Variations of Contaminants in the Road Side Agricultural Soil of Thana Malakand Agency

[1]SULTAN ALAM*, [2]ILYAS AHMAD, [1]ZIA-UD-DIN AND [3]FAZLULLAH KHAN BANGASH
[1]*Department of Chemistry, Govt. Post Graduate Jahanzeb College, Saidu Sharif, Swat, Pakistan.*
[2]*Department of Botany, Govt. Post Graduate Jahanzeb College, Saidu Sharif, Swat, Pakistan.*
[3]*Institute of Chemical Sciences, University of Peshawar, N.W.F.P, Pakistan.*

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Summary: Agricultural soil samples were collected from the G. T. road side of Thana Malakand Agency, at various distances and were studied for different parameters. pH of soil samples was found in the range of 6.9 to 7.3 which is neutral in nature. Iron was found in the range of 5.8 to 40.45 mg/ L. At low level, iron causes chlorophyll deficiency. Nickel was in the range of (4.2 to 22.5 mg/ L) and is needed for the metabolism of plant nitrogen. Copper was found in the range of 6.55 to 25.41 mg/ L. Functions of copper include chlorophyll synthesis and protein metabolism. Zinc was in the range of 8.41 to 50.23 mg/ L. Cadmium was found in the range 5.12 to 42.12 mg/ L, which is higher than the desirable level for fertile soil therefore it may cause diseases like wilting and red orange coloration of leaves. Lead was found 5.23 to 56.12 mg/ L. Manganese was found from 6.55 to 60.12 mg/ L. Manganese is essential for nitrogen and inorganic acid metabolism. The concentration of chromium was found in the range of 3.2 to 23.4 mg/ L. Concentration between 5-30 mg/ Kg is considered of critical importance for plants and deviation could cause yield reduction. The highest concentrations of metals were found in the sample S-1, which is near the main bazaar, decreasing gradually from S-1 to S-12. This may be due to the fact that different sources near the main bazaar contaminate the agricultural soil thus raising its concentration.

Introduction

Heavy metal pollution is a problem associated with areas of intensive industry. However, roadways and automobiles now are considered to be one of the largest sources of heavy metals [1]. Zinc, copper and lead are three of the most common heavy metals released from road transport. Lead concentrations, however, have been consistently decreasing since leaded gasoline was discontinued. Smaller amounts of many other metals such as nickel and cadmium could also be found in road runoff and exhaust. About half of the zinc and copper contribution pollution in the environment (from urbanization) is from automobiles. Brakes release copper, while tire wear releases zinc [2, 3]. Motor oil also tends to accumulate metals as it comes in contact with surrounding parts as of running engine, oil leaks are another pathway by which metals enter the environment. Soil particles and loose dust also carry charge. Most clay minerals have a net negative charge. Soil organic matter tends to have a variety of charged sites on its surface, both positive and negative. The negative charges of the soil particles tend to attract and bind the metal cations and prevent them from dissolving in water. The soluble form of metals is considered more dangerous because it is easily transported and more readily available to plants and animals. By contrast, soil bound metals tend to stay in place. Metal behavior in the aquatic (streams, lakes and rivers) environment is surprisingly similar to that outside a water body. Streambed sediments exhibit the same binding characteristics found in the normal soil environment. As a result many heavy metals tend to be sequestered at the bottom of water bodies. Some of these metals will dissolve. The aquatic environment is more susceptible to the harmful effects of heavy metal pollution because aquatic organisms are in close and prolonged contact with the soluble metals. pH tends to be a master variable in this whole process. As a cation is attracted to the negative charges of the soil and sediment particles, in acid conditions, there are enough H^+ ions to occupy many of the negatively charged surfaces of clay and organic matter. Little room is left to bind metals and as a result more metals remain in the soluble phase [1].

The purpose of this study was to find the variations in contaminants in the road side agricultural soil of Thana Malakand Agency and to discuss the effect of each metal on plant growth and associated disease.

*To whom all correspondence should be addressed.

Results and Discussion

Samples were collected from road side agricultural soil of village Thana Malakand Agency and were investigated for selective metals.

pH of soil samples was found in the range of 6.9 to 7.3 (Table-3). The soil of study area was neutral in nature. pH value of a soil is influenced by the kinds of parent materials from which the soil is formed. Rainfall and organic pollutants also affect the soil pH. Water passing through the soil leaches basic nutrients, such as calcium and magnesium from the soil and is replaced by acidic elements such as aluminum and iron. For this reason soils formed under light rainfall conditions are more acidic than those formed under arid conditions [4].

Iron in the soil samples of agricultural fields, Thana Malakand agency, was found in the range of 5.8 to 40.45 mg/ L as shown in Table-4 and Figs. 1 and 2. The highest concentration of iron was found in the sample S-1 which is near the main bazaar, then its concentration gradually decreases (from S-1 to S-12). This may be due to the fact that different sources near the main bazaar contaminate the agricultural soil thus its concentration rises. Iron deficient soil is expressed as yellow leaves (chlorosis) in plants. Severe iron deficiency may cause leaves to turn completely yellow or almost white, and then brown as leaves die [5].

The concentration of nickel in the soil samples was found in the range of 4.2 to 22.5 mg/ L. The highest concentration of nickel was found in the sample S-1 and the lowest was found in S-12, as shown in Table-4 and Figs. 1 and 2. Average nickel concentration in earth crust is about 80 mg/ L. Nickel is essential for plants supplied with urea and for those in which ureides are important in nitrogen metabolism. When the concentration of nickel is more than 0.5 to 1.0 mg/ L then it adversely affects the plant growth [6].

Copper was found in the range of 6.6 to 25.4 mg/ L. The highest concentration of copper was found in the sample S-1 and the lowest was found in S-12, as shown in Table-4 and Figs. 1 and 2. The suitable value for agricultural soil ranges from 1 to 50 mg/ L [7]. Functions of copper in plant body include catalysis for respiration, chlorophyll synthesis, carbohydrate and protein metabolism and as part of an enzyme constitution [8]. Deficiency symptoms of copper are dieback of stems and twigs, yellowing of leaves, stunted growth, and pale green leaves that wither easily. Cereal crops are especially susceptible to low Cu levels, with curled leaves at tillering, head and stem bending, shriveled grain, and delayed maturity. At greater concentration it may cause stunting and reduce branching [9]. The concentration of copper in the soil sample is within the permissible limit.

Zinc was found in the range of 8.41 to 50.23 mg/ L. The highest concentration of zinc was found in the sample S-1 and the lowest was found in S-12 (Table-4 and Figs. 1 and 2). The required level of Zn in soil is 10-300 mg/ L [10]. The functions of zinc in plants are formation of growth hormones, promotion

Table-1: Atomic absorption spectrophotometer Conditions.

Element	Wavelength (nm)	Slit width (nm)	Lamp Current (mA)	Flame
Iron (Fe)	248.8	0.2	30	Air-Acetylene
Zinc (Zn)	213.9	0.7	15	Air-Acetylene
Manganese (Mn)	279.5	0.2	20	Air-Acetylene
Cobalt (Co)	240.7	0.2	30	Air-Acetylene
Chromium (Cr)	357.9	0.7	25	Air-Acetylene
Nickel (Ni)	232.0	0.2	25	Air-Acetylene
Copper (Cu)	324.8	0.7	15	Air-Acetylene
Lead (Pb)	283.3	0.7	10	Air-Acetylene
Cadmium (Cd)	228.8	0.7	4	Air-Acetylene

Table-2: Sampling plan of the study area.

Sample No.	Sample Code	Date of collection	Distance of field from the G.T. road
1	S-1	16th March. 2007	Main Bazaar
2	S-2	16th March. 2007	Upper Bazar
3	S-3	17th March. 2007	Lower Bazar
4	S-4	18th March. 2007	200 m from Main Bazar
5	S-5	19th March. 2007	300 m from Main Bazar
6	S-6	20th March. 2007	350 m from Main Bazar
7	S-7	21th March. 2007	400 m from Main Bazar
8	S-8	21th March. 2007	450 m from Main Bazar
9	S-9	21th March. 2007	500 m from Main Bazar
10	S-10	22nd March. 2007	550 m from Main Bazar
11	S-11	22nd March. 2007	600 m from Main Bazar
12	S-12	22nd March. 2007	650 m from Main Bazar

Table-3: pH of soil samples.

S. No.	Sample Code	pH
1	S-1	7.0
2	S-2	7.1
3	S-3	6.9
4	S-4	7.1
5	S-5	7.3
6	S-6	7.2
7	S-7	7.2
8	S-8	7.1
9	S-9	7.2
10	S-10	7.2
11	S-11	7.1
12	S-12	7.1

of protein synthesis, seed and grain maturation and production [6]. Zinc deficiency symptoms are short internodes and a decrease in leaf size [6].

Cadmium was found in the range of 5.1 to 42.1 mg/ L. The highest concentration of cadmium was found in the sample S-1 and the lowest was

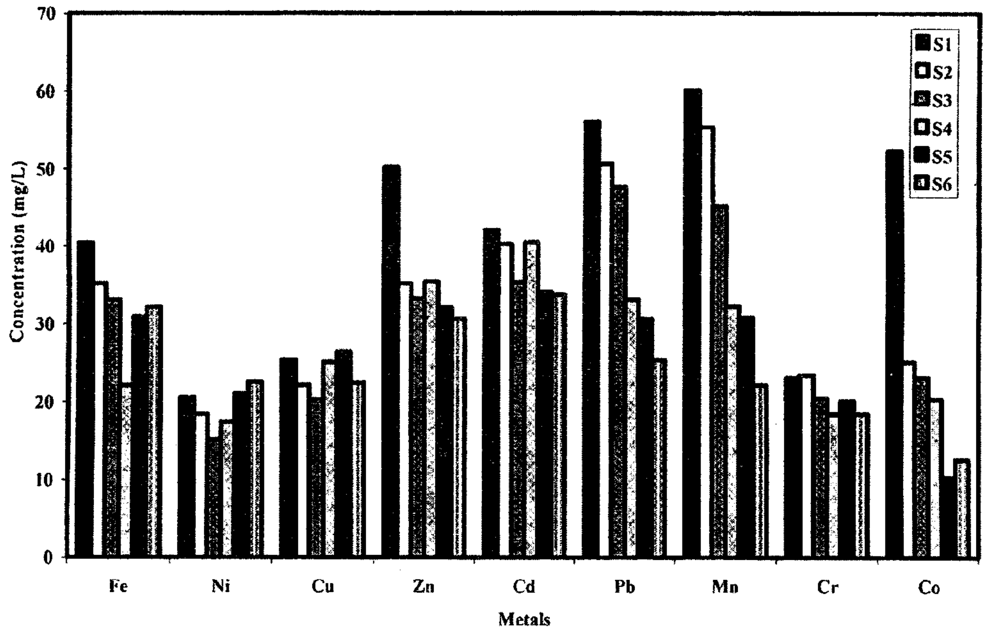

Fig. 1: Concentration of metals in the soil samples collected from different localities of Thana Malakand Agency.

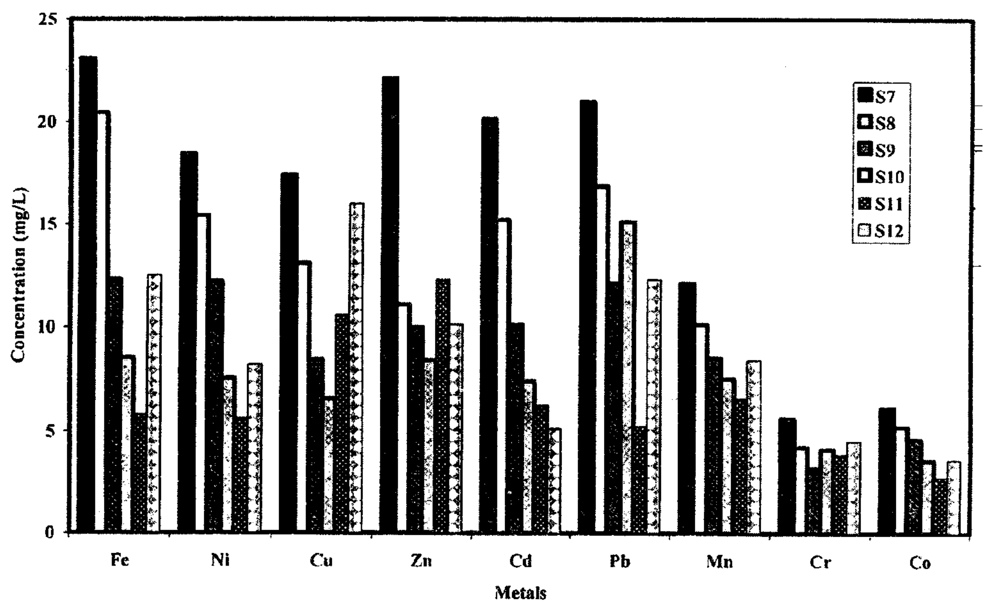

Fig. 2: Concentration of metals in the soil samples collected from different localities of Thana Malakand Agency.

Table-4: Concentration of specific metals in the agricultural soil samples

Metals	Soil samples											
mg/h	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12
Fe	40.4 ± 0.12	35.2 ± 6.2	33.1 ± 5.2	22.1 ± 2.2	30.8 ± 2.3	32.1 ± 5.2	23.1 ± 3.2	20.4 ± 2.2	12.3 ± 4.2	8.5 ± 2.3	5.8 ± 1.2	4.5 ± 2.3
Ni	20.5 ± 1.24	18.4 ± 4.5	15.1 ± 2.3	17.4 ± 2.3	20.9 ± 6.5	22.5 ± 2.3	18.4 ± 4.6	15.4 ± 5.2	12.2 ± 4.1	7.5 ± 1.2	5.6 ± 1.2	4.2 ± 1.2
Cu	25.4 ± 2.2	22.1 ± 6.5	20.2 ± 6.2	25.1 ± 3.2	26.4 ± 8.1	22.4 ± 2.2	17.4 ± 5.2	13.1 ± 3.1	8.4 ± 2.3	6.5 ± 1.2	10.5 ± 2.3	6.0 ± 2.3
Zn	50.2 ± 1.56	35.2 ± 6.4	33.2 ± 6.2	35.4 ± 3.3	32.1 ± 6.1	30.6 ± 3.2	22.1 ± 6.1	11.1 ± 2.9	9.9 ± 2.3	8.4 ± 0.4	12.3 ± 2.6	10.1 ± 1.3
Cd	42.1 ± 4.5	40.2 ± 4.4	35.3 ± 5.4	40.5 ± 7.2	34.1 ± 5.2	33.7 ± 4.2	20.1 ± 2.3	15.2 ± 4.8	10.1 ± 2.2	7.4 ± 0.2	6.2 ± 2.5	5.1 ± 1.2
Pb	56.1 ± 6.3	50.6 ± 5.3	47.7 ± 4.7	33.1 ± 8.2	30.6 ± 6.3	25.4 ± 2.3	20.9 ± 3.3	16.8 ± 2.4	12.1 ± 3.1	15.1 ± 1.2	5.2 ± 2.3	2.3 ± 1.8
Mn	60.1 ± 6.4	55.4 ± 3.3	45.2 ± 1.8	32.2 ± 3.6	30.7 ± 3.3	22.1 ± 2.2	12.1 ± 2.3	10.1 ± 3.8	8.5 ± 1.2	7.5 ± 1.3	6.5 ± 2.4	4.4 ± 5.2
Cr	23.1 ± 2.3	23.4 ± 2.3	20.4 ± 2.9	18.4 ± 1.2	20.1 ± 2.5	18.4 ± 3.2	5.6 ± 1.2	4.2 ± 2.3	3.2 ± 3.3	4.1 ± 1.1	3.8 ± 1.0	2.5 ± 1.1
Co	52.4 ± 5.5	25.1 ± 3.3	23.1 ± 3.7	20.3 ± 5.2	10.2 ± 2.3	12.5 ± 2.6	6.1 ± 1.1	5.2 ± 2.1	4.6 ± 2.3	3.6 ± 1.4	2.7 ± 1.1	1.6 ± 1.2

± Standard Deviation.

found in S-12 (Table-4 and Figs. 1 and 2). Which is higher than the desirable level for fertile soil therefore it may cause diseases like necrosis, wilting, red orange coloration of leaves & general reduction in growth desirable level is 0.1-1.0 mg/ L. Cadmium accumulation in plant materials varies with crop type and plant part *i.e.* broadleaf plants accumulate more cadmium than grasses while plant leaves and stems accumulate more than seeds. Broad-leave vegetables, such as lettuce accumulate more cadmium [6].

The concentration of lead in the samples was found in the range of 5.2 to 56.1 mg/ L. The highest concentration of lead was found in the sample S-1 and the lowest was found in S-12 (Table-4 and Figs. 1 and 2). Wide variations in soil lead levels have been reported, ranging from less than 100 mg/ L to 11000 mg/ L [11]. Natural levels of lead in surface soils are usually below 50 mg/ L [12].

Manganese in the soil samples was found in the range of 6.6 to 60.12 mg/ L. The highest concentration of manganese was found in the sample S-1 and the lowest was found in S-12 (Table-4 and Figs. 1 and 2). The functions of manganese in plants are nitrogen and inorganic acids metabolism, carbon dioxide assimilation during photosynthesis, carbohydrates breakdown and formation of carotene, riboflavin and ascorbic acid. Deficient manganese soil causes interveinal chlorosis of leaves followed by brown spots producing a checkered effect. Whereas an excess may cause reduction in growth, brown spotting on leaves and in severe cases leaf tissue begins to die at the leaf margin and continues back from the margins as toxic conditions increase [13].

Chromium was found in the range of 3.2 to 23.4 mg/ L. The highest concentration of chromium was found in the sample S-1 and the lowest was found in S-12, as can be seen in Table-4 and Figs. 1 and 2. At elevated concentration it could be toxic for plants and animals. Concentration between 5-30 mg/ Kg is considered critical for plants and could cause yield reduction [14]. As the concentration of chromium in our sample is low therefore it cannot cause any adverse effects.

Cobalt was found 0.16 mg/ L and 0.12 mg/ L. The highest concentration of cobalt was found in the sample S-1 and the lowest was found in S-12, as can be seen in Table-4 and Figs. 1 and 2. The functions of cobalt are synthesis of amino acids and metabolism activation of enzymes [14].

Experimental

Soil samples were taken from 0-15 cm depth of the agriculture fields on the road side of Thana, Malakand Agency (Table-2) and then dried at 105 °C. The dried soil sample was screened and the particle size was reduced by means of pestle and mortar, then one gram of soil sample was taken in conical flask and treated with 4 cm^3 nitric acid and covered with watch glass. The flask was heated on an electric hot plate for one hour. After the completion of heating time the contents of the flasks were cooled then 4 cm^3 of nitric acid was added and 2 cm^3 H_2O_2 (30%) and then the flasks were heated again for an hour. After one hour heating the watch glass was removed from the conical flask and the heating was continued until the volume of the contents was reduced to semi dried mass. The contents of the flask were cooled and diluted to 100 cm^3 with double distilled water, then filtered through ordinary filter paper. The sample was stored in bottles for the determination of elements such as iron, nickel, copper, zinc, cadmium, lead, manganese, chromium and cobalt through atomic absorption spectrometer (A-Analyst 700-PerkinElmer USA). pH of the soil samples was measured by pH meter (Hanna HI 8418).

Conclusions

The following conclusions were drawn from the present study.

1. Soil samples were found neutral in nature.
2. The highest concentrations of metals (iron, nickel, copper, zinc, cadmium, manganese, chromium and cobalt) were found in the sample S-1 which is near the main bazaar and then the concentration gradually decreases (from S-1 to S-12). This may be due to the fact that different sources near the main bazaar contaminate the agricultural soil thus its metal concentration is raised.

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