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Research Article

Rational Assessment of Physico-Chemical Parameters of Agricultural Soil from Selected Places of Banepa, Nepal

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Abstract

Physico-chemical parameters are among the basic attributes for the study of soil as they play a critical role in the assessment of soil health. In the present study, an attempt was made to study the physicochemical parameters in soil samples collected from six places of Banepa (Sinagal, Budole, Janagal, Chandeswori, Nayabasti, and Dhaneswor). The soil characterization was carried out for parameters like moisture content (%), pH, electrical conductivity (EC), chloride (Cl^-), sulphate (SO_4^{2-}), and phosphate (PO_4^{3-}) ions. Chloride and sulphate were analyzed by argentometric titration and gravimetric method. The molybdenum blue method was employed for analysis of phosphate. In the present study, the pH of different soil samples ranged from 4.02-6.46 indicating a strongly to slightly acidic nature. EC values ranged from 0.05-0.45 mS/cm which showed that all soil samples were non-saline. The concentration of Cl^-, SO_4^{2-} and PO_4^{3-} were in the range of 10142-16904 ppm, 1440-3907 ppm, and 1.8-3.8 ppm, respectively. Analysis of these parameters helps to determine the nature, fertility status of soil which is important for agricultural chemists for plant growth and soil management. Such studies provide the necessary information required to maintain optimum fertility year after year.

Keywords: *Agricultural Soil, Soil pH, Soil chemistry, Conductivity, Physico-chemical parameters*

Introduction

Soil supports as a medium for plant growth, water modulation, nutrients, and pollutant transport (Scholes et al., 2013). The modern concept of soil quality is to sustain biological activity, promote plant, animal, human health, and maintain the quality of the environment (Dorana and Zeiss, 2000). A healthy soil roughly comprises 40% minerals, 23% water, 23% air, 6% organic material, and 8% living organism (Zaiad, 2010). Soil can be classified into different types depending upon the proportion of particles of various sizes. Soil Physico-chemical properties influence soil behavior therefore knowledge of soil is crucial (Rao et al., 2013). Soil fertility testing is the only way to determine available nutrient status in soil and develop fertilizer recommendations. Fertility testing is a combination of three interrelated processes: analysis, interpretation, and recommendation. Soil characterization of an area is important for sustainable agricultural production. There are reports of change in physico-chemical parameters of soil due to change in land use, place, and time (Wang et al., 2011). The understanding of such parameters is salient for the management of water resources, land use, and crop productivity (Saikia and Singh, 2003).

Soil pH ranges roughly from acidic (pH<3.5) to a very strongly alkaline (pH>9.0). It acts as a master characteristic in soil's chemical properties and specifically determines the availability of nutrients essential for crop production (Fageria and Zimmermann, 1988). Similarly, the electrical conductivity of soil water mixture indicates the total amount of salt present in the soil. The EC is higher in soil with higher clay content and lowers in the soil with high sand content (Castro and Molin, 2008). Excess and too few salts may lead to moisture stress and soil crusting. Moreover, the chlorine is also an essential micronutrient for plants and minimal requirement of 1g/kg dry weight has been suggested (Marschner, 1995). Chlorine plays a major role in osmotic adjustment, photosynthesis, and suppression of plant disease. Water containing chloride concentration of less than 150 mg/l are safe for most plants. Further, the plant requires sulphur at a concentration between 0.1 to 0.5 % of their dry weight for healthy growth. Mineralization of organic sulphur and sulphate deposition from the atmosphere provide enough supply of sulphur in soil (Radojevic and Bashkin, 1999). However, it is very mobile and prone to leaching in wet soil conditions. The sulphur acts as a structural and enzymatic component of plants. Meanwhile, the phosphorus is available to plants in orthophosphate form (Chaube and Gupta, 1983). The bioavailability of phosphorus is greatest at a pH range of 6.0 to 7.0. It stimulates root development, improves flower formation. Nucleic acids such as DNA and RNA are made up of a polyester chain of phosphate and sugar with an organic base (Borkar, 2015). Deficiency in phosphorus is difficult to diagnose as it displays no obvious symptoms other than the stunting of the plant during early growth and dark colouration of older leaves.

In the present study, we have analyzed the soil samples collected from the fertile agricultural hub Kavreplanchock district, Nepal. The capacity of soil to provide different nutrients and retain water for flora and fauna are assessed through various parameters. We carried out the simple but very important analysis technique for the evaluation of several parameters that affect and/or support plant growth and development. The fundamental information about the soil parameters in this area is expected from our study which would be helpful to support the reasonable utilization and management of soil resources.

Methodology

Study Area

The study area, Banepa is a valley located at 27.63º N and 85.52º E; at about 4800 ft above sea level in central Nepal. Its floor comprises of quaternary deposit composition of gravel, sand, and clay. At its top, there is topsoil. About 63% of total land has been used for agriculture. Punyamati river (seasonal river) plays a great role in irrigation, however, recently due to haphazard sewage and solid waste accumulation, quality of water and land has been degraded in this area. There are few reports on physico-chemical parameters to evaluate the quality of its soil. The present study is therefore, an attempt to analyze different parameters like moisture, pH, electrical conductivity, chloride, sulphate and phosphate of soil of six different places in Banepa as shown in **Figure 1**.

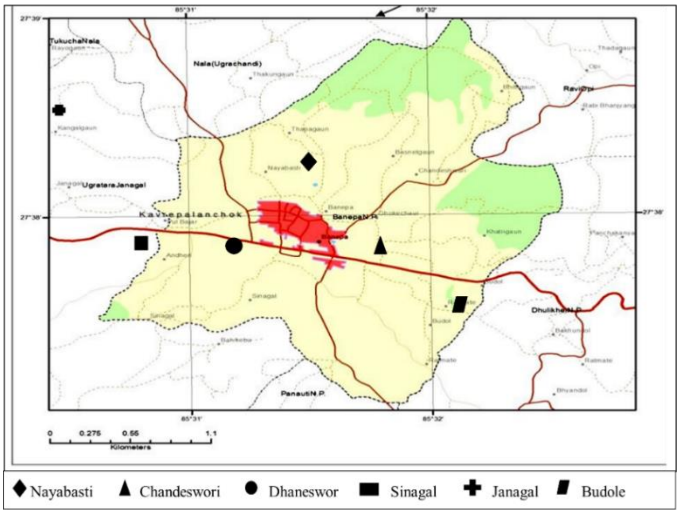

Figure 1: Location map of the study area

Soil Sampling

The samples of different areas like Sinagal, Janagal, Nayabasti, Dhaneswor, Chandeswori, Budole were collected from the surface of soil in the depth of 15 cm. They were bulked together in polythene bag. The lumps were broken using hand. Particles were crushed and sieved with mesh sieve, stored in airtight plastic bag and labelled.

Instrumentation

The spectral measurements were made using UV-visible spectrophotometer (model ELICO SL 177). The pH readings were obtained by using pH meter (model DELUXE pH METER – 101) and electrical conductivity was analysed by conductivity meter (model MAX ME – 75) available in the department laboratory. All other instruments and apparatus are also used from the department laboratory of chemistry, Tri-chandra Multiple Campus, Kathmandu.

Preparation of Reagents

All the chemicals of AR grade were used without any further refinement.

Potassium chromate indicator (5%)

Potassium chromate indicator was prepared by dissolving 5 g of potassium chromate powder in 30 ml of distilled water and saturated solution of $AgNO_3$ solution was added to it until slight red precipitate was formed. The solution was filtered and made up to 1000 ml by adding distilled water.

Silver nitrate solution (0.01N)

0.0410 g of silver nitrate powder was dissolved in 250 ml distilled water in a volumetric flask. After that it was stored in a dark place before use.

Barium chloride solution (10%)

10 g of barium chloride powder was dissolved in 100 ml distilled water in a volumetric flask.

Stock phosphate solution (1000 ppm)

1.8735 g of $Na_2HPO_4.2H_2O$ was weighed out accurately and dissolved in a distilled water and final volume was made to 1000 ml in a volumetric flask.

Ammonium molybdate reagent (I)

12.25 g of ammonium heptamolybdate $[(NH_4)_6Mo_7O_{24}.4H_2O]$ L.R grade was dissolved in 87.5 ml of distilled water. 140 ml of concentrated H_2SO_4 was added to 200 ml of distilled water cautiously. It was cooled and added to ammonium molybdate solution and diluted upto mark in 500 ml volumetric flask.

Ammonium molybdenum reagent (II) (5%)

20.05 g of ammonium molybdate reagent was dissolved in 250 ml of distilled water. 198 ml of ammonium molybdate (I) was added to the reagent (II), cooled and diluted upto 500 ml with distilled water. Now the concentration of reagent (II) was 5%.

Working solution of ammonium molybdate (0.5%)

0.5% of reagent was made by diluting 25 ml of 5 % of ammonium molybdate reagent (II) to 500 ml.

Sulphuric acid solution (1.5 M)

1.5 M sulphuric acid solution was prepared by diluting 41.6 ml of concentrated sulphuric acid to 500 ml with distilled water in a volumetric flask.

Hydrazine hydrate solution

1.22 ml of concentrated hydrazine ($N_2H_4.H_2O$) was diluted upto mark in a 50 ml volumetric flask; the strength of solution was 0.5 M.

Determination of moisture content in soil

Soil moisture content was determined by oven drying method. 20 g of composite soil sample was taken, and oven dried at 100º C for 24 hours. The loss in weight corresponds to the amount of water present in the soil sample. The following formula was used to calculate the percentage of moisture content in each of the soil sample (Joel and Amajuoyi, 2009).

$$\text{Moisture content (\%)} = \frac{loss\ in\ weight\ on\ drying(g)}{initial\ sample\ weight\ (g)} \times 100 \quad \ldots (1)$$

Estimation of soil pH

The pH of soil sample was measured in water suspension (1:5). The mixture was stirred with glass rod for 15 minutes and was allowed to stand for 30 minutes. The pH meter was calibrated using standard buffer solution of pH 4.0 and 9.0. Then electrode of the pH meter was inserted into the supernatant solution and the pH reading was taken.

Determination of electrical conductivity in soil

Electrical conductivity of water was measured in soil water suspension (1:5). The mixture was stirred with glass rod for 15 minutes and allowed to stand for 30 minutes without any disturbances. The conductivity meter was standardized. EC value was measured inserting electrical conductivity meter into the supernatant solution. The electrode was positioned in the solution just above soil layer.

Estimation of chloride ion concentration in soil

First, 1:2 soil water suspensions was prepared, allowed to stand for two days and then filtered. 20 ml of filtrate was pipetted out and diluted upto mark into 100 ml volumetric flask. Then 10 ml of this solution, 50 ml distilled water and 1 ml of chromate indicator were added in conical flask. The mixture was carried out the argentometric titration with standard 0.01 N silver nitrate solutions. The consumed volume of the silver nitrate solution was noted down when the colour changed into dark brick red. The titration was repeated until the concurrent reading was obtained. Then chloride content was calculated using the formula (Dhakal et al., 2013)

Cl^- content (gm/l) = $\frac{Normality\ of AgNO_3 \times eq.wt.of cl^- \times 100}{vol.of\ liquid\ taken\ in\ ml.}$ … (2)

Chloride (in ppm) = gm/l × 1000 … (3)

Determination of sulphate ion concentration in soil

At first, 1:5 soil water suspension was prepared and tightly covered by cork and was shaken for half hour and then it was filtered using Whatmann-42 filter paper. Whole filtrate was taken into a 250 ml beaker and 1 ml of concentrated hydrochloric acid was added in it. The mixture solution was heated near the boiling point and 10 ml of 10% barium chloride solution was added to acidified filtrate solution, stirred it, and then kept overnight for complete precipitation then filtered using Whatmann filter paper and the residue was washed with hot water until chloride free from residue using silver nitrate solution. Finally, the filter paper containing barium chloride residue was placed in a pre-weighed crucible and ignited at 800ºC for about 2 hours using muffler furnace. Then cooled and weight of residue was noted. In this way, weight of sulphate residue was estimated, and weight of sulphate content was calculated using $= \frac{weight of residue}{weight of sample\ taken} \times \frac{96}{233.39} \times 100$ following formula (Dhakal et al., 2013). % of SO_4^{2-} … (4)

SO_4^{2-} (in ppm) = % of sulphate content in soil × 10000… (5)

Determination of phosphate ion concentration in soil

Firstly, 2.5 g of each sample was weighed and transferred to 250 ml conical flask. It was shaken with a measured volume of 50 ml of sodium bicarbonate solution of pH 8.5. 42 g of sodium bicarbonate diluted upto 1 litre then adjusted to pH of 8.5 with 50% NaOH or acetic acid and continued the shaking for another 30 minutes. Then, it was kept aside for 20-30 minutes to attain equilibrium and filtered through Whatmann filter paper. The clear filtrate was collected in a 50 ml volumetric flask and volume of 10 ml of filtrate was transferred into a 50 ml of beaker. It was acidified by dropwise addition of about 1 ml of dilute sulphuric acid. The acidification of the filtrate could be easily noticed by ceasing of evolving gas bubbles. Then the solution was transferred into a 25 ml volumetric flask and diluted to volume with water. It was used for determination of its phosphate content.

$PO_4^{3-} + 12(NH_4)2MoO_4 + 24H^+ \longrightarrow (NH_4)_3PO_4.12MoO_3 + 21NH_4^+ + 12H_2O$ … (1)

$(NH_4)_3PO_4.12MoO_3 + (N_2H_4.H_2O) \longrightarrow$ Molybdenum blue … (2)

Colour development

In each sample solution, 2.5 ml of 1.5 M sulphuric acid, 2 ml of 0.5 % ammonium molybdate and 3 ml of 0.5 M hydrazine hydrate were added successively. This was settled for some time for colour development.

Calibration curve for spectrophotometric determination of phosphate ion concentration in soil

A calibration curve was established under the optimum condition. For that phosphate solution of different concentration of 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 ppm were prepared in 100 ml volumetric flask by pipetting 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9 ml from stock phosphate solution. A series of 25 ml volumetric flasks were arranged. In all cases, 2.5 ml of dilute solution were pipette out then in each flask, 2.5 ml of sulphuric acid, 2 ml of 0.5% of ammonium molybdate and 3 ml of 0.5 M hydrazine hydrate were added successively. Each solution was let at room temperature for 35 minutes for complete colour development. Absorbance of above prepared solutions was measured at 860 nm against blank solution.

Results and Discussion

The results of various physico-chemical parameters of soil analyzed in six different places of Banepa based on moisture, pH, electrical conductivity, and nutrients analysis with reference to chloride, and sulphate are presented in **Table 1.**

Table 1: Results of physico-chemical parameters of the soil

S.N.	Places	Moisture content (%)	pH	Electrical cond. (mS/cm)	Cl^- ion conc. (ppm)	SO_4^{--} ion conc. (ppm)
1.	**Dhaneswor**	22.59	6.07	0.456	14200	1645
2.	**Janagal**	26.40	6.46	0.1719	12241.37	3907
3.	**Chandeswori**	25.76	4.70	0.059	16904.76	1440
4.	**Budole**	24.54	5.14	0.084	10142.85	3690
5.	**Nayabasti**	18.54	4.02	0.215	11093.75	1850
6.	**Sinagal**	30.94	5.36	0.110	12678.57	2673

Analysis of moisture content

Soil moisture content is expressed by weight as the ratio of water present to the dry weight of the soil sample. The weight is the difference between the weights of wet and dry oven samples. The temperature of oven is based on water boiling temperature and does not consider the soil physical and chemical characteristics. The obtained data are shown in **Table 1 and Figure 2**. The highest moisture content was found in soil of Sinagal with 30.94% and the lowest was found to be 18.54% in Nayabasti as indicated in **Figure 2**. The soil of Budole, Chandeswori and Janagal showed the consecutive values i.e., 24.54%, 25.76% and 26.40% respectively. Soil moisture affect leaf water potential, stomatal conductance, leaf area effectively. Plants grown in Nayabasti may experience moisture stress leading to reduced leaf growth rate, net assimilation rate whereas too much moisture in soil of Sinagal reduce the amount of oxygen available to roots that may affect plant physiological processes like transpiration, photosynthesis.

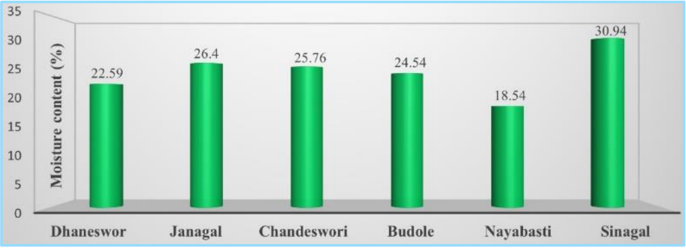

Figure 2: Moisture content in the soil samples of different places in Banepa

Analysis of pH

Soil pH estimation is critical in the assessment of soil health. It affects availability of soil nutrients and activity of soil micro flora. Hence it is regarded as a key variable. The obtained data are shown in **Table 1 and Figure 3**. In present study, the value of pH of sample Chandeswori and Nayabasti ranges from 4.02 to 4.70 indicating soils are predominantly acidic. The pH ranged from 5.14 to 6.46 for other four samples indicating moderately acidic nature of soil as indicated in **Figure 3**. The acidic nature of these soils could be attributed to leaching of basic cations such as Ca^{++}, Mg^{++}, K^+ and Na^+ at expense of H^+ and Al^{3+} leading to high soil acidity. Plants grown in such soil can experience aluminium toxicity leading to root growth inhibition, thickened lateral roots and root tips as well as nutrient deficiencies of Ca^{++} and Mg^{++}.

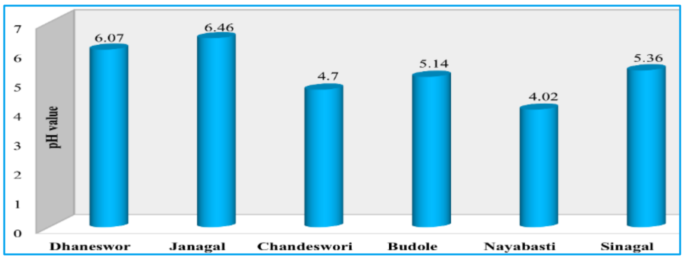

Figure 3. pH value of soil of different places

Analysis of electrical conductivity

It is used to estimate soluble concentration in soil and influence plant's ability to absorb water. EC below 0.4 mS/cm are regarded as non-saline while above 0.8 mS/cm are considered severely saline (Wagh et al., 2013). The result obtained in this analysis is shown in **Table 1 and Figure 4**. In above sample, EC value ranged from 0.0592 to 0.456 mS/cm indicating the highest EC in sample Dhaneswor and lowest in Budole as shown in **Figure 4**. The soil under analysis was found to be non-saline. Plants grown in such area have optimum pressure around roots and lead to efficient water absorption by plants.

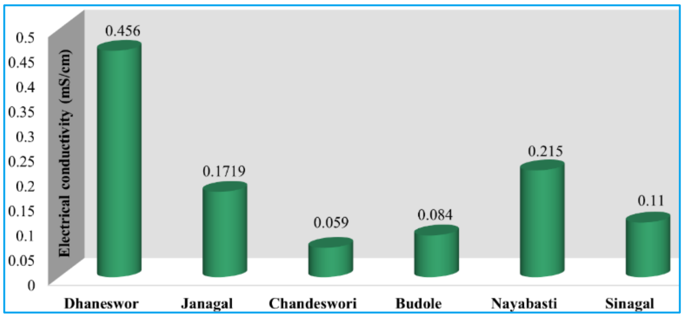

Figure 4: Electrical conductivity (EC) of soil of different places

Analysis of chloride

Chloride is an essential micronutrient required by all plants in small quantities. It is important in cation balance and transport within plant, diminishes effect of fungal infection. The optimum level of Cl^- is unknown for most plants. The result of this analysis is shown in **Table 1 and Figure 5**. The concentration of Cl^- is the highest in Chandeswori soil 16904. 76 ppm, while lowest in Budole is 10142.85 ppm as shown in **Figure 5**. There was no marked variation in concentration of Cl^- in other samples. Plants grown in such areas experience chloride toxicity leading to scorched or burned leaves with smaller size than usual and may drop early. Since chloride is easily leached, toxicity can be alleviated through frequent watering.

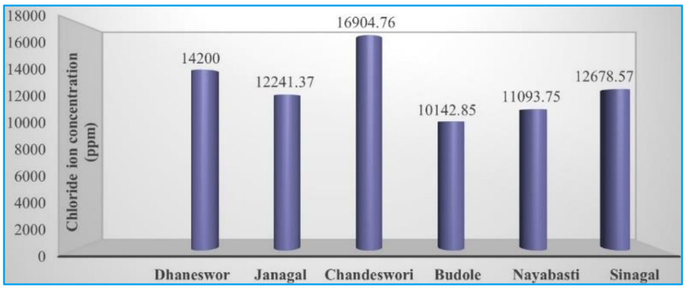

Figure 5: Amount of chloride ion concentration in soil samples of different places

Analysis of sulphate

About 95% of total sulphur is associated with organic matter in soil which is converted or mineralized to SO_4^{--}. Plants absorb SO_4^{--} from soil pore. It is essential for chlorophyll formation and fixation of nitrogen in legumes. The result of this analysis is shown in **Table 1 and Figure 6**. It can be seen that the highest concentration of SO_4^{--} was found to be 3907 ppm in Janagal followed by 3690 ppm in Budole, 2673 ppm in Sinagal soil, 1850 ppm in Nayabasti, 1645 ppm in Dhaneswor and the lowest in Chandeswori i.e., 1440 ppm as indicated in **Figure 6**. Low native sulphur content, coarse texture, inherent low organic matter content and soil conditions are responsible for lowest value in Chandeswori. Such low value requires correction by applying sulphur fertilizers to avoid crop yielding limiting factor due to sulphur deficiency.

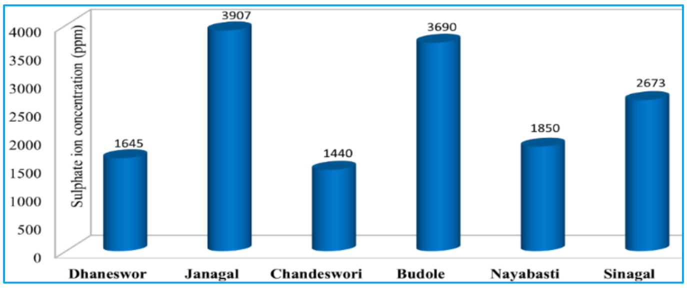

Figure 6: Amount of sulphate ion concentration in soil samples of different places

Analysis of phosphate

The absorbance of formed phosphomolybdenum blue was measured from 780 nm- 900 nm and λ_{max} was determined. The wavelength at which maximum absorbance was observed was considered as the $\lambda_{max.}$ On plotting absorbance against wavelength, the λ_{max} was found at 860 nm. The result obtained is shown in **Table 2.**

Table 2: Determination of maximum wavelength (λ_{max}) for the analysis of phosphate ion concentration

S.N.	Wavelength	Absorbance	S.N.	Wavelength	Absorbance
1.	780	0.114	8.	850	0.157
2.	790	0.116	9.	860	0.169
3.	800	0.1172	10.	870	0.145
4.	810	0.120	11.	880	0.139
5.	820	0.125	12.	890	0.130
6.	830	0.140	13.	900	0.126
7.	840	0.146			

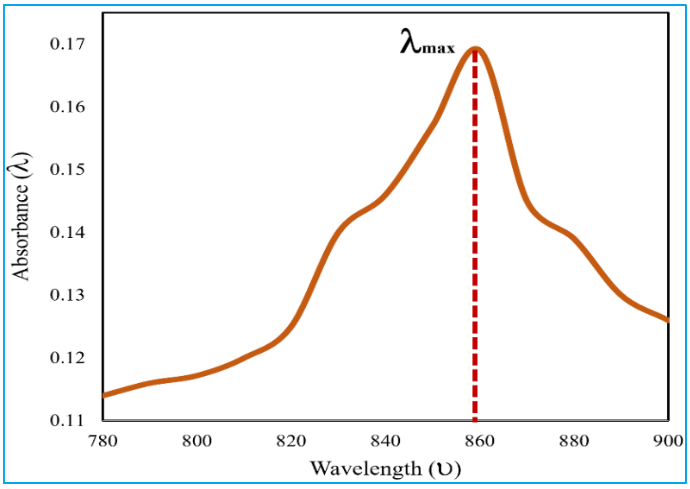

Figure 7: Plot of absorbance against wavelength

Calibration curve

Calibration curve for the phosphate analysis is shown in **Figure 8**. The curve is obtained by plotting absorbance as a function of concentration of phosphate (ppm) at the wavelength 860 nm. The plot is linear and obey Lambert-Beer's law in the range 0-9 ppm. The amount of phosphate within this range was determined. The result is shown in **Table 3**.

Table 3: Analysis of phosphate

Phosphate (ppm)	Absorbance
0	0
1	0.0905
2	0.1801
3	0.2912
4	0.3811
5	0.4714
6	0.5934
7	0.6871
8	0.7783
9	0.8615

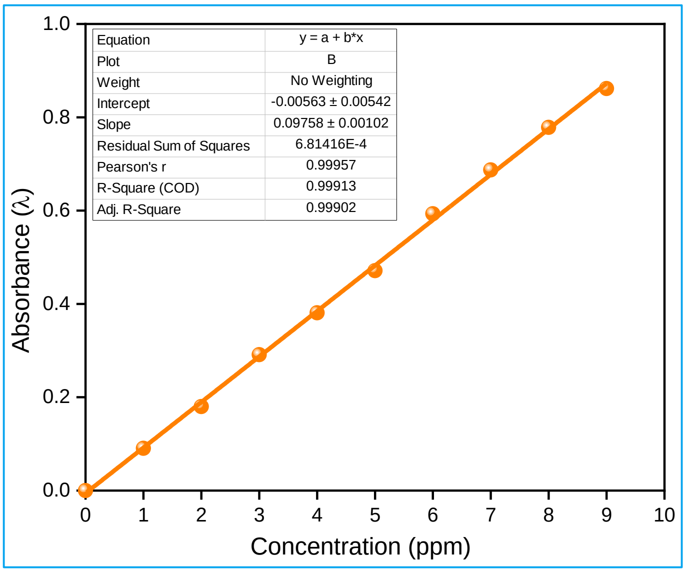

Figure 8: Determination of calibration curve by the plot between concentrations vs. absorbance

Phosphate ion concentration in soil

The concentration of phosphate ion concentration in soil samples are displayed in **Table 4 and Figure 9**. It was observed that the highest concentration of phosphate was found in Janagal soil 3.8 ppm and lowest in Dhaneswor soil 1.8 ppm (**Figure 9**). The high concentration may be attributed to overuse of fertilizers. It may interfere with plant uptake of micronutrients such as iron, zinc, and also with nitrogen absorption. As a result, symptoms of phosphorus toxicity are actually the symptoms of zinc, iron deficiency. Using low phosphorus or phosphorus free fertilizer to drop its level in soil can be a remedy to maintain its optimum value in soil.

Table 4: Phosphate concentration in soil samples

Places	Absorbance	Phosphate (ppm)
Janagal	0.360	3.8
Sinagal	0.313	3.3
Chandeswori	0.190	2.0
Dhaneswor	0.171	1.8
Budole	0.264	2.6
Nayabasti	0.229	2.3

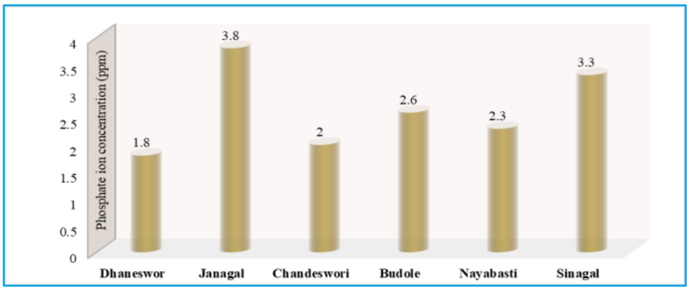

Figure 9: Phosphate ion concentration in soil samples of different places

Conclusion

The physico-chemical parameters of soil from six different locations of Banepa were analyzed. Soil pH analyzed in relation to this work is one of the indices for measuring soil productivity. From the result of analysis, the pH of the soil ranges from 4.02-6.46 indicating strongly to slightly acidic nature. The acidic nature is not good for most agricultural production hence needs further treatment to make it suitable for agriculture. The measurement of conductivity gives a clear idea of soluble salt present in soil. The present study shows that all the soil samples of study are non-saline. The concentration of chloride is found to be high in soil of Banepa. Water quality and irrigation management are major factors that affect concentration of chloride in soil. Therefore, proper irrigation management must be adopted to keep Cl^- level below threshold level that can be tolerated by crop. Soils of Janagal and Budole have higher range of sulphate. It can be attributed to high organic content present in soil. However, sulphur in soil is prone to leaching due to different factors like heavy rainfall, pollution etc which results in deficiency. The amount of phosphate is determined by molybdenum blue method. The system obeys Lambert-Beer's law at 860 nm in concentration range of 0-9 ppm. Thus, it can be concluded that the recognition of significance of analysis of various parameters for plant growth as well as crop yield has made it necessary to analyze such parameters in soil sample.

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