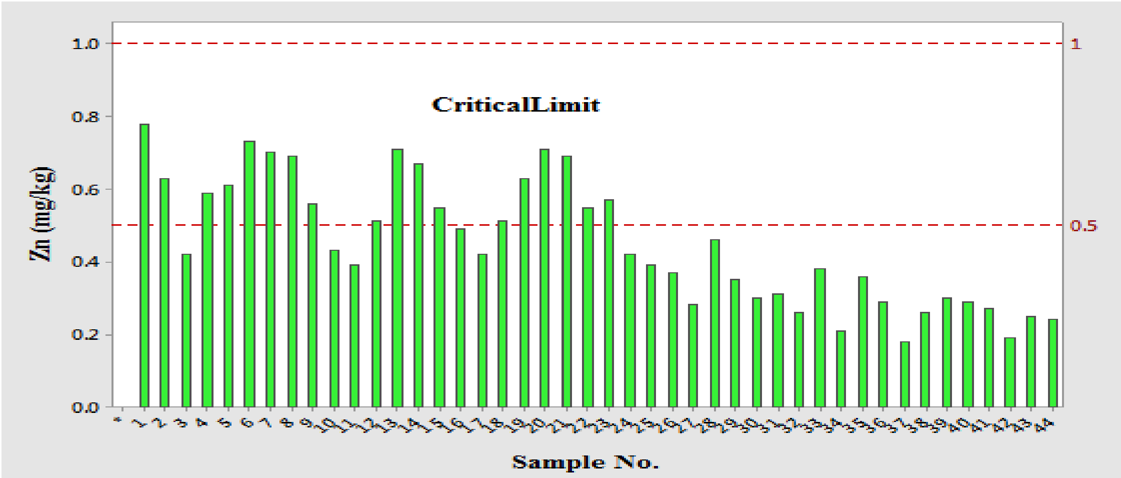

Fig.11 bSoil Zn at 30 cm depth in the sampled locations

5.3 Determination of copper in soil

Copper is an important component of proteins found in the enzymes that regulate the rate of many biochemical reactions in plants and is required in small amounts in the soil.The critical limit for copper is 0.66 mg/kg (Chaudhari et al., 2012.

- The concentration of copper in the soil at 15 cm depth ranged from 0.19mg/kg to 0.9mg/kg with the mean value of 0.50mg/kg.
- The concentration of copper in the soil at 30 cm depth ranged from 0.05mg/kg to 0.18mg/kg with the mean value of 0.12mg/kg.
- 27.27% of soil samples are above critical limit at 15cm depth and all the soil samples are below critical limit at 30 cm depth.
- Hence, the present soil in the study area is deficient in copper content as shown in Figs. 12a and b.

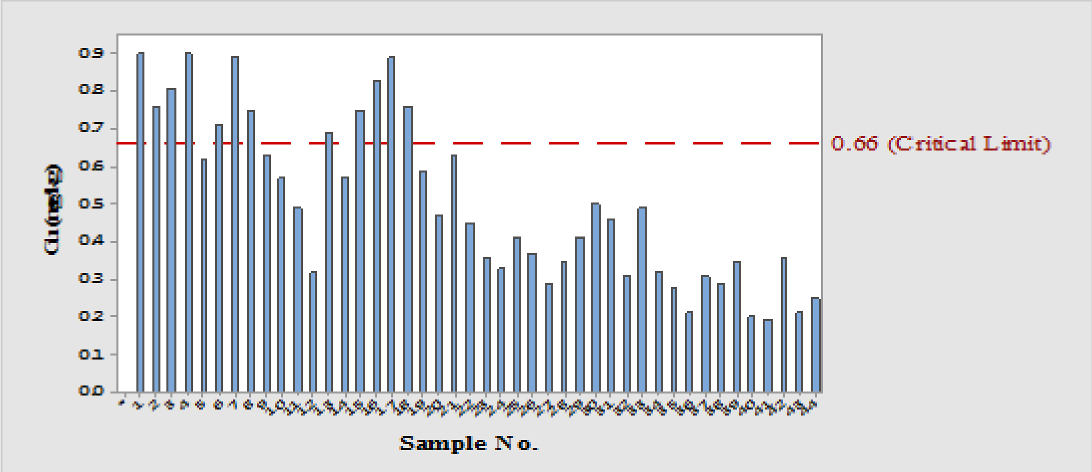

Fig.12 aSoil Cu at 15 cm depth in the sampled locations

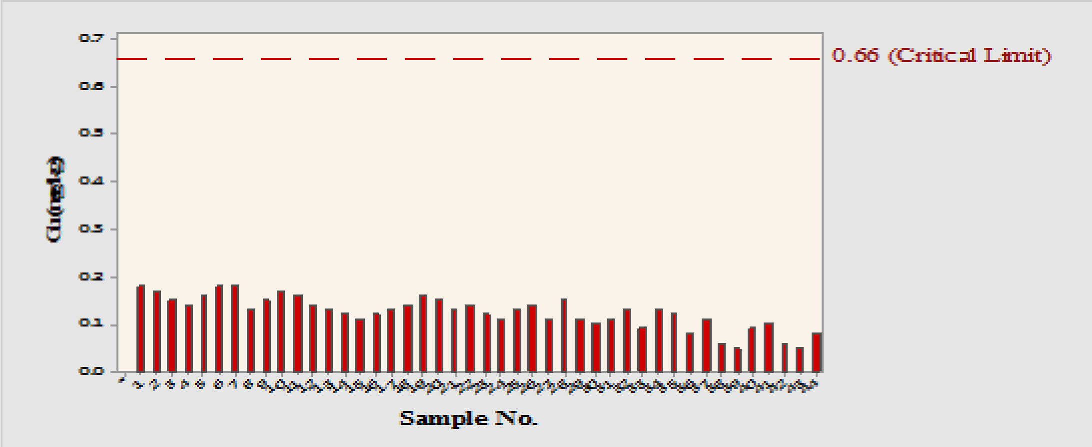

Fig.12 bSoil Cuat 30 cm depth in the sampled locations

Determination of manganese in soil

Manganese isone of the most commonly found micronutrients in nature. Total manganese in soil isnot used to predict plant response but soil extractable Mn is a reliable predictor ofplant response. Manganese supports the formation of organic nitrogen complexes and humic substances in soil. Manganese availability is mostly affected by soil pH, organic matter and soil moisture.Manganese is most available in the acidic conditions.

The critical limit for available manganese is 3.0 to 4.7 mg/kg (Chaudhari et al., 2012).

- The concentration of Mn in the soil at 15 cm depth ranged from 2.86mg/kg to 5.98mg/kg with the mean value of 4.00mg/kg.
- The concentration of Mn in the soil at 30 cm depth ranged from 1.63mg/kg to 4.48mg/kg with the mean value of 2.88mg/kg.
- 97.27% of soil samples are above critical limit at 15 cm depth and 47.72% of soil samples are above critical limit at 30 cm depth.
- Hence, the present soil in the study area has sufficient manganese content as shown in Figs. 13a and b.

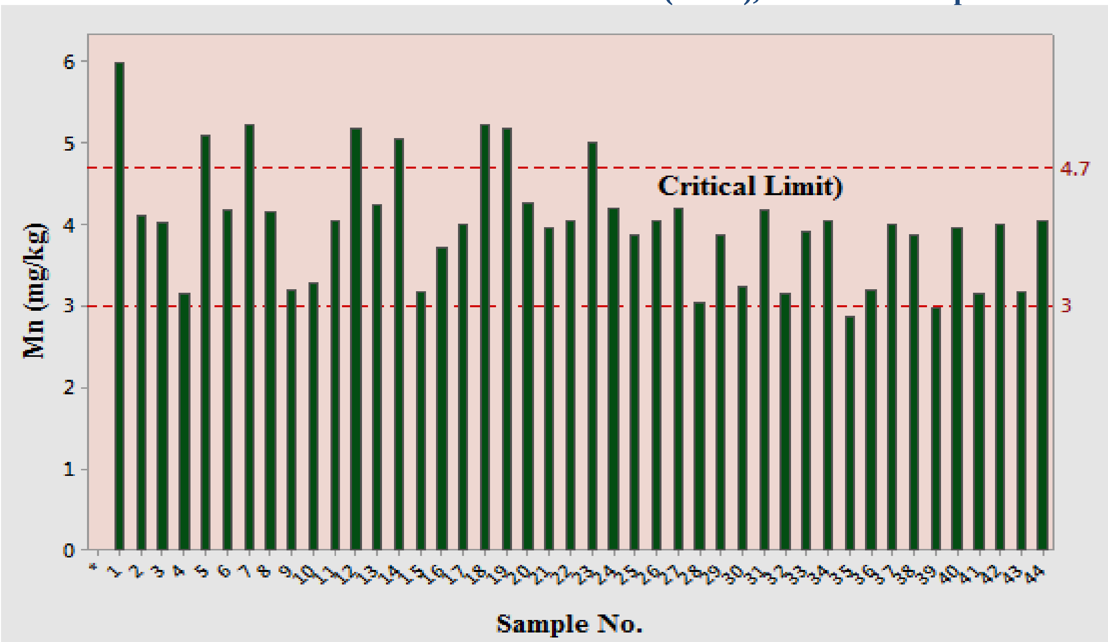

Fig.13 aSoil Mn at 15 cm depth in the sampled locations

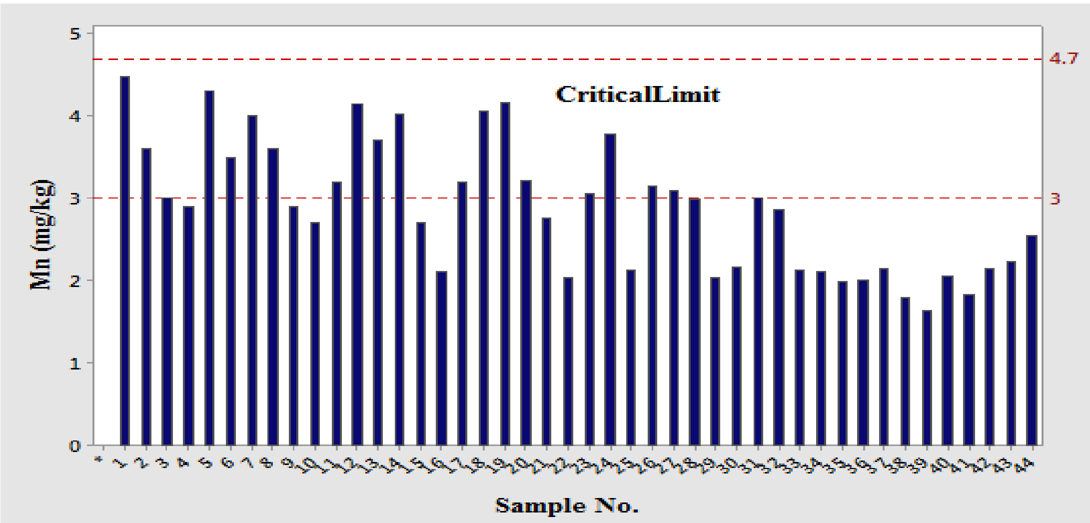

Fig.13 bSoil Mnat 30 cm depth in the sampled locations

Determination of chloride in soil

Chloride is required insmall quantities by all the crops. Chloride has a direct role in photosynthesis and also plays an important role in stomatal regulation. Thecritical rangefor chloride is 4 to 8 mg/kg (Chaudhari et al., 2012).

- The concentration of Cl in the soil at 15 cm depth ranged from 0.11mg/kg to 1.21mg/kg with the mean value of 0.45mg/kg.
- The concentration of Cl in the soil at 30 cm depth ranged from 0.1mg/kg to 0.8mg/kg with the mean value of 0.31mg/kg.
- Hence, the present soil in the study area has low chloride content as shown in Figs. 14a and b.

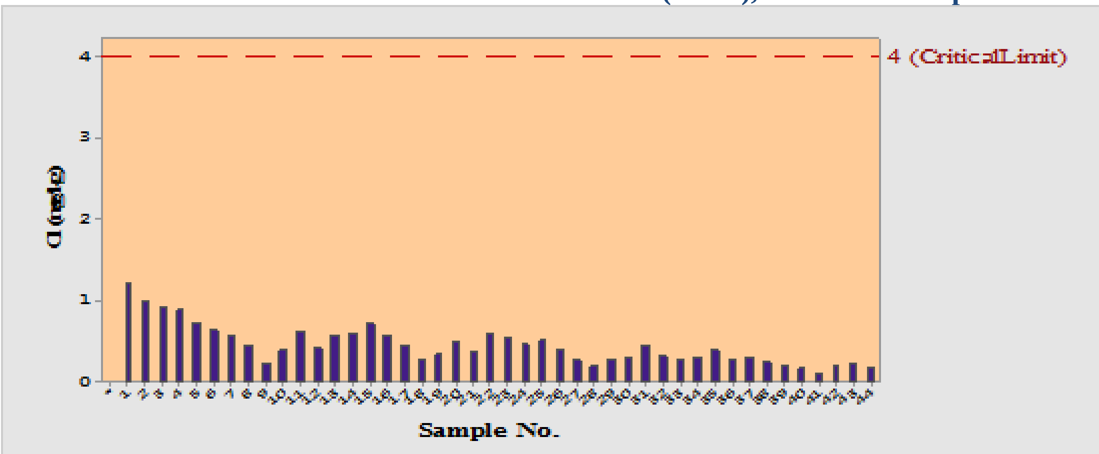

Fig.14 aSoil Cl at 15 cm depth in the sampled locations

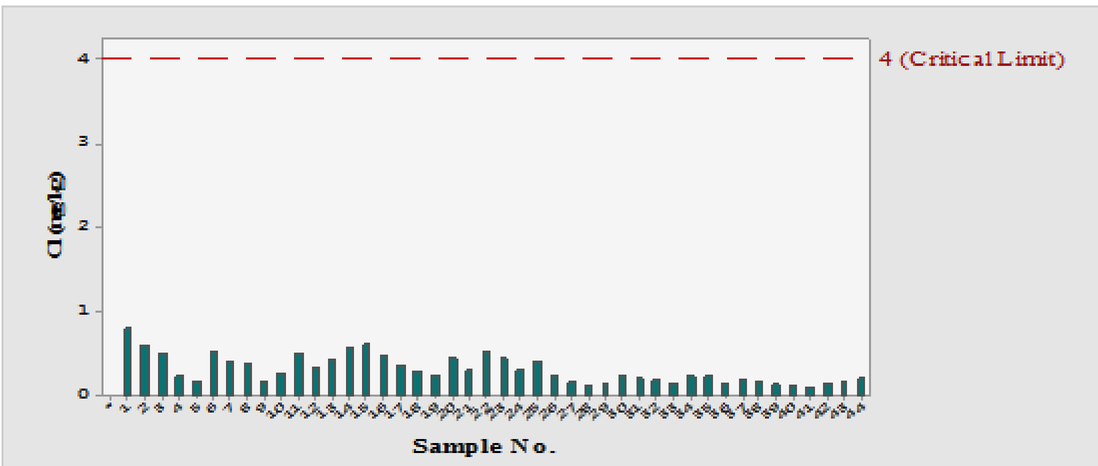

Fig.14 b Soil Clat 30 cm depth in the sampled locations

STATUS OF HEAVY METAL

The status of heavy metals like: cadmium and lead concentration in the soil at 15cm and 30 cm depth are shown in Table 9.

Determination of cadmium in soil

Cadmium helps in increasing lipid peroxidation and also promotes the production of inflammatory cytokines. The permissible limit of cadmium in soil is 1.5ppm (Lindsay and Norvell, 1978).

- The concentration of Cd in the soil at 15 cm depth ranged from 4.3ppm to 10.9ppm with the mean value of 7.26ppm.
- The concentration of Cd in the soil at 30 cm depth ranged from 0.05ppm to 0.23ppmwith the mean value of 0.14ppm.

Hence, the present soil in the study area has high cadmium content at 15 cm but low at 30 cm and their distribution were shown in Figs.15 a and b.

Table: 9 Heavy metal status of the soil of the study area

Sr.No.	Sampling Locations	Block	Name of the village	Cd (ppm) (depth)		Pb (ppm) (depth)	
				15 cm	30 cm	15 cm	30 cm
1	L1	Ludhiana I	Kohara	10.9	0.23	9.9	2.9
2	L2		Sahnewal	8.6	0.19	8.3	1.83
3	L3		Ramgarh	7.3	0.21	7.6	2.01
4	L4		Gill	6.2	0.2	8.5	1.91
5	L5		Gobindgarh	5.9	0.18	9.1	2.15
6	L6		Jandiali	9.3	0.16	9.5	1.98
7	Ld1	Ludhiana II	Sherian	8.6	0.21	8.9	2.01
8	Ld2		KumKalan	7.4	0.2	7.2	1.86
9	Ld3		Kadian	8.1	0.16	7.1	1.75
10	Ld4		Johnewal	9.3	0.17	6.9	1.62
11	Ld5		FatehgarhGujran	8.7	0.19	5.8	2.05
12	Ld6		Balliawal	9.1	0.21	6.1	1.76
13	Ld7		BonkarGujran	10.1	0.18	6.5	1.61
14	Ld8		MachianKalan	6.2	0.16	7.1	1.95
15	Ld9		Rayian	7.9	0.18	8	2.08
16	M1	Machhiwara	Udhowalkalan	8.4	0.17	9.13	1.76
17	M2		Iraq	9.3	0.15	6.2	1.53
18	M3		Hambowal	8.7	0.14	5.9	1.26
19	M4		Kaunkd	9.1	0.17	4.9	1.43
20	M5		Jasowal	10.03	0.18	6.2	1.75
21	M6		Powat	9.2	0.15	7.1	1.86
22	M7		Bhattian	8.9	0.14	8.01	2.04
23	M8		Manewal	7.6	0.13	6.3	1.83
24	M9		RajewalJattan	7.9	0.2	5.4	1.75
25	S1	Samrala	Ghulal	6.5	0.15	4.6	1.64
26	S2		NeelonKhurd	5.4	0.13	6.9	1.57
27	S3		Bijlipur	6.1	0.12	7.2	1.28
28	S4		Rajewal	5.9	0.1	8.9	1.18
29	S5		Utalan	8.3	0.11	6.4	1.09
30	S6		Dialpur	7.5	0.09	6.1	1.15
31	D1	Doraha	Kaddon	6.3	0.11	5.1	1.04
32	D2		Mahlipur	5.2	0.15	5.8	1.13
33	D3		KotlaAfgana	5.7	0.06	4.2	0.96
34	D4		Katana Sahib	6.1	0.07	4.9	0.82
35	D5		Bilaspur	5.2	0.05	5.3	0.71
36	D6		Rajgarh	4.3	0.1	5.4	0.56
37	K1	Khanna	Kauri	4.9	0.09	4.9	0.41
38	K2		Kotla Duck	5.6	0.1	3.8	0.63
39	K3		Daheru	6.5	0.08	3.5	0.71
40	K4		BirKishan Singh	6.0	0.12	4.1	0.52
41	K5		RajewalRohnon	5.9	0.13	4.8	0.49
42	K6		Libra	5.6	0.11	5.2	0.86
43	K7		Chima	5.2	0.06	4.9	0.9
44	K8		Payal	4.9	0.09	5.6	0.52
			Minimum	**4.3**	**0.05**	**3.5**	**0.41**

	Maximum	**10.9**	**0.23**	**9.9**	**2.9**
	Average	**7.26**	**0.14**	**6.43**	**1.42**
	Standard deviation	**1.70**	**0.04**	**1.63**	**0.57**

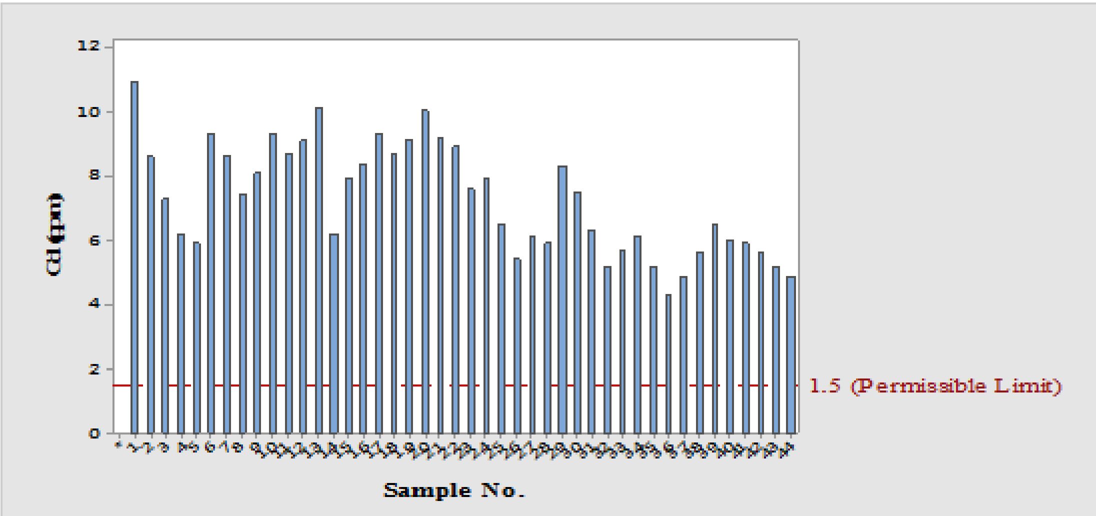

Fig.15 aSoil Cd at 15 cm depth in the sampled locations

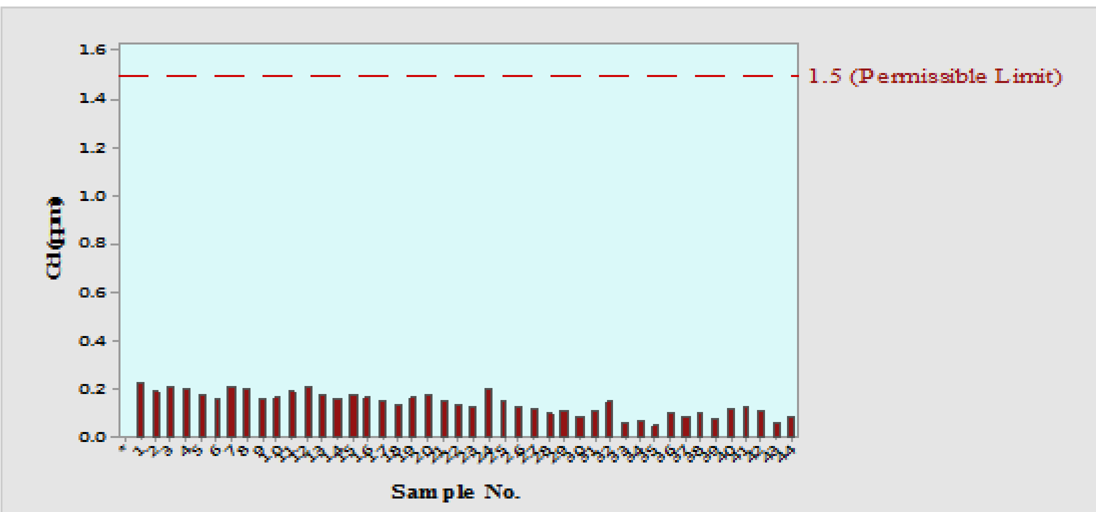

Fig.15 bSoil Cd at 30 cm depth in the sampled locations

Determination of lead in soil

Lead is deposited in soil from anthropogenic sources. It does not biodegrade or decay, hence it remains in the soil at elevated levels. The permissible limit of lead in soil is 32 ppm (Lindsay and Norvell, 1978).

- The concentration of lead in the soil at 15 cm depth ranged from 3.5ppm to 9.9ppm with the mean value of 6.43ppm.
- The concentration of lead in the soil at 30 cm depth ranged from 0.41ppm to 2.9ppm with the mean value of 1.42ppm.
- Hence, the present soil in the study area has low lead content as shown in Figs. 16a and b.

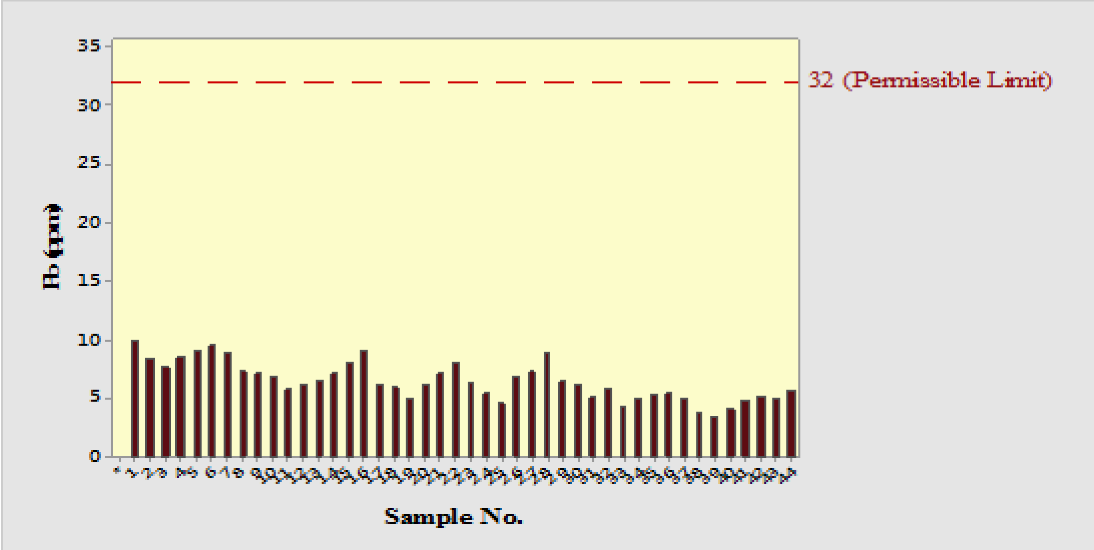

Fig.16 aSoil Pb at 15 cm depth in the sampled locations

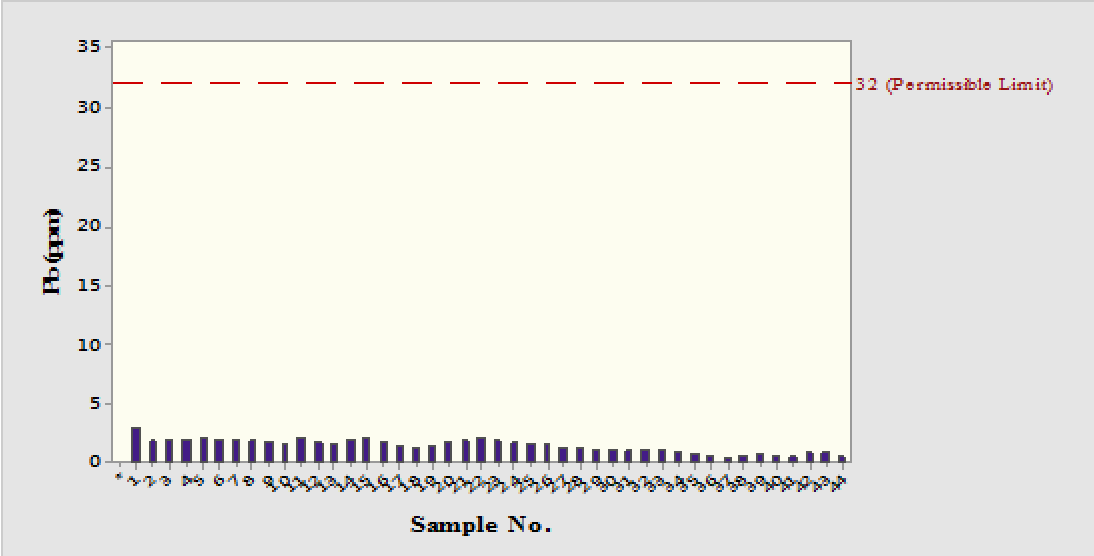

Fig.16 bSoil Pb at 30 cm depth in the sampled locations

Table 10 shows the status of various parameters in the soil of the study area.

Table: 10 Status of various soil parameters in the soil of the study area

Sr. No.	Parameters	Concentration of soil parameters	Status at 15 cm depth	Status at 30 cm depth
1.	pH	6.5-8.7 (Normal-optimum for all crops)	Normal	Normal
2.	EC (dS/cm)	Below0.8 (Normal-suitable for all crops)	Normal	Normal
3.	OC (%)	0.40-0.75	Low- Medium	Low-Medium
3.	Nitrogen (kg/ha)	<217	Low	Low
4.	Phosphorus (kg/ha)	12-22	Low- Medium	Low- Medium
5.	Potassium (kg/ha)	136-333	Low- Medium	Low- Medium
6.	Iron (mg/kg)	4.5	Sufficient	Sufficient
7.	Zinc (mg/kg)	0.5-1.0	Deficient	Deficient
8.	Copper(mg/kg)	0.66	Deficient	Deficient
9.	Manganese(mg/kg)	3.0-4.7	Sufficient	Sufficient
10.	Chloride(mg/kg)	4-8	Low	Low
11.	Cadmium(ppm)	1.5	High	Low
12.	Lead (ppm)	32	Low	Low

SODIUM ABSORPTION RATIO OF THE SOIL

Table 11 shows the values of sodium, calcium, magnesium and SAR values of the soil.

Determination of sodium

The presence of sodium is not required by the plants as it inhibits the absorption of potassium and also disturbs the soil water balance (Pendias and Pendias, 1992).

- The concentration of Na^+ in the soil of the study area ranged from 47.83mg/l to 150.30 mg/l with the mean value of 85.74 mg/l.

Determination of calcium

Ca^{2+}isthe most abundant mineral in the soil and is also very vital element for plants.These are, however, known as secondary nutrients as they are required in comparatively small amount. Amount of Ca^{2+} present in soil varies greatly from 0.05 to 25% of the whole soil weight (Hausenbuiller,1972).Calcium sustains the soil pH neutral for plants and micro-organisms endurance, that is why the crops grow quickly when Ca^{2+} is adequate in soil.(Bohn et al., 2001). Ca^{2+} deficiency results in root damage, chlorosis, and deformity of younger leaves (Jain, 2006).

- The concentration of Ca^{2+} in the soil of the study area ranged from 293.38 mg/l to 502.67 mg/l with the average value of 362.04 mg/l.

Table: 11 Values of Na^+, Ca^{2+}, Mg^{2+} and SAR in the soil of the study area

Sr.No.	Sampling Locations	Location	Na^+ (meq/l)	Ca^{2+} (meq/l)	Mg^{2+} (meq/l)	SAR (meq/l)
1	L1	Kohara	6.54	22.56988	8.783723	1.65
2	L2	Sahnewal	5.76	18.5428	8.133046	1.57
3	L3	Ramgarh	4.98945	21.87663	8.418488	1.28
4	L4	Gill	5.48535	14.36351	7.319495	1.66
5	L5	Gobindgarh	5.1417	17.50786	6.325794	1.48
6	L6	Jandiali	4.56315	18.00984	8.65622	1.24
7	Ld1	Sherian	4.30215	17.82799	8.337051	1.18
8	Ld2	KumKalan	5.08515	21.38183	6.578332	1.36
9	Ld3	Kadian	3.80625	17.33005	5.663601	1.12
10	Ld4	Johnewal	3.34515	13.66981	8.063948	1.01
11	Ld5	FatehgarhGujran	3.98895	18.71836	7.316204	1.10
12	Ld6	Balliawal	4.71975	21.4631	8.057367	1.22
13	Ld7	BonkarGujran	5.2896	14.76626	8.4917	1.55

14	Ld8	MachianKalan	4.44135	16.51018	7.90025	1.27
15	Ld9	Rayian	3.2103	22.00145	6.233663	0.85
16	M1	Udhowalkalan	2.99715	15.49679	5.67923	0.92
17	M2	Iraq	4.99815	13.74434	4.760386	1.64
18	M3	Hambowal	2.86665	18.70714	7.2578	0.79
19	M4	Kaunkd	2.43165	20.51526	6.588203	0.66
20	M5	Jasowal	2.18805	17.8711	6.418748	0.62
21	M6	Powat	4.75542	16.39344	5.751619	1.42
22	M7	Bhattian	2.92929	13.51984	7.374609	0.90
23	M8	Manewal	3.40692	16.4123	5.382272	1.03
24	M9	RajewalJattan	3.86802	13.27558	6.351295	1.23
25	S1	Ghulal	3.21987	13.96929	4.859921	1.04
26	S2	NeelonKhurd	4.569675	18.03409	4.608205	1.35
27	S3	Bijlipur	5.969505	15.49544	4.139323	1.90
28	S4	Rajewal	3.30252	16.61839	3.855526	1.03
29	S5	Utalan	2.90754	15.49095	6.33731	0.88
30	S6	Dialpur	2.367705	13.25268	4.595866	0.79
31	D1	Kaddon	4.41612	13.56519	7.140991	1.378
32	D2	Mahlipur	3.91587	16.4792	7.50458	1.13
33	D3	KotlaAfgana	3.841485	13.20464	6.165387	1.23
34	D4	Katana Sahib	2.56737	15.80839	4.490573	0.80
35	D5	Bilaspur	2.255475	13.17276	3.791363	0.77
36	D6	Rajgarh	2.880135	18.14319	4.85663	0.84
37	K1	Kauri	2.080605	14.01149	6.351295	0.65
38	K2	Kotla Duck	2.097135	13.21991	5.751619	0.68
39	K3	Daheru	2.87622	13.52523	5.11904	0.94
40	K4	BirKishan Singh	2.485155	15.62565	3.786428	0.79
41	K5	RajewalRohnon	2.089305	13.1997	4.247084	0.70
42	K6	Libra	3.83322	13.2464	5.51471	1.25
43	K7	Chima	3.175935	13.51715	4.689643	1.05
44	K8	Payal	2.128455	13.20374	4.223228	0.72
		Minimum	2.080605	13.17276	3.786428	**0.62**
		Maximum	6.53805	22.56988	8.783723	**1.90**
		Average	3.729136	16.25588	6.178904	**1.11**
		Standard deviation	1.194802	2.836334	1.504515	**0.32**

Determination of magnesium

Magnesium is an important part of chlorophyll and helps in the translocation of starch within plant tissues. It is also substantial in the formation of plant oils and fats and for the growth of new cells (Bohn et al., 2001). Magnesium deficiency leads to chlorosis and necrotic patches on leaves (Jain, 2006). Soils with high Mg content experience some problems like high pH and thus soil is partially fit for the agricultural use.

- The concentration of Mg^{2+} in the soil of the study area ranged from 46.03mg/l to 106.78 mg/l with the mean value of 75.11 mg/l.

Sodium hazard of irrigation soil can be well understood by knowing SAR. Sodium Absorption ratio (SAR), which is given by the following relation (Richards, 1954).

- SAR= $Na^{+}/ (Ca^{2+}+Mg^{2+})^{1/2}/2$

  Where, all the parameters are expressed in meq/l.

Sodium absorption ratio influences infiltration rate of water. So, low SAR is always desirable.

- In the studied samples, SAR values of the soil are ranged from 0.62 meq/l to 1.90meq/l with the average value of 1.11meq/l

ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

CORRELATION ANALYSIS

Correlation refers to any broad class of statistical relationships involving dependence. A correlation coefficient of +1 indicates that two variables are perfectly related in a positive linear sense; a correlation coefficient of -1 indicates that two variables are perfectly related in a negative linear sense, and a correlation coefficient of 0 indicates that there is no linear relationship between the two variables.

The direction of the dependent variable's change depends on the sign of the coefficient. If the coefficient is a positive number, then the dependent variable will move in the same direction as the independent variable; if the coefficient is negative, then the dependent variable will move in the opposite direction of the independent variable.
The correlation matrices for 13 variables were prepared for soil at the depth of 15cms and 30 cms respectively by using Minitab 16. The result of correlation matrix at 15cm and 30 cm depth is shown in Tables 12 and 13, respectively.

Table: 12 Correlation analysis of soil parameters at 15 cm depth

	pH	EC	OC	N	P	K	Zn^{2+}	Fe^{2+}	Cu^{2+}	Mn^{2+}	Cl^-	Cd^{2+}	Pb^{2+}
pH	1												
EC	0.37	1											
OC	0.40	**0.53**	1										
N	**0.78**	0.37	0.36	1									
P	**0.67**	0.27	0.19	**0.63**	1								
K	**0.82**	0.42	0.38	**0.82**	**0.70**	1							
Zn^{2+}	**0.57**	0.35	0.26	**0.69**	0.40	**0.74**	1						
Fe^{2+}	0.33	0.37	0.30	0.46	0.40	0.35	0.40	1					
Cu^{2+}	**0.65**	0.42	0.46	**0.65**	0.47	**0.73**	**0.70**	**0.58**	1				
Mn^{2+}	0.29	0.31	0.34	0.34	0.17	0.42	**0.56**	0.23	0.34	1			
Cl^-	**0.60**	0.26	0.37	**0.66**	**0.53**	**0.77**	**0.66**	0.40	**0.70**	0.41	1		
Cd^{2+}	0.49	0.38	0.22	**0.54**	0.30	**0.60**	**0.73**	0.35	**0.63**	0.45	0.48	1	
Pb^{2+}	**0.61**	0.36	0.48	**0.74**	**0.52**	**0.70**	**0.64**	**0.55**	**0.68**	0.26	**0.68**	0.44	1

- There is a strong positive correlation between pH and the soil parameters. This shows that soil is suitable for many crops.
- There is weak correlation between OC and soil parameters. This shows that there is minimum amount of organic content in the soil.
- Nitrogen shows strong positive relationship between phosphorus (0.63), potassium (0.820, zinc (0.69), copper (0.65), chloride (0.66), cadmium (0.54) and lead (0.64) respectively at 15 cm depth of the study area.
- Zinc shows positive correlation with copper (0.70), manganese (0.56), chloride (0.66), cadmium (0.73) and lead (0.64).

Table: 13 Correlation analysis of soil parameters at 30 cm depth

	pH	EC	OC	N	P	K	Zn^{2+}	Fe^{2+}	Cu^{2+}	Mn^{2+}	Cl^-	Cd^{2+}	Pb^{2+}
pH	1												
EC	0.38	1											
OC	0.05	0.42	1										
N	**0.75**	0.41	0.30	1									
P	**0.80**	0.31	0.17	**0.80**	1								
K	**0.79**	0.46	0.19	**0.81**	**0.85**	1							
Zn	**0.63**	0.39	0.27	**0.73**	**0.63**	**0.77**	1						

Fe	**0.54**	0.39	0.40	**0.62**	**0.63**	**0.59**	**0.63**	1					
Cu	**0.63**	0.41	0.40	**0.77**	**0.63**	**0.71**	**0.69**	**0.65**	1				
Mn	**0.56**	0.49	0.40	**0.68**	**0.55**	**0.67**	**0.71**	**0.59**	**0.67**	1			
Cl	0.46	0.22	0.18	**0.60**	**0.53**	**0.66**	**0.67**	0.45	**0.54**	0.47	1		
Cd	**0.73**	0.50	0.29	**0.77**	**0.62**	**0.81**	**0.71**	**0.66**	**0.69**	**0.72**	**0.65**	1	
Pb	**0.64**	0.48	0.45	**0.81**	**0.67**	**0.80**	**0.82**	**0.71**	**0.73**	**0.68**	**0.79**	**0.82**	1

- There is a strong positive correlation between pH and the soil parameters. This shows that soil is suitable for many crops as it enhances the physical, chemical and biological properties of soil.
- There is weak correlation between OC and soil parameters. This shows that minimum amount of soil organic content in the soil.
- There is a positive correlation between the heavy metal as they are insusceptible to leaching and cause soil contamination.

CONCLUSION

The soil of the study area had pH between 6.5 to 8.7 i.e. under normal category which is optimum for the crops. EC is below 0.8dS/cm and is also optimum for the crops. The organic carbon content in the soil is low to medium. The content of macronutrients like: nitrogen, phosphorus and potassium is generally low to medium in the study area. The content of micronutrient like: zinc and copper are deficient but iron and manganese are in sufficient amount. The content of chloride is also low in the study area. The content of heavy metal like cadmium is high at 15cm depth but is low at 30cm depth. The concentration of lead in the soil is low. The SAR value of the soil varies from 0.62 meq/l to 1.90 meq/l which is good for the crops.Thus, it is evident from the above parameters, that the soil is good for agricultural purposes in the study area.

REFERENCES

1. **Bates, R.G. (1954).** Electrometric pH determinations, 16-33.
2. **Benbi, D.K., Nayyar, V.K .and Brar, J.S. (2006).** The Green Revolution in Punjab: Impact on Soil Health, Indian Journal of Fertilizers, **2(4)**: 57-66.
3. **Black, C.A. (1965).** Methods of soil analysis. Part 2. Chemical and Microbiological Properties, 1367-1378.
4. **Bohn, H.L., McNeal, B. L. and Connor, G.A. (2001).** Soil Chemistry, 3rd ed. New York, John Wiley and Sons, 30-286.
5. **Brady, C.N. and Weil, Z.D.M. (2002).** Nature and properties of soils, 13th Edition, prentice hall, 90-139.
6. **Central Pollution Control Board (2001).**Pollution Control Acts, Rules, and Notifications, 4th ed., New Delhi: Central Pollution Control Board, Ministry of Environment and Forests, Government of India.
7. **Chaudhari, P.R., Ahire, D.V. and Ahire, V.D. (2012).** Correlation between physic-chemical properties and available nutrients in sandy loam soils of Haridwar, Journal of Chemical, biological and Physical Sciences, **3**: 1493-1500.
8. **Hausenbuiller, R.L. (1972).** Soil Science: Principles and Practices, Wm. C. Brown Company Publishers, USA,9-69.
9. **Jackson, M.L. (1957).** Soil Chemical Analysis, 38-56.
10. **Jackson, M.L. (1967).**Soil Chemical Analysis, 243-246.
11. **Jain, V.K. (2006).** Fundamentals of Plant Physiology, S. Chand and Company Ltd. Ram Nagar, New Delhi, India, 23-30.
12. **Lindsay, W.L. and Norvell, W.A. (1978).** Development of a DTPA soil test for zinc, iron, manganese and copper, Soil science society America journal, **42**: 421-428.
13. **Marschner, H. (1995).** Mineral Nutrition of Higher Plants, 2nd ed. Academic Press, London, 483-507.
14. **Merwin, H.D. and Peech, M. (1950).** Exchangeability of soils potassium in the sand, silt and clay fractions as influenced by the nature of the complementary exchangeable cations. Soil Sci. Soc. Amer. Proc. **15**: 125-128.
15. **Olsen, S.R., Cole, C.V. Watanabe, F.S. and Dean, L.A. (1954).** Estimation of available phosphorus by extraction with sodium bicarbonate. U.S.D.A. Circular 939-19.

16. **Pendias, K.A. and Pendias, H. (1992).** Trace Elements in Soils and Plants, 2nd ed. CRC Press. Inc. Boca Raton, Florida, 13-45.
17. **Randhawa, S.S. (2012).** Environmental Education, Vikas publishers, Jalandhar city, Punjab, 78-90.
18. **Richards, L.A. (1954).** Diagnosis and improvement of saline and alkali soils, US Department of Agriculture, Hand Book No. 60, 160.
19. **Smith, J.L. and Doran, J.W. (1996).** Measurement and use of pH and delectrical conductivity for soil quality analysis: In methods for assessing soil quality. Soil Science Society of America Special Publication, **49**: 169-182.
20. **Soil Science Laboratory Manual (1997).** Soil Fertility (Soils 201), Soil Science Laboratory Manual, Ludhiana Chapter, Indian Society of Soil Science, Department of Soils, Punjab Agricultural University, Ludhiana, 3rd ed.,10:17 -24.
21. **Sparks, D.L. (2003).**Environmental soil chemistry. 2ndedn. Acedamic Press. California, USA, 288-290.
22. **Subbiah, B.V. and Asija, G.L. (1965).** A rapid procedure for the estimation of available nitrogen in soils. Curr. Sci., **25**: 259-60.
23. **Szabolcs, I. (1989).** Salt affected soils. CRC Press Inc. Boca Raton, 113–132.
24. **Trivedi, R.K. and Goel, P.K. (1986).** Chemical and Biological methods for water pollution studies. Envir. Publication, Karad, 247.
25. **Walkley, A. and Black, C.A. (1934).** An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Sci., 37: 27-38.