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Determination of Phosphate Content in Agricultural Soil by UV–Visible Spectrophotometric Method

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Abstract: *Phosphorus is an essential macronutrient required for plant growth, soil fertility, and agricultural productivity because it plays an important role in energy transfer reactions, photosynthesis, root development, and nucleic acid synthesis. However, excessive accumulation of phosphate compounds in soil may lead to serious environmental problems such as environmental pollution, eutrophication, and ecological imbalance. Elevated phosphate levels in agricultural soils are commonly associated with excessive fertilizer application, agricultural runoff, contaminated irrigation water, and improper waste disposal. Therefore, continuous monitoring of phosphate concentration in soil is important for sustainable agricultural management and environmental protection.*

The present study focuses on the quantitative determination of phosphate content in agricultural soil samples using UV–Visible spectrophotometric analysis. Soil samples collected from sugarcane, onion, and wheat cultivation fields were analyzed using the ammonium molybdate–stannous chloride colorimetric method. In this method, phosphate ions react with ammonium molybdate under acidic conditions to form a phosphomolybdate complex, which is subsequently reduced by stannous chloride to produce a blue-colored complex. The intensity of the blue color is directly proportional to phosphate concentration and was measured spectrophotometrically at 690 nm.

Standard phosphate solutions in the concentration range of 0.5–3.0 mg/L were prepared for calibration curve construction, and the calibration graph exhibited good linearity between absorbance and phosphate concentration according to Beer–Lambert's law. Among the analyzed soil samples, sugarcane farm soil collected from Pune showed the highest phosphate concentration (0.029 mg/L), whereas wheat farm soil exhibited the lowest phosphate concentration (0.007 mg/L). The comparatively higher phosphate concentration observed in sugarcane soil may be attributed to intensive fertilizer application, agricultural runoff, and contaminated irrigation practices.

The study confirms that UV–Visible spectrophotometry is a simple, sensitive, economical, and reliable analytical technique for phosphate determination in soil samples. Continuous monitoring of phosphate levels is essential for maintaining soil fertility, preventing environmental pollution, and promoting sustainable agricultural and ecological management.

Keywords: determination of phosphate content in agricultural soil by uv–visible spectrophotometric method

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I. INTRODUCTION

Soil is one of the most important and valuable natural resources on Earth because it supports life and maintains ecological balance. It acts as a medium for plant growth, a reservoir of essential nutrients, a storage system for water, and a habitat for numerous microorganisms. Soil is a highly complex and dynamic environmental system composed of mineral matter, organic matter, water, air, and living organisms. The interaction among these components determines soil fertility, agricultural productivity, and environmental quality. Healthy soil is essential for sustainable agriculture, food production, and maintenance of ecosystem stability.

Among the various nutrients present in soil, phosphorus is one of the essential macronutrients required for normal plant growth and development. Phosphorus plays a significant role in several biochemical and physiological processes including photosynthesis, energy transfer reactions, ATP synthesis, nucleic acid formation, root development, flowering, and seed formation. In nature, phosphorus mainly occurs in the form of phosphate compounds because elemental phosphorus is highly reactive and does not exist freely. Phosphate ions strongly adsorb onto soil particles, thereby influencing nutrient availability and soil chemistry.

Although phosphate is essential for agricultural productivity, excessive accumulation of phosphate compounds in soil and water can create serious environmental problems. Phosphate contamination may arise from both natural and anthropogenic sources. Natural sources include weathering of phosphate-containing rocks and decomposition of organic matter, whereas anthropogenic sources mainly involve chemical fertilizers, agricultural runoff, sewage contamination, domestic waste disposal, human and animal excreta, and industrial discharge. Excessive use of phosphate fertilizers in agriculture significantly contributes to phosphate accumulation in soil and nearby water bodies.

One of the major environmental problems associated with excessive phosphate concentration is eutrophication. When phosphate-rich runoff enters lakes, rivers, and other water bodies, it promotes excessive algal growth and aquatic plant proliferation. This process leads to depletion of dissolved oxygen concentration in water, resulting in fish mortality, water pollution, unpleasant odor, and ecological imbalance. Therefore, continuous monitoring of phosphate concentration in agricultural soils is essential for environmental protection, sustainable farming, and proper nutrient management.

The present study focuses on the determination of phosphate concentration in agricultural soil samples using UV–Visible spectrophotometric analysis. The major objectives of the study include determination of phosphate concentration in different agricultural soil samples, analysis of phosphate contamination using spectrophotometric techniques, comparison of phosphate levels among different soil types, study of fertilizer application effects on phosphate accumulation, and evaluation of environmental implications associated with excessive phosphate concentration.

UV–Visible spectrophotometry is one of the most widely used analytical techniques for phosphate determination because of its simplicity, sensitivity, accuracy, rapid analysis, and cost-effectiveness. Spectrophotometry measures the absorption of electromagnetic radiation by chemical substances. In phosphate analysis, phosphate ions react with ammonium molybdate and stannous chloride to form a blue-colored phosphomolybdate complex. The intensity of the blue color is directly proportional to phosphate concentration according to

where (A) represents absorbance, is molar absorptivity, (b) is the path length, and (c) is the concentration of the solution. The maximum absorbance of the phosphomolybdate complex was observed at 690 nm, which was used for quantitative phosphate determination in the present investigation.

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II. MATERIALS AND METHODS

Agricultural soil samples collected from different cultivation fields were used for phosphate analysis. The soil samples included sugarcane soil from Pune (S1), sugarcane soil from Satara (S2), onion soil from Pune (S3), and wheat soil from Pune (S4). These samples were selected to compare phosphate concentration levels among different agricultural soils subjected to varying fertilizer application and cultivation practices.

Various analytical grade chemicals were used during the experimental work, including sulphuric acid (0.002 N), perchloric acid (70%), sodium hydroxide solution (1 N), ammonium molybdate solution, stannous chloride solution, potassium dihydrogen phosphate, and phenolphthalein indicator. Potassium dihydrogen phosphate was used for preparation of standard phosphate solutions required for calibration curve construction.

The experimental analysis was carried out using a UV–Visible spectrophotometer for absorbance measurements. Laboratory glassware and apparatus such as volumetric flasks, conical flasks, pipettes, burettes, and Whatman No. 50 filter paper were also used during sample preparation, filtration, reagent preparation, and spectrophotometric analysis.

Ammonium molybdate solution was prepared by dissolving ammonium molybdate in distilled water followed by mixing with dilute sulphuric acid solution. Stannous chloride solution was prepared by dissolving stannous chloride in concentrated hydrochloric acid and subsequently diluting the solution with distilled water. Standard phosphate solution was prepared using potassium dihydrogen phosphate (KH_2PO_4), which served as the reference standard for quantitative phosphate determination and calibration graph preparation.

III. EXPERIMENTAL PROCEDURE

The phosphate content in agricultural soil samples was determined through a series of extraction, digestion, and spectrophotometric analysis steps. Initially, 1 g of air-dried soil sample was accurately weighed and transferred into a flask, followed by the addition of 200 mL sulphuric acid solution. The mixture was shaken continuously for about 30 minutes to facilitate extraction of phosphate compounds from the soil matrix. The resulting suspension was then filtered using Whatman filter paper to obtain a clear filtrate for further analysis.

A measured volume of 25 mL filtrate was evaporated to dryness, and the obtained residue was dissolved in perchloric acid for digestion of phosphate-containing compounds. After digestion, phenolphthalein indicator was added to the solution, and neutralization was carried out by titration using sodium hydroxide solution. Subsequently, ammonium molybdate reagent and stannous chloride solution were added to the reaction mixture, resulting in the formation of a characteristic blue-colored phosphomolybdate complex.

The intensity of the developed blue color was measured spectrophotometrically at 690 nm using a UV–Visible spectrophotometer. Distilled water was used as the blank solution during absorbance measurements. The absorbance values obtained were compared with the calibration curve prepared using standard phosphate solutions to determine phosphate concentration in the analyzed soil samples.

IV. OBSERVATION TABLE

STANDARD CALIBRATION DATA

Concentration (mg/L)	Absorbance
0.00	0.000
0.50	0.230
1.00	0.386
1.50	0.580

2.00	0.759
2.50	0.831
3.00	1.172

CALIBRATION CURVE

- A linear relationship observed between absorbance and concentration.
- Beer–Lambert's law successfully obeyed.

ABSORBANCE OF SOIL SAMPLES

Soil Sample	Absorbance
Sugarcane (Pune)	1.169
Sugarcane (Satara)	0.980
Onion (Pune)	0.632
Wheat (Pune)	0.285

FINAL PHOSPHATE CONCENTRATION

Soil Sample	Phosphate Content
Sugarcane (Pune)	0.029 mg/L
Sugarcane (Satara)	0.024 mg/L
Onion (Pune)	0.015 mg/L
Wheat (Pune)	0.007 mg/L

IV. RESULTS AND DISCUSSION

The phosphate analysis of agricultural soil samples revealed significant variation in phosphate concentration among different cultivation fields. Sugarcane soil samples exhibited the highest phosphate concentration among the analyzed samples. The elevated phosphate level observed in sugarcane soil may be attributed to intensive fertilizer application, contaminated irrigation water, and high nutrient accumulation resulting from continuous agricultural practices. In contrast, wheat soil samples showed the lowest phosphate concentration, which may be due to comparatively lower fertilizer usage, shorter crop cycle, and reduced nutrient accumulation in the soil.

The results indicate that excessive application of phosphate-containing fertilizers significantly increases phosphate accumulation in agricultural soils. Continuous fertilizer usage not only alters soil chemistry but also contributes to environmental pollution through phosphate runoff and nutrient imbalance. Excess phosphate present in soil can easily enter nearby water bodies through agricultural runoff, thereby increasing the risk of eutrophication and environmental degradation.

High phosphate concentrations in soil and water may contaminate surrounding aquatic systems, accelerate eutrophication, reduce water quality, and disturb aquatic ecosystems. Excessive phosphate availability promotes abnormal algal growth, leading to dissolved oxygen depletion and ecological imbalance in water bodies. Therefore, regular monitoring of phosphate concentration in agricultural soils is essential for environmental protection and sustainable nutrient management.

The UV–Visible spectrophotometric method used in the present study demonstrated excellent analytical performance, including good sensitivity, excellent linearity, high precision, rapid analysis, and reproducibility. The method proved to be highly suitable for quantitative phosphate determination in soil samples. In addition, the spectrophotometric method

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offers several analytical advantages such as simple experimental procedure, rapid analysis, cost-effectiveness, high sensitivity, and good accuracy. Environmental advantages of the method include minimal chemical consumption, reduced waste generation, and suitability for routine environmental monitoring.

V. CONCLUSION

The present study successfully determined phosphate content in agricultural soil samples using UV–Visible spectrophotometric analysis. The ammonium molybdate–stannous chloride colorimetric method proved to be simple, accurate, sensitive, and reliable for phosphate estimation. Among the analyzed samples, sugarcane soils exhibited comparatively higher phosphate concentration than onion and wheat soils, indicating the influence of intensive fertilizer application and irrigation practices on phosphate accumulation.

The study highlights the importance of continuous phosphate monitoring for effective soil fertility management, environmental protection, and sustainable agricultural practices. The results also demonstrate that UV–Visible spectrophotometric analysis is highly suitable for routine phosphate determination in environmental and agricultural samples because of its simplicity, sensitivity, rapidity, and economical nature.

Future Scope

Future research in this field may focus on seasonal variation studies of phosphate concentration in agricultural soils and water bodies. Additional investigations may include heavy metal contamination studies, groundwater pollution assessment, GIS-based soil nutrient mapping, and application of advanced analytical techniques such as ICP-MS and ion chromatography for more precise environmental analysis and monitoring.

REFERENCES

1. Weier TE, Stocking CR, Barbour MG. *An Introduction to Plant Biology*. 5th ed. University of California; 1973.
2. Van Loon GW, Duffy SJ. *Environmental Chemistry: A Global Perspective*. 2nd ed.; 2005.
3. Radojevic M, Bashkin VN. *Practical Environmental Analysis*. Royal Society of Chemistry; 1999.
4. Daji JA. *A Textbook of Soil Science*. Asia Publishing House; 1970.
5. Chapman HD, Pratt PF. *Methods of Analysis for Soil, Plant and Water*. 1996.
6. Murphy J, Riley JP. A modified single solution method for determination of phosphate. *Anal Chim Acta*. 1962.
7. Brady NC, Weil RR. *The Nature and Properties of Soils*. 14th ed.; 2008.
8. Sharpley AN, et al. Phosphorus transport in agricultural runoff. *J Environ Qual*. 2001.
9. Carpenter SR, et al. Nonpoint pollution of surface waters. *Ecol Appl*. 1998.
10. Vogel AI. *Textbook of Quantitative Chemical Analysis*. 5th ed.; 1991.

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