# AN INVESTIGATION ON PHYSICO-CHEMICAL PROPERTIES OF SOIL IN POKHARA

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**ABSTRACT**

In the present research physico-chemical properties of soil samples: soil moisture, compactness, bulk density, soil atmosphere, water holding capacity, texture, $P^H$, organic matter, Nitrogen, Phosphorus, Potash, zinc, iron, copper, and boron were analyzed by using specific techniques. The observed physical properties were agreeable. The essential macronutrient elements nitrogen, phosphorus and potash were remained within the permissible range for most of the samples. The essential micronutrient elements zinc, copper and boron in four samples were within the acceptable range. The content of iron was higher than that required as essential crop nutrient. The availability of iron for the crops from the soil can be reduced by increasing $P^H$ and adding carbonates and bicarbonates in soil.

**KEYWORDS:** Bulk density, Essential nutrients, Physico-chemical properties, Pokhara soil texture, Spectrophotometer

## 1. INTRODUCTION

The soil is defined as the weathered surface of the earth crust which is mixed with organic materials in which micro-organisms live and plants grow. On the basis of different eco-climatic zone, types of soil in Nepal are Terai soil, Bhabar soil, Churiya soil, Valley soil and mountain soil (Lekhak & Lekhak, 2009). The earth's crust is made up of several elements: oxygen, 46.6 percent by weight; silicon, 27.7 percent; aluminum, 8.1 percent; iron, 5 percent; calcium 3.6 percent, sodium, 2.8 percent; potassium 2.6 percent, and magnesium, 2.1 percent (Lutgens & Tarbuck, 2000). The principal components of the soil are: soil atmosphere (20–30%), moisture (20–30%), organic matter (5%), and mineral-organism (5%) and mineral matter (45%) (Ambasht & Ambasht, 2005). The physical properties of the soil are color, soil moisture, compactness, dispersibility, infiltration rate, bulk density, soil atmosphere, water holding capacity and soil texture. The chemical properties of soil include the mineralogical composition, base saturation, humans and organic matter content. Biological properties refer to a content of microbes in soil which include bacteria, fungi, worms and insects. For plants, the essential micro-nutrients are: boron, chlorine, sodium, copper, iron, manganese, zinc, vanadium and molybdenum. The essential macronutrients are carbon, hydrogen, nitrogen, phosphorus, potassium, calcium and magnesium (De, 2010). The quantity of macronutrients and micronutrients of plants in soil can be determined only after soil analysis. From the known essential nutrients present in the soil the picture of soil fertility and productivity can be identified and then a particular crop harvesting can be recommended. The physical and chemical (inorganic and organic) components of the soil analysis were expressed by A.K. De (2010). Khopkar (2011) were analyzed and justified the micronutrients in soil in the soil. Different types soil in India had expressed by Kannan (1991). The physico-Chemical Parameters of soil temperature, colour, soil texture and structure, soil density, porosity, soil moisture, salinity, soil $p^H$, organic matter, toxic metals, heavy metals, pesticides were explained by Asthana & Asthana (1998). The moisture, $p^H$, nitrogen, organic carbon, urease and catalyse activities were analyzed by Manandhar and Manandhar (2040). Agricultural Experimental station, Oregon state University Corvallis present "Methods of Soil Analysis Used in the Soil Testing Laboratory at Oregon State University (1971).

In this research, the physico-chemical properties soil moisture, bulk density, soil atmosphere, water holding capacity, soil texture, $P^H$, organic matter, content of nitrogen, phosphorus, potash, zinc, iron, copper, and boron were analyzed by using specific techniques.

## 2. STUDY AREA

Pokhara city is situated almost central part of the Nepal, 200 km west from the capital Kathmandu in front of Machhapuchre mountain with altitude 827 metre in the southern part to 1740 in the north. The temperature of this area ranges from 6 $^oC$ in winter to 34 $^oC$ in summer. The latitude is 28.266 N and longitude 83.968 E. Seven sampling sites were selected for this study in the Pokhara Metropolitan city which are given in table 1.

**Table 1: Sampling Sites**

| S.No. | Sample No. | Name of Sampling Sites |
|---|---|---|
| 1 | $S_1$ | Nadipur, Pokhara -3 |
| 2 | $S_2$ | Malepatan, Pokhara -5 |
| 3 | $S_3$ | Foolbari, Pokhara -11 |
| 4 | $S_4$ | Kundhar, Pokhara -13 |
| 5 | $S_5$ | Chauthe, Pokhara -14 |
| 6. | $S_6$ | Birauta, Pokhara -17 |
| 7. | $S_7$ | Hemja, Pokhara – 25 |

## 3. MATERIALS AND METHODS

### Materials

For the study of physico-chemical properties of soil samples in Pokhara, a large number of apparatus, scientific equipments and chemicals of analytical reagent (AR) grade were used in laboratory. Main apparatus required for this research are: mechanical shaker, whatman no. 42 filter paper, aluminum moisture box, analytical balance, beaker, buffer solutions of $p^H$ 4, 7 and 9, calcium chloride, calcium sulphate, centrifuging machine, cylindrical hollow pipe, desiccators, electric oven, funnel, glass jar, glass road , mesh sieve, moisture boxes (cans), permanent marker, $p^H$ meter, automatic pipette, polythene sheets, potassium hydrogen phthalate, pulveriser, sample collection baskets, scale, sharp pointed pencil like needle, soil texture analysis worksheet, stirrer, stop watch, conductivity meter, muffle furnace spectrophotometer, analytical balance etc.

The chemicals required for this analysis are: calcium chloride, buffer solutions of $P^H$ 4, 7 and 9, calcium, buffer solutions of $p^H$ 4, 7 and 9, calcium sulphate, potassium hydrogen phosphate, copper sulphate, sulphuric acid, sodium hydroxide, sodium carbonate, methyl red, salicyclic acid, hydrochloric acid, molybdate reagent, potassium chloride, ammonium acetate, barium chloride, potassium sulphate, barium sulphate, ammonium acetate, acetic acid, azometnane-H, nitric acid, phosphoric acid, muroxide, sodium diethyl dithiocarbamate, manitol, L-ascorbic acid. diethylenetriamminepentaacetic acid (DTPA), dithiozone etc.

### Methods

Different seven sample sites were selected from agricultural farm in Pokhara by random sampling method. Required amount of soil samples were taken out from 9 to 12 inches below the ground level. Water holding capacity was determined directly in the farm site by gravimetric Method. Collected samples were dried in a forced draft drying cabinet at temperature less than 50 $^oC$ at about 24 hours, pulverized and then analyzed by using specific techniques (Table 2).

Soil moisture was determined by gravimetric method and expressed in percentage. Bulk density was determined by gravimetric and volumetric method. $P^H$ was determined by $P^H$ meter. Soil texture was determined by 'The Jar Test Worksheet" method. Available nitrogen was estimated by Regular Micro Kjeldal Method, available phosphorus by Olsen's method (Olsents et al. 1954) for neutral or alkaline soil or Bray's method for acidic soil, available potassium by Flame photometer method. Micronutrient elements zinc, iron, copper in the form of their divalent ions in soil were determined by extraction method followed by chemical method (volumetric analysis) or instrumental techniques (like spectrometry). Available boron was determined by AAS or spectrophotometric method.

**Table 2: Methods Used for Analysis of Physico-chemical Properties**

| S.N. | Properties | Methods used for analysis | Expressed Unit |
|---|---|---|---|
| 1 | Soil moisture | Gravimetric | Percentage |
| 2 | Bulk Density | Gravimetric and volumetric | g $cm^{-3}$ |
| 3. | $P^H$ | $P^H$ meter | $P^H$ scale |
| 4. | Soil Texture | The Jar test worksheet | |
| 5. | Water holding Capacity | Gravimetric | Percentage |
| 6. | Soil atmosphere | Volumetric | Percentage |
| 7. | Nitrogen | Regular Micro Kjeldal method | Percentage |
| 8. | Phosphorus | Olsen's or Bray's | kg $hector^{-1}$ |
| 9. | Potassium | Flame Photometer | ppm |
| 10. | Zinc | Extraction followed by chemical | ppm |
| 11. | Iron | Extraction followed by chemical | ppm |
| 12. | Copper | Extraction followed by chemical | ppm |
| 13. | Boron | AAS or spectrophotometric | ppm |

The soil samples for different micronutrient element estimation are extracted with suitable buffers. Iron & zinc with ammonium acetate buffer of $P^H$ 4.8 and 6.5 respectively. Copper is extracted with ammonium cyanate buffer ($p^H$ = 8.5) and boron with sodium carbonate buffer with $P^H$ 6.0. The organic content from extract was destroyed by dry ashing with nitric perchloric acid if analyzed by AAS. In the extracted sample, amount of copper was determined by bathocuporine ($\lambda_{max}$ = 484 nm) method, iron by bathophenanthroline method and amount of zinc by spectrophotometry method using zincon (2 carboxy, 2' hydroxyl 5' sulphormazyl). Examined physico-chemical properties of soil were compared with standard values.

Physical properties soil moisture, soil atmosphere and bulk density, soil $p^H$, texture etc. and Chemical properties organic matter, nitrogen, phosphorus, potash, zinc, iron, copper, boron etc. were determined in chemistry laboratory of Prithivi Narayan Campus (Tribhuvan University), Pokhara and Regional Soil Testing Laboratory, Pokhara Kaski, Government of Nepal.

## 4. RESULTS AND DISCUSSION

The observed results of physico-chemical properties of soil sample are presented in the following table 3 and 4.

**Table 3: Observed Physical Properties of Soil Samples**

| S.No. | Sample No. | Soil moisture (%) | Bulk density ($gcm^{-3}$) | Soil atmosphere (%) | Water holding capacity (%) | % of | | | Soil texture |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Sand | Silt | Clay | |
| 1 | $S_1$ | 5.0 | 1.30 | 28.25 | 45.0 | 49 | 49 | 2 | Silty loam |
| 2 | $S_2$ | 10.5 | 1.10 | 25.0 | 48.0 | 45 | 45 | 10 | Loam |
| 3 | $S_3$ | 4.5 | 1.34 | 27.50 | 35.5 | 67 | 31 | 2 | Sandy loam |
| 4 | $S_4$ | 9.2 | 1.30 | 23.50 | 35.5 | 60 | 35 | 5 | Sandy loam |
| 5 | $S_5$ | 6.5 | 1.40 | 25.50 | 32.5 | 76 | 22.5 | 1.5 | Loamy sand |
| 6 | $S_6$ | 3.2 | 1.15 | 27.82 | 35.2 | 55 | 35 | 10 | Loamy sand |
| 7 | $S_7$ | 8.5 | 1.45 | 24.55 | 45.9 | 46 | 45 | 9 | Loam |

Source: Researcher's Observation and Calculation

**Table 4: Observed Chemical Properties of Soil Samples**

| S.N. | Sample No. | $p^H$ | Organic Matter (%) | Nitrogen (%) | Phosphorus (kg $hecta^{-1}$) | Potash (kg $Hecto^{-1}$) | Zinc (ppm) | Iron (ppm) | Copper (ppm) | Boron (ppm) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | $S_1$ | 7.8 | 2.54 | 0.13 | 63.99 | 113.22 | 4.11 | 31.46 | 2.56 | 1.20 |
| 2 | $S_2$ | 7.5 | 2.1 | 0.15 | 60.15 | 117.68 | 2.85 | 20.25 | 1.44 | 0.92 |
| 3 | $S_3$ | 7.8 | 0.77 | 0.08 | 50.68 | 113.22 | 1.20 | 27.94 | 1.75 | 0.98 |
| 4 | $S_4$ | 7.4 | 1.45 | 0.10 | 55.55 | 105.75 | 1.22 | 25.44 | 1.89 | 0.75 |
| 5 | $S_5$ | 7.8 | 0.77 | 0.04 | 50.85 | 79.62 | 0.90 | 22.34 | 1.20 | 0.42 |
| 6 | $S_6$ | 7.7 | 2.20 | 0.12 | 48.25 | 99.85 | 1.50 | 18.61 | 1.11 | 0.51 |
| 7 | $S_7$ | 7.4 | 2.65 | 0.15 | 58.15 | 109.65 | 3.76 | 30.58 | 1.31 | 0.87 |

Source: Researcher's Observation and calculation

Observed soil moisture of the samples ranged from 5.0 to 10.5% which remains within a normal range (2-50%). Bulk density of soil samples ranged from 1.10 to 1.45 g $cm^{-3}$ which is below the upper range 1.6 g $cm^{-3}$. Soils with a bulk density higher than 1.6 g $cm^{-3}$ tend to restrict root growth. On the basis of this parameter, soil samples are fit for crop production. Observed soil atmosphere of samples ranged from 23.5 to 28.25% which also remains within a theoretical range (20-30%). This space is occupied by primary soil gases nitrogen (79.2%), oxygen (20.6%) and carbon dioxide (0.25%) (Pierzynski et al., 2018). For good plant growth, good soil aeration is necessary. During the decay of organic matter in the soil consumes $O_2$ and produce $CO_2$. On decreasing $O_2$, nitrogen fixation rate decrease and on increasing level of $CO_2$ in soil atmosphere acidity of soil and then weathering of carbonate minerals increases (De, 2010).

$$\text{Soil } \} Ca^{++} + 2CO_2 + 2H_2O \longrightarrow \text{Soil} \} 2H^+ + Ca^{2+}\,(\text{root}) + 2HCO3^-$$

Water holding capacity of observed samples ranged from 32.5 to 48% which was within the permissible range (30-50%). This value is important in determining irrigation intervals. (Veihmeyer & Hendrickson,1931). More water holding soil becomes chemically more reducing and reduces Mn and Fe. Fe (II) is toxic at high level for plants.

$$MnO_2 + 4H^+ + 2e^- \longrightarrow Mn^{2+} + 2H_2O$$

$$Fe_2O_3 + 6H^+ + 2e^- \longrightarrow 2Fe^{2+} + 3H_2O$$

The soil texture obtained by experimental observation was loam, loamy sand, sandy loam and silty loam. Observed $p^H$ of Soil Sample ranged from 7.4 to 7.8. The optimum $p^H$ range for most of the plants was between 5.5 and 7.5. Greater $p^H$ of some samples may due to formation of soil due to calcium carbonate materials and adding organic fertilizer in the soil. Organic matter of most of the sample was medium but that of two samples was low. Nitrogen content of five samples was medium but two samples was very low. Nitrogenous fertilizer should be added during the plantation of crops. Phosphorus content of four samples was high and remaining three is medium. In the soil $H_2PO_4^{2-}$ are the species utilized by plants. In acidic soil, the orthophosphate ions are either precipitated or sorbed by cations like $Al^{3+}$, $Fe^{3+}$. In alkaline soil, hydroxyapatite is precipitated.

$$6HPO^{2-}{}_4 + 10CaCO_3 + 4H_2O \longrightarrow Ca_{10}\,(PO_4)_6\,(OH)_2 \downarrow + 10HCO^-{}_3 + 2OH^-$$

The potash contain of sample ranged from 79.62 to 117.68. This value for sample $S_5$ was low but medium for remaining samples. In most of the farms, the content of potassium was reasonable. The contents of micronutrients zinc and copper analyzed for more of the samples was medium. Boron content of four samples were medium, two samples were low and that of one was high. Boron occurs in the soil mainly in the form of boric acid $B(OH)_3$ or $B(OH)^-{}_4$. $B(OH)_4$ occurs in higher $p^H$ conditions.

$$B(OH)_3 + H_2O \rightleftharpoons B(OH)^-{}_4 + H^+.$$

The anion is adsorbed by Al, Fe oxides, clay minerals and the adsorption is stronger at higher soil $P^H$ (Goldberg & Forster, 1991). The content of zinc was medium in four samples, high in two samples and low in one sample. Zinc is important but toxic at higher concentration for plants. The content of copper ranged from 1.11 to 2.56 ppm. Its value was medium for three samples and higher for four samples. Copper acts as enzyme activator and support for photosynthesis for plants. But at higher concentration copper also acts as poison by reducing plant growth and reducing iron concentration. The iron content in most of the agricultural soil ranged from 2.5 to 4.5 ppm theoretically. In the observed result iron ranged from 18.61 to 31.46 ppm. These values are very high than theoretical values required for economically crops production. Iron is an essential micronutrient element mainly required in very small amount for chlorophyll formation, protein synthesis, enzyme

activity but toxic at higher concentration. Availability of iron for the plants from the soil can be reduced by increasing $P^H$ up to 7 or above 7 by adding carbonates and bicarbonates in soil. This makes iron unavailable and fixed in soil.

## 5. CONCLUSION

Physico-chemical properties of soil samples of different farm stations in Pokhara Metropolitan city, Nepal were determined. Observed physical properties and essential macronutrient elements nitrogen, phosphorus and potash were within the theoretical range for most of the samples. The amount of iron in three samples was very high and in other four samples was high where as the content of other essential micronutrient elements zinc, copper and boron in most of the samples were acceptable. Iron is the most abundant metal in nature and earth's crust contains 50 mg/g of iron on an average. Therefore, content of iron in soil was also higher than that required for plants. Higher concentration (toxicity) of iron invites physiological diseases for crops mainly for rice (like bronzing, alkagara, akiochi and scana disease). Excess of iron can be locked in soil by adding carbonates and bicarbonates. (Kannan,1997). This research will be beneficial for researchers, agricultural farming persons, planners and government authorities.

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