Academic View

Estimation of Nitrite (NO_2^-), Phosphate (PO_4^{3-}) and Sulfate (SO_4^{2-}) in Soil Samples of Kathmandu Valley and Western Nepal

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Abstract

Soil is a dynamic resource that interacts with the ecosystems such as water, air, flora and fauna that influence plant, life on earth. Soil fertility largely affects agriculture, plant and animal productivity. It requires to preserve water and air quality to sustain human health and habitation. Nitrite, phosphate, and sulfate of soil samples from 10 different places were estimated. Nitrite was analyzed by the addition of benzidine, hydrochloric acid solution, dimethylaniline followed by the addition of NaOH, a pink red colored azo dye was formed and was measured spectrophotometrically in the range of 0.068 to 0.213 mg/L. At a pH of 8.5 the available phosphates were extracted with sodium bicarbonate solution and acidified with H_2SO_4. In the presence of ammonium molybdate and hydrazine hydrate, a light blue colored ammonium phosphomolybdate complex was formed and was measured by spectrophotometer in the range of 0.158 to 0.279 mg/L. In presence of excess of $BaCl_2$, sulfate ion was then determined by turbidimetry method in the range of 0.130 to 0.271 mg/L.

Keywords: *Nitrite, Phosphate, Spectrophotometer, Sulfate, Turbidimetry*

Introduction

The nature and properties of soil are influenced by the type of rocks, their mineral constituents and the nature of weathering. Soil formed from rocks and minerals is rich in nutrients and is usually productive. The soil contaminated with acid rain, use of excess fertilizers, pesticides as well as industrial effluents (Dhakal, 2007). Soil chemistry determines the capability to provide available plant nutrients and health of microbial population affecting its physical properties, stability, corrosive nature, and ability to absorb pollutants. The high specific surface area of colloids and their net charges on them determines the ability to hold and release ions. The nature of ionic charges determines the exchange capacity of the soil and influences its chemical properties (Kharal et al., 2018 and Bajracharya et al., 2007). With the decrease in pH, the capacity for holding anions increases, with rainfall or irrigation the available nitrogen becomes water-soluble and moves through the soil profile (Mussa et al., 2009).

Sixteen elements are essential for plant growth and reproduction such as C, H, O, P, K, S, Ca, Mg, Fe, B, Mn, Cu, Zn, Mo, Ni and Cl. The nutrients adsorbed onto the surface of clay colloids

and soil organic matter provides a more accessibility and acts as reservoir of many plant nutrients (Shanthi and Balasubramanian, 1994). However, N and P are required in appreciable quantities, while requirement of sulfur is less. Sulfur and phosphorous are taken up by plant roots from soil solution as SO_4^{2-}, and $H_2PO_4^-$ respectively. Nitrogen and sulfur deposition from the atmosphere and mineralization (Jalani, 2007). The use of land affects some physiological and biological processes. Unscientific lands of land, deforestation, erosion and improper use of chemical fertilizer have affected a large population depending upon agriculture leading to decease in soil fertility, land degradation and poor soil health (Kharal et al., 2018). The function of specific kinds of soil within natural and managed ecosystem is to sustain plant and animal productivity, maintain water and air quality, and support human health and habitation (Bajracharya et al., 2007). The inorganic anions and cations released from domestic and industrial effluent deteriorate the water quality. Most of the groundwater will be highly polluted and some of the water bodies will be covered by vegetation as a result of eutrophication (Kipngetich et al., 2013).

This study provides the status of available nutrients and fertility of the soil and will help the farmer choose the appropriate crop and need of specific fertilizers to increase agricultural production.

The objective of the study was to estimate nitrite, phosphates and sulfates in the soil of agricultural land.

Methods

Collection of soil samples

Soil samples were collected from ten different sites in Kathmandu valley and western Nepal. These samples were collected at a depth of 15 cm by digging a 15 cm × 15 cm area and were placed in a plastic bag. It was then air-dried under a shade at room temperature (Hooda and Kaur, 1999). The soils were then sieved using a sieve having diameter 2 mm.

Nitrite present in the soil sample

Determination of λ_{max}

0.015% of $NaNO_2$ solutions were prepared as stock solution. Then a series of standard nitrite solutions 0.05 to 0.50 ug/mL were prepared. 1 mL of 0.5% benzidine and 2 mL of 1 M hydrochloric acid solutions were added and the solution was shaken for about 4 minutes to allow the completion of tetrazotization. Then, 1 mL of 0.5% dimethylaniline, 1 mL of 0.5 M sodium hydroxide solutions was added. Then it was diluted to 25 mL using distilled water. The aliquot was then allowed to stand for 10 minutes and the absorbance of the pinkish red coloured dye solution at 10 nm intervals over the range of 450 nm to 700 nm with reference to the corresponding blank reagent and then for the series of standard nitrite solutions were measured by using Spectronic 21D UV/Visible Spectrophotometer and glass cells.

Nitrite determination in soil samples

2.5 g of each soil samples 0.5% solution of sodium hydroxide (1:10) was taken and shaken for an hour and filtered by using Whatmann number 41. The filtrate was made up to the mark in 25 mL standard volumetric flask. The reagents similarly used for the determination of λ_{max} and the absorbance were measured for the different soil samples with reference to the blank reagents. The absorbance of nitrite ion in the soil samples was measured and then estimated using the calibration curve.

Phosphate present in the soil sample

Determination of λ_{max}

0.571% of disodium hydrogen orthophosphate solutions were prepared as stock solution. Then a series of standard phosphate solutions 0.1 ug/mL to 1.0 ug/mL were prepared. In each flask 2.5 mL of sulfuric acid, 2 mL of 0.5% ammonium molybdate and 3 mL of 0.5 M hydrazine hydrate was added, stirred and the volume was made 25 mL by adding distilled water. Each solution was kept at room temperature for 35 minute for the development of bluish color. The absorbance by using Spectronic 21D UV/Visible Spectrophotometer and glass cells at an interval of 10 nm over the range 770 nm to 990 nm with reference to the corresponding blank reagent for the selection of λ_{max} and then for the series of standard phosphate solutions were measured.

Phosphate determination in soil samples

2.5 g of each soil samples 0.5% solution of sodium hydroxide (1:10) was taken and shaken for an hour and filtered by using Whatmann number 41. The obtained filtrate was made up to the mark in 25 mL standard volumetric flask. The reagents were similarly used for the determination of λ_{max} and the absorbance was measured for the different soil samples and for the blank. The absorbance of phosphate ions in the soil samples was measured and then estimated using the calibration curve.

Sulfate present in the soil sample

Determination of λ_{max}

0.071% of sodium sulfate solutions were prepared as stock solution. Then a series of standard phosphate solutions 0.1 ug/mL to 0.5 ug/mL were prepared. In each flask 2.5 mL of sulfate solution, 2.5 mL of conditional reagents, and 0.3 gm $BaCl_2$ crystal was added and stirring for 1 minute. Finally, the solution was poured in silica cell using distilled water as blank reference. The absorbance of the solutions at an interval of 10 nm from 350 nm to 700 nm and then for the series of phosphate solutions were measured by using Spectronic 21D UV/Visible Spectrophotometer and glass cells.

Sulfate determination in soil samples

2.5 g of each soil samples was taken in a 250 mL conical flask and 25 mL of distilled water was added and shaked for 10 minute, was allowed to stand for 30 minutes and was filtered using filter paper Whatmann number 41. To the 2 mL of sample solution 1.2 mL conditional reagents (glycerol in conc. HCl) was added and stirred with about 0.1 gm $BaCl_2$ crystals. The absorbance of a series of standard

sulfate ion solutions was measured at λ_{max} by using Spectrophotometer. The absorbance of sulfate ion in the soil samples was measured and then estimated using the calibration curve.

Results

Estimation of nitrite in the soil samples

Beer's-Lambert's law was verified using the standard nitrite solution having concentration in the range of 0.05-0.50 mgL^{-1} of nitrite. The maximum absorbance (λ_{max}) of nitrite solution was found at 540 nm. Then the absorbance of the series of standard nitrite solutions and different soil solution samples were determined at the wavelength 540 nm. The plots for λ_{max} and a calibration curve of nitrite solutions are shown in the Figure 1 and Figure 2 respectively:
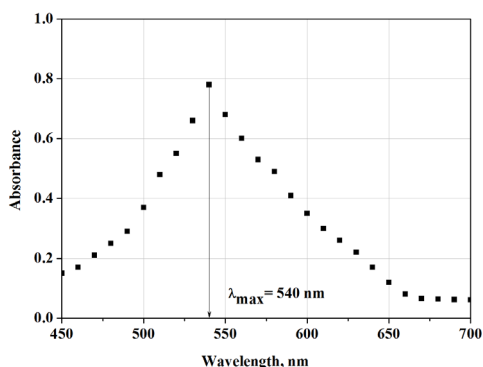

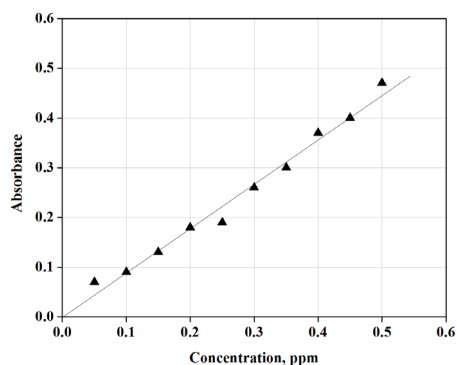**Figure 1:** *Plot of absorbance of NO_2^- ion solution with wavelength.*

Figure 2: *Plot of standard NO_2^- ion solution with absorbance.*

The absorbances of soil sample solutions were measure at the wavelength 540 nm. Using the calibration curve nitrite ion concentration of the soil sample at 10 different places were estimated using the calibration curve of nitrite ion and are shown in the Figure 7.

Estimation of phosphate in the soil samples

The absorbances of the standard phosphate (KH_2PO_4) solution in the range of 0.1-0.9 mgL^{-1} were measured and were plotted against concentration. The plots for λ_{max} and calibration curve of phosphate solutions are shown in the following Figure 3 and Figure 4 respectively:
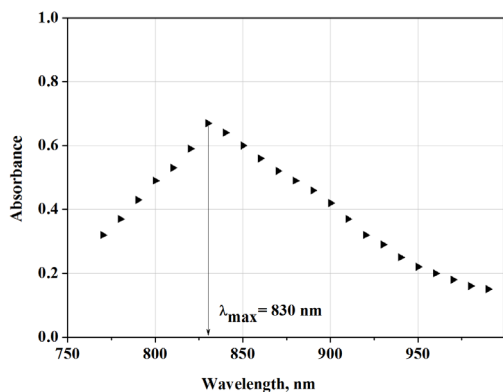
Figure 3: *Plot of absorbance of PO_4^{3-} ion solution with wavelength.*
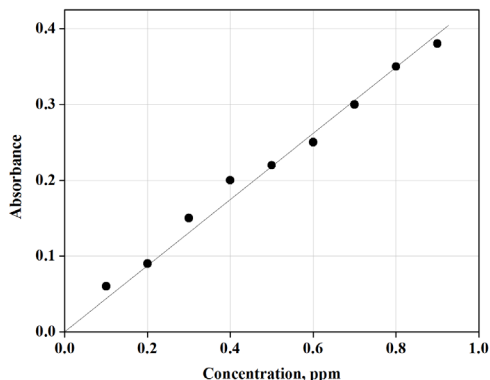

Figure 4: *Plot of standard PO_4^{3-} ion solution with absorbance.*

The plot shows the verification of Beer's-Lambert's law. The maximum absorbance (λ_{max}) of phosphate solution was found at 830 nm. Then the absorbance of the solution of different soil samples was determined at the 830 nm. The absorbances of phosphate ion in the soil samples at 10 different places were measured. The concentrations of PO_4^{3-} ions in soil samples were estimated using the calibration curve shown in the Figure 4.

Estimation of sulfate in the soil samples

Beer's-Lambert's law was verified using the standard sulfate (Na_2SO_4) solution having concentration in the range of 0.05-0.50 mgL^{-1}. The plots for λ_{max} and calibration curve of solution containing sulfate ions are shown in the Figure 5 and Figure 6 respectively:
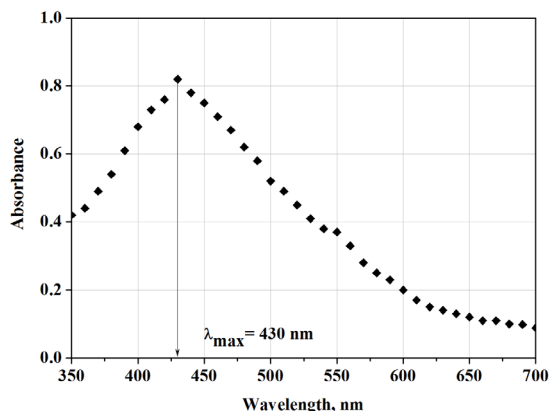

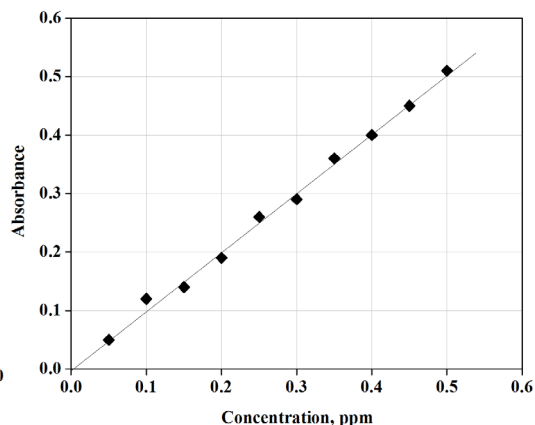**Figure 5:** *Plot of absorbance of SO_4^{2-} ion solution with wavelength.*

Figure 6: *Plot of standard SO_4^{2-} ion solutions with absorbance.*

The maximum absorbance (λ_{max}) of sulfate solution was found at 430 nm. Absorbances of the solution of different soil samples were determined at 430 nm. The absorbances of the soil sample solutions at 10 different places were measured and were estimated using the calibration curve of sulfate ion.

The NO_2^-, PO_4^{3-}, and SO_4^{2-} of soil samples were estimated from the respective calibration curves and are shown in the Figure 7:

Figure 7:

Plot of nitrite, phosphate and sulfate ions concentration in the soil sample at different places.
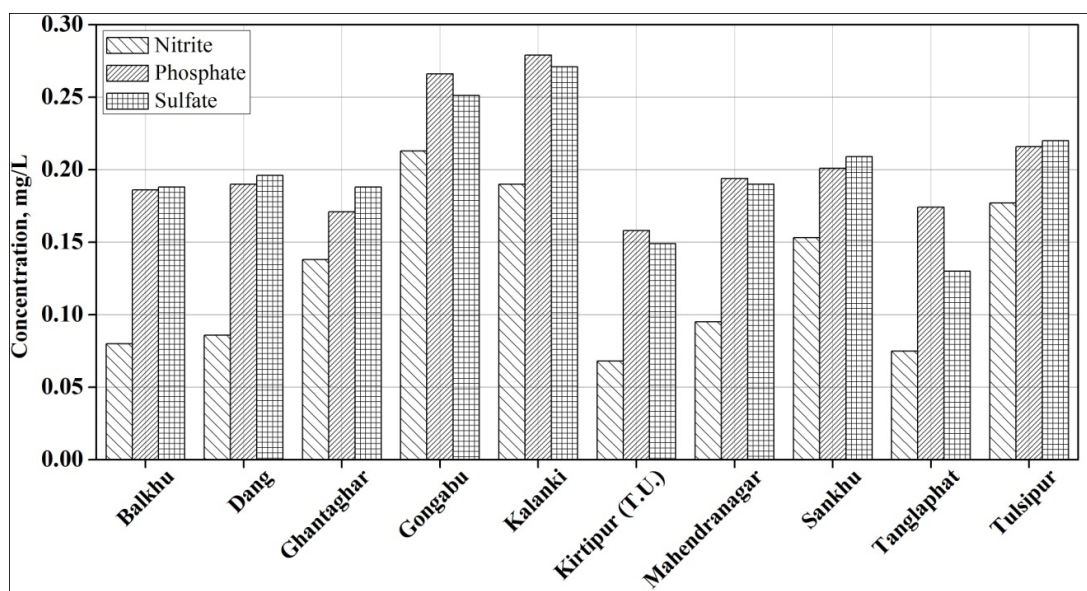
The selected areas are of agricultural significance, nutrient status of the soil is expected to help for local management of soil fertility and multi-crop production.

The minimum value of nitrite, phosphate, and sulfate ions in the soil samples were found to be 0.068, 0.158, 0.130 mgL^{-1} at Kirtipur (T.U.), Kirtipur (T.U.), and Tanglaphat respectively. And maximum value of nitrite, phosphate and sulfate ions in the soil samples were found to be 0.213 mgL^{-1}, 0.279, 0.271 at Gongabu, Kalanki and Kalanki respectively.

Discussion

In soil, NO_2^- ion present in lesser quantity, normally plants use nitrogen in only in the form of ammonium and nitrate ions. The presence of nitrite in soil may be due the biochemical process of nitrogen cycle, biodegradation of nitrate, ammonical nitrogen and nitrogenous fertilizers. Urea is the most widely used solid nitrogen fertilizers. Others are potassium nitrate, ammonium nitrate etc. A deficiency of nitrite shows a lack of vigor as older leaves become yellow due to a lack of chlorophyll. The presence of nitrite even in trace amount in potable water may result in methanoglobimenia, which hinders the transport of oxygen to the cells called blue baby syndrome (Chandrasekhar et al., 2015).

Phosphorous occurs entirely as phosphate in organic and inorganic forms, which are important in plants. Diammonium phosphate, monoammonium phosphate and triple super phosphate are used as a fertilizers as a sources of phosphorous. The deficiency of phosphorous reduces vegetative growth and grain yields. The presence in high concentration of phosphate in soil may be due to the use of fertilizers, agricultural run-off, sewage, paper industry are detergents and is highly susceptible to contaminate the water body. It increases the rates of plant growth which causes eutrophication (Kipngetich et al., 2013).

The presence of sulfate in soil may be from irrigation using untreated waste water, sulfate deposition from the atmosphere, water-soluble salts etc. Organic matter is the major reservoir of sulfur in most soils; all sources of sulfur must be present in the form of sulfate ion. Ammonium sulfate is used by farmers to get best in farming. The initial symptom of sulfur deficiency is yellowing entire leaves including veins, starting with the younger leaves. Leaf tips become yellow and curl downward.

Conclusions

Spectrophotometric analysis of nitrite using benzidine, hydrochloric acid and dimethylaniline to develop a pink-red colored azo dye is an effective method for the inorganic ions determination and was found in the range of 0.068 to 0.213 mg/L. The spectrophotometric analysis of phosphate using ammonium molybdate is an effective method. The phosphate content in the soil sample at different places was found in the range of 0.158 to 0.279 mg/L. The analyses of sulfate ions by turbidimetry method in excess of $BaCl_2$ solution at different places were found in the range of 0.130 to 0.271 mg/L.

Acknoledgements

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