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Heavy Metal Concentration and Physico-Chemical Parameters in Koder Kamza Soils

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Abstract:

This study aims to provide information on some physicochemical parameters and some heavy metals concentration in Koder Kamza soils. The sample was taken in 0-30 cm depth. Characterization of soil parameters included moisture content, particle size, electrical conductivity, pH, iron (Fe), nitrogen (N), phosphorous (P), potassium (K) and heavy metals like cadmium (Cd) copper (Cu), Cobalt (Co), nickel (Ni) lead (Pb), zinc (Zn). Particle size analysis was determined via the hydrometer method of Bouyoucous (1951); EC and TDS were determined by using Conductivity meter Cond 7110; soil pH was measured electrometrically with a glass electrode pH meter Sartorius Basic Meter PB-11; the concentrations of Fe and heavy metals (Cd, Cu, Co, Ni, Pb and Zn) were determined by using atomic absorption spectrophotometer (AAS). N and P total presence in the soil were determined by colorimetric method, total K was determined by Flame Photometer Models PFP7. Total carbon (C) and total organic matter (OM) were also determined by modified Walkley and Black method. Moisture content results ranged from 4.35% to 4.38%, the values of soil pH ranged from 6.33 to 6.52, i.e. within the range for optimal growth of plants, total carbon ranged between 1.16 and 1.17%, total organic matter content between 2 and 2.02 %, an electrical conductivity between 75.6 and 93.5µS/cm. The texture resulted to be sandy loam with average composition of 61.83 % sand, 21.77 % silt and 16.4 % clay. Nitrogen 0.13 and 0.14 % is slightly higher than that of the control soil. Phosphorus 0.09 and 0.1% contents were low and high respectively. Total concentration of Fe ranged between 3083.07-3263.10 mg/kg. Cd and Cu was found in lower levels (<0.001 mg/kg dry soil). Total concentration Co, Ni, Pb and Zn ranged between 8.41-16.45, 28.65-28.69, 109.29-121.06, 12.9-13.7mg/kg dry soil and were all below the recommended limits by the European Community. In conclusion, this study serves as baseline data toward future ecological studies and normal plant cultivation.

Keywords: Soils characteristics, physicochemical parameters, heavy metal, extraction methods

1. Introduction

As of the pedological concept, soils are natural three dimensional bodies, covering part of the earth surface and supporting plant growth, thanks to the influential combination of climate, organisms (flora and fauna) and relief on parental material over a period of time. Nature and the relative importance per each factor in land forming vary in time and space. Through the application of agriculture, man has become an important factor that affects the formation and qualities of land [1]. The study of soil physicochemical parameters is important to the agricultural farmer for plant growth and soil management. Soil is one of the most significant ecological factors, on which plants depend for their nutrients, water and mineral supply [2]. Soil testing is the only way to determine the available nutrient status in soil and the only way we can develop specific fertilizer recommendations. Results of physical and chemical tests provide information about the capacity of soil to supply mineral nutrients [3]. Soil characterization in relation to evaluation of fertility status of the soils of an area or region is an important aspect as far as sustainable agricultural production is concerned. Nitrogen, phosphorous, potassium and sulphur are important soil elements that control its fertility and yields of crops [4].

So it is essential to analyze the physicochemical characteristics of the soil, because the more we increase the use of chemical fertilizer to the soil, the more difficult it becomes to control the adverse effects of chemical fertilizer to the soils, plants, animals and human beings.

2. Materials and Methods

Study site and methods

Sample Preparation: The present study was conducted in Koder Kamza soils. Sample was taken in 0-30 cm depth. Sample was air dried, crushed, passed

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through a 2 mm mesh sieve and kept at ambient temperature. The collected soil samples were stored in labeled polythene bags and were taken to the laboratory for analysis for the determination of physicochemical properties and heavy metals.

Determination of Some Physicochemical Parameters of the Soil Samples: Soil samples were analyzed for the following physicochemical parameters: moisture content, pH, electrical conductivity, organic carbon, organic matter, particle size analysis of soils, total nitrogen (as NH_4), total phosphorus (as PO_4), total potassium, heavy metal.

Moisture Content Soil moisture content was determined by oven drying method. 10 g of composite soil sample was taken. The samples were oven dried at 105°C for 24 hrs. Dry weight of the sample was taken till it showed its constant weight. The loss in weight corresponds to the amount of water present in the soil sample. The formula below was used to calculate the percentage of moisture content in each of the soil samples [5] [6].

Moisture content (MC) (%) =Loss in weight on drying (g)/Initial sample weight (g) x 100

The corresponding moisture correction factor (mcf) for analytical results or the multiplication factor for the amount of sample to be weighed in for analysis was calculated as follows:

Moisture correction factor (mcf) = 100 + moisture %/100

Particle size distribution Particle size distribution otherwise known as mechanical analysis was determined by hydrometer method [7] using sodium hexametaphosphate as dispersant. The texture class was also determined using the 'textured triangular diagram' [8].

Electrical Conductivity Suspension of air-dried soil was made up of 5 times its volume with water to dissolve the electrolytes [9]. 10g air dried soil was weighed and transferred to a shaking bottle. 50ml of distillated water at a temperature of 25 ± 1^oC was added. The bottle was closed and placed in horizontal position in the shaking device. It was shaken for 30 minutes, then filtered directly through a filter paper and the EC was measured by inserting electrical conductivity probe into the supernatant solution. The results were recorded with an accuracy of 1 decimal place, expressed in µS/cm or mS/m.

pH The pH of the soil samples was measured in ratio 1:5 (volume fraction) of soil in water (pH-H_2O). Air dried soil of 10 g was taken in a plastic bottle and water was added at an amount of 5 times the volume of the test portion. The suspension was shaken for 60 min ±10 min using a shaking device. Suspension was settled for at least 1 h, but not longer than 3 h. The pH meter (Sartorius Basic Meter PB-11) was calibrated using standard buffer solution of pH 4.0, 7.0 and 10.0 at $20^oC \pm 2^oC$. Then electrode of the pH meter was inserted into the supernatant solution and the pH reading was taken [10].

Organic Carbon and Organic Matter The organic carbon content of the soil samples was determined by the method of Walkey and Black [11]. 0.5-1 g finely ground soil sample was passed through 0.5 mm sieve and was taken without loss into 500 ml conical flask, to which 10 ml of 1 N potassium dichromate and 20 ml conc. H_2SO_4 were added with measuring cylinder. The contents were shaken for a minute and allowed to stand for 30 min. Then 200 ml distilled water, 10 ml orthophosphoric acid and 1 ml diphenylamine indicator were added. The solution was titrated against 0.5 N ferrous ammonium sulfate till the colour flashed from blue-violet to green. The blank titration was carried at the beginning without soil. The results was calculated by the following formulas:

Easily-oxidized carbon, percent = 10 x (1-sample titer, ml/blank titer, ml) x 0.3: mass of soil (1)

Total carbon, percent = Equation (1) x 1.3

Easily-oxidized matter, percent = Equation (1) x 1.72

Total organic matter, percent = Equation (1) x 1.3 x 1.72

Total nitrogen (finally measured as NH_4) Spectrometric measurement at about 655 nm of the blue compound was formed by reaction of ammonium with salicylate and hypochlorite ions in the presence of sodium nitroprusside. Calibration of the spectrophotometer apparatus was prepared via a series of standards by diluting standard solution in a 50 ml volumetric flask [12].

Total Phosphorus (measured as PO_4^{3-}) Ammoniummolybdate and potassium antimonyl tartrate reacted in medium acid with orthophosphate to form a phosphomolybdic acid that was reduced to intensely coloured molybdenum blue by ascorbic acid. Then absorbance was measured at 880nm between 10-30 min with a 1cm cell [13].

Total Potassium The PFP7 flame photometer is low temperature single channel emission flame photometer designed for the routine determination of

mineral salts. Light is emitted at characteristic wavelengths for each metal as the electron returns to the ground state. Standard solutions are prepared by dilution of stock solutions. From 1000 ppm (mg/l) K^+ stock solution (made by dissolving of A.R. KCl in volumetric flack); we prepared 1, 2, 4, 8 and 10 mg/l solution for calibration of the photometer [14].

Determination of Metal Sample size concentration: 0.3 g max of dried sample was accurately weighted into a digestion tube and 8 ml of HNO_3 (65%) and 2 ml of H_2O_2 (30%) were measured and added into the digestive tube and swirled gently to mix the sample property. The digestion tubes were then placed on digestive furnace (Model: ETHOS One**,** MA 133) and heated at a temperature of 180°C for 30 min. All the digests were cooled and filtered through Whatman No.42 filter paper in to 50 ml volumetric flask. Each sample was digested in replicates of five and transferred to acid washed stopper glass bottle, labeled and kept for metal analysis. Final concentration of the element in soil samples was calculated as: Concentration of the element in soil (mg/kg) =*Conc*. (mg/L) x (ml)/(g), where: *Conc.* is the concentration of the element obtained in mg/L, *V* is the final volume of the digested solution (50 ml) and *W* is the weight of the soil sample [15].

3. Results and Discussion

The result of soil analysis in comparison with FAO and WHO [16] [17] are present in table 1. The mean pH value of soil samples in the study area ranged from 6.33-6.52 indicated that soil samples are acidic in nature, and were within the range for optimal growth of a wide range of plants, as only at pH values below 4.2 the H^+ ions in the soil can stop or even reverse cation uptake by roots [18]. Electrical conductivity (EC) expresses ion contents of solution, which determine the current carrying capacity. This is used to estimate soluble salt concentrations in soil as well as to measure salinity. Soils with EC below 0.4 mS/cm are considered as marginally or non-saline, while soils above 0.8 mS/cm are considered severely saline [19]. Electrical conductivity value ranged from 75.6 to 93.5 µS/cm (Table 1), so this soil is non-saline. The % O.M values are above the average level of 3% for tropical soil as of FAO standard. Organic matter plays an important role in supplying nutrients and water and provides good physical conditions to the plants [20] reported soil OM content of < 2.0 % as low; 2.1- 3.0 % as medium and >3.1% as high. Following this classification the agricultural soil investigated had medium OM. The higher levels of OM present could be attributed to the application of animal manure. Because soil texture plays a very important role in the establishment and development of plant species it also influences physical parameters of the soil. The result has been presented in table 1 and the texture was discovered to be sandy loam with average composition of 61.83 % sand, 21.77 % silt and 16.4 % clay. Nitrogen is part of chlorophyll, the green pigment of the plant that is responsible for photosynthesis. It helps plants grow rapidly, thus increasing seed and fruit production and improving leaf quality. So the content of nitrogen presented in table 1 shows that these areas are classified as medium soil. Just like nitrogen, phosphorus is also an essential part of the process of photosynthesis. Phosphorus helps with the transformation of solar energy into chemical energy for the plant. The concentration levels of potassium in the selected soil samples were 4863.76 mg/kg. Potassium plays a key role in a vast majority of physiological processes. It is vital for plant growth from protein synthesis to maintain water balance. Potassium is a soluble cation in solution, yet its mobility in soil is very slow. Soils ability to absorb and hold K is of great importance as it serves to decrease leaching and provides continuous supply of available K [21].

Tab.1 Physicochemical characteristics of the experimental site

Characteristics	**Value**
Sand (%)	61.83
Silt (%)	21.77
Clay (%)	16.4
Soil pH (1:5)	6.42
Electrical conductivity (µS/cm)	84.55
Organic carbon (%)	1.16
Organic Matter (%)	2.01
Mineral N (mg kg^{-1} soil)	1350
Total phosphorus (mg kg^{-1} soil)	950
Total Potassium (mg kg^{-1} soil)	4863.76

The accumulation of metals in agricultural soil and plants from sources of terrestrial pollutants may lead to low quality of soil and may increase human health risks. The concentrations of the soil available Pb, Cu, Cr, Ni, Cd and Zn determined by AAS have been presented in Table 2 and as seen, they are within the allowed European standards expect for Pb, which is above permitted level. The

maximum allowable limits of heavy metals in soils and vegetables have been established by standard regulatory bodies, such as World Health Organization (WHO), Food and Agricultural Organization (FAO) and Ewers U, Standard Guidelines in Europe as shown in Table 2:

Tab.2. Heavy metal contents in soil samples & Maximum Allowable Limits of Heavy Metal in Soils (mg/kg)

Chemical Element	Mean	Standard Deviation (S.D.)	Maximum permissible level in soils (mg/kg)
Co	12.43	5.685139	50
Ni	28.67	0.028284	50
Pb	115.175	8.322647	100
Zn	13.3	0.565685	300

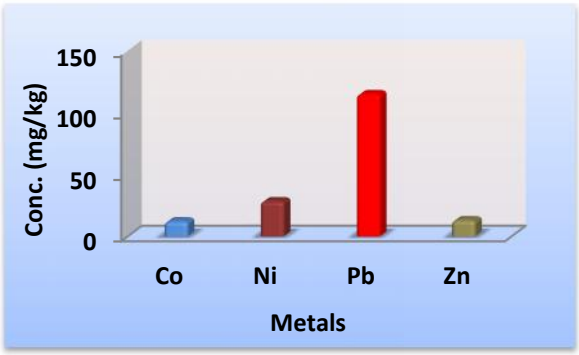

Fig.1 Heavy metal contents in soil samples

4. Conclusion

The major objective of the research in the present study was to explore soil quality in order to assess the impacts of agrochemical application in terms of its physicochemical properties with special emphasis on heavy metal accumulation. The present study demonstrated that all the soil parameters ranged within normal limits. This study gives information about the nature of soil and the presence of nutrients in soil. As of this information farmers arrange the amount and type of fertilizers and nutrients needed for the soil to increase the percentage of crop yields. Also the concentration of the metals, Cd, Cu, Co, Mn, Ni and Zn are all within tolerable levels set by FAO and WHO for agricultural soil, hence the area can be used for agricultural and recreational purposes.

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