Evaluation Of Soil Quality And Heavy Metal Contaminants In Agricultural Soils

K. Chitra[1], G.B. Kamala[2]

[1]**Bharathiar University, Coimbatore, Tamilnadu, India**

[2]**Bharathiar University, Coimbatore, Tamilnadu, India**

[1]**drkchitraa@gmail.com** , [2]**aishugokul325@gmail.com**

Abstract

Agriculture is an important and significant sector in all the countries. Soil serves as a natural medium for the growth of the plants. Agricultural soil should be periodically tested for the improvement of crops. Soil physicochemical properties indicates the soil nutrient content and characteristics. The physicochemical parameters and heavy metal contamination in different agricultural soils of Coimbatore were analyzed. Soil samples were collected at the depth of 15 cm from five agricultural field. Soil samples were analyzed for physicochemical parameters and heavy metal contamination in the laboratory using standard protocols. Different agricultural soil samples were analyzed for parameters like pH, electrical conductivity (EC), TDS and salinity. Macronutrients nitrogen, phosphorus and potassium were estimated. Micronutrients like sodium and potassium also estimated for all the samples. Heavy metals like nickel, cadmium, lead, zinc, copper and manganese were estimated to check contamination status. The results stated that, all the soil samples were acidic in nature. Paddy cultivated soil was slightly alkaline in nature. All the soil samples were non-saline. Micro and macro nutrients were present in optimum level in all the soil samples. Heavy metals were present within their threshold limit and permissible limit. The study concluded that soil physicochemical parameters and heavy metal concentrations varied in five agricultural soils. Soils are good in their physicochemical parameters. This study indicates the quality of agricultural soil and it is useful to farmers regarding the nutritional and contamination status.

Key words: *Agriculture, physicochemical parameters, nutrients, heavy metal contamination, soil quality.*

Introduction:

Soil is the thin layer of earth's crust. Genetic and environmental factors influences the unconsolidated mineral matter which are present in soil [1]. In nature, soil is one of the valuable and important resource. Solar radiation is the main sources of soil temperature.Soil temperature alters decomposition of organic matter and also mineralization of different organic matter in soil. Ideal soil temperature is 18-24°C. Soil is considered as the most significant ecological factor. Plants depends on this ecological factor for their nutrients, water and mineral supply [2]. The capacity of soil to supply mineral nutrients based on the analysis of physicochemical parameters [3]. Soil macronutrients and sulfur controls the soil fertility and yield of crops [4].

Agriculture is the backbone of many countries. Soil quality determines the yield of agricultural production. Soil quality depends on physicochemical parameters and nutrient content [5]. Soil parameters express the quality of soil. Soil pH influences the available nutrient balance in

(*K.Chitra)

soil. Electrical conductivity of the soil serve as a measurement of soluble nutrients and it is correlated with the mineralization of organic matter in soil [6, 7].

In the environment, soil is polluted in number of ways. To preserve soil fertility and increase crop productivity, there is an urgency in controlling the soil pollution. Application of pesticide, sewage sludge amendment and other human activities leads to the exposure of terrestrial environment to hazardous substance [8]. In agricultural ecosystems, soil is the most important basic natural resource. Soil supports agricultural production systems [9]. In these ecosystems agricultural productivity depends on their physicochemical and biological characteristics [10, 11]. Environmental variations cause changes in soil parameters [12].

Anthropogenic activities like mining, changes in the use of soils and the use of agrochemicals in conventional agriculture have some impact on soil. They have altered physicochemical properties of soil, decreases in edaphic populations and increases in concentrations of some pollutants [13]. Agricultural production systems are a source of pollutants. Physicochemical characteristics of the soil facilitate pollutants transfer through soil-plant, soil-groundwater and surface-soil water [14].

Heavy metals and pesticides are the pollutants in agricultural soils [15]. Naturally heavy metals are present in small quantities or traces in the Earth's crust, soils and plants.

The natural concentrations of heavy metals can be affected by the implementation of chemical fertilizers and pesticides, manures and conventional solid waste compost [16, 17]. In edaphic systems, use of synthetic products such as fertilizers and pesticides are an important source of pollutants [18, 19].

Heavy metals and metalloids contaminate the soil by the emission from the industrial areas, mine tailings, high metal wastes disposal, leaded gasoline and paints, application of fertilizers to agricultural areas, animal manure, sewage sludge, application of pesticides, wastewater irrigation, coal combustion residues, spillage of petrochemicals and atmospheric deposition [20, 21]. Soil analysis is the only way to determine the physicochemical parameters and available nutrients in soil. Through soil testing only we can suggest specific fertilizer recommendations to the farmers.

Materials and methods:

Sample Collection:

The field was divided into different agriculture homogenous units based on the visual observation. The surface litter and waste was removed at the sampling spot. The auger was driven to plough depth of 15 cm and draw the soil sample. Each soil sample was collected from each sampling unit and placed in polythene bags. The total soil samples collected from five different agriculture lands, and they were named as soil sample A, B, C, D, and E respectively.

Details of collected soil samples and study area:

- ✓ *Solanum melongena* L.
- ✓ *Ablemoschus esculentus* L. Moench
- ✓ *Oryza sativa* L.
- ✓ *Curcuma longa* L.
- ✓ *Zea mays* L.

The soil samples Zea mays L. and Curcuma longa L. were collected from Thondamuthur and Oryza sativa L., Ablemoschus esculentus L. Moench, Solanum melongena L. collected from Boluvampatti, Coimbatore District.

Results and Discussion:

Physicochemical characteristics of agricultural soils:

(*K.Chitra)

Soil temperature was 12.11°C, moisture was 8.1. Soil pH optimum range is 5.8 to 6.5 the observed value of pH was (6.87). EC was (79.7). The soil was non-saline. TDS was (51.9 ppm), and salinity was (60.3 ppm). The estimated nitrogen value was (134 kg ha^{-1}), the phosphorus value was (26 kg ha^{-1}) and potassium value was (311kg ha^{-1}). The nitrogen value was within the optimum level (75-300 kg ha^{-1}). But phosphorus was below the optimum level (30-224 kg ha^{-1}). Potassium was present in higher amounts (0-80 kg ha^{-1}) [22]. The observed sodium value was (36.9 ppm), for calcium (90.5 ppm).

Soil temperature was 10.6°C, moisture was 8.5. Soil pH optimum range is 6-6.8 (ICAR- CCARI). The observed value of pH was (6.79). EC was (81.1), TDS was (53.5 ppm), and salinity was (61.6 ppm). The estimated nitrogen value was (116 kg ha^{-1}), the phosphorus value was (16 kg ha^{-1}) and potassium value was (194 kg ha^{-1}). The nitrogen value was just above the optimum level (100 kg). But phosphorus was below the optimum level (60 kg). Potassium was present in higher amounts (50 kg). The observed sodium value was (36.6 ppm), for calcium (56.1 ppm).

Soil temperature was 7.7°C, moisture was 28. Paddy grown well in acidic soil ranges from (6.0 – 7.0), because microbial activity was higher in this acidic soil. pH was observed as 7.3. Nitrogen and phosphorus were more available in this soil [23]. The soil EC was (83.0),TDS was (54.5 ppm),and salinity was (62.5 ppm). The prescribed value of available phosphorus is > 30 kg/ha. Phosphorus in the soil sample was 26 kg/ha. Phosphorus content was normal or optimum in paddy soil. Available potassium in soil was 311 kg/ha. The permissible limit of potassium in paddy soil is > 305 kg/ha is better for cultivation of paddy. Potassium value was slightly higher in soil samples. The observed sodium value was (36.9 ppm), for calcium (90.5 ppm).

Soil temperature was 9.01°C, moisture was 13. Soil pH optimum range is 5.8 and 6.5 the observed value of pH was (7.23). EC was (83.8), TDS was (056.7 ppm), and salinity was (066.2 ppm). The estimated nitrogen value was (170 kg ha^{-1}), the phosphorus value was (18 kg ha^{-1}) and potassium value was (240 kg ha^{-1}). The nitrogen value was within the optimum level (75-300 kg ha^{-1}). But phosphorus was below the optimum level (30-224 kg ha^{-1}). Potassium was present in higher amounts (0-80 kg ha^{-1}). The observed sodium value was (36.9 ppm), for calcium (92.7) ppm.

Soil temperature was 6.90°C, moisture was 14.7. Soil pH optimum range is 5.8 and 6.5 the observed value of pH was (6.74). EC was (094.7), TDS was (051.9 ppm), and salinity was (071.4 ppm). The estimated nitrogen value was (124 kg ha^{-1}), the phosphorus value was (9 kg ha^{-1}) and potassium value was (117kg ha^{-1}). The nitrogen value was within the optimum level (75-300 kg ha^{-1}). But phosphorus was below the optimum level (30-224 kg ha^{-1}). Potassium was present in higher amounts (0-80 kg ha^{-1}). The observed sodium value was (36.9 ppm), for calcium (88.8 ppm).

Soil temperature is mainly affected by variations in air temperature and solar radiation [24]. Soil temperature determined by the amount of radiation received by the soil. Soil temperature influences the biological processes such as seed germination, seedling emergence, plant root growth and availability of nutrients in soil [25].

Heavy metals in agricultural soils

In brinjal cultivated soil nickel, cadmium, lead, zinc, copper and manganese concentration was estimated as 3.01 mg kg^{-1}, 0.25 mg kg^{-1}, 35.06 mg kg^{-1}, 3.81 mg kg^{-1}, 10.18 mg kg^{-1}, and 3.89 mg kg^{-1} respectively. In okra cultivated soil nickel, cadmium, lead, zinc, copper and manganese concentration was estimated as 4.22 mg kg^{-1}, 0.22 mg kg^{-1}, 42.21mg kg^{-1}, 2.87 mg kg^{-1}, 8.91 mg kg^{-1}, and 3.84 mg kg^{-1} respectively. In paddy cultivated soil nickel, cadmium, lead, zinc, copper and manganese concentration was estimated as 2.85 mg kg^{-1}, 0.21 mg kg^{-1}, 45.80 mg kg^{-1}, 3.02 mg kg^{-1}, 14.22 mg kg^{-1}, and 3.25 mg kg^{-1} respectively. In turmeric cultivated soil nickel, cadmium, lead, zinc, copper and manganese concentration was estimated as 3.83 mg kg^{-1}, 0.14 mg kg^{-1}, 47.60 mg kg^{-1},

(*K.Chitra)

3.12 mg kg^{-1}, 14.95 mg kg^{-1}, and 2.25 mg kg^{-1} respectively. In corn cultivated soil nickel, cadmium, lead, zinc, copper and manganese concentration was estimated as 3.84 mg kg^{-1}, 0.12 mg kg^{-1}, 48.80 mg kg^{-1}, 2.94 mg kg^{-1}, 12.70 mg kg^{-1}, and 2.70 mg kg^{-1} respectively [26].

Conclusion:

All the agricultural soils have nearly ideal soil temperature and moisture. They were good in their physicochemical parameters and nutrient content. Four agricultural soils were acidic in nature and paddy soil is slightly alkaline in nature. They are non-saline. Nutrient content was present in appropriate level in all the soil samples. In heavy metals, lead was present in higher amount and cadmium was present in lower amount in all the agricultural soils. Sodium level was low in all the agricultural soil samples and calcium level was very low in all the agricultural soil samples. So all the agricultural soils are good for agricultural production and they are not contaminated with heavy metals. But farmers should concentrate on the sources of accumulation of lead in their soils. In future it will become more available in agricultural soils. So farmers should take necessary action to check the accumulation of lead in agricultural soils.

Acknowledgement:

The authors greatly acknowledge financial support from the DST-FIST and UGC-SAP grants to carry out this research work in the Department of Botany, Bharathiar University, Coimbatore, Tamilnadu, India.

References:

1. *Manimegalai, K. and Sukanya, S. (**2014**). Assessment of physicochemical parameters of soil of MuthannanKulam wetland, Coimbatore, Tamilnadu, India. International Journal of Applied Sciences & Biotechnology 2(3):302-04.*
2. *Shaikh, P.R. and Bhosle, B. (**2013**). Heavy metal contamination in soils near Siddheshwar Dam Maharashtra, India. Research Journal of Chemical Sciences 3(1):6–9*
3. *Ganorkar, R.P. and Chinchmalatpure, P.G. (**2013**). Physicochemical assessment of soil in Rajura Bazar in Amravati district of Maharastra (India). International Journal of Chemical, Environmental and Pharmaceutical Research 4(2&3): 46-49.*
4. *Singh, R.P. and Mishra, S.K. (**2012**). Available macronutrients (N, P, K and S) in the soils of Chiraigaon block of district Varanasi in relation to soil characteristics. Indian Journal of Scientific Research 3(1): 97-100.*
5. *Njoyim, E.B.T., Mvondo-Zé, A.D., Mofor, N.A. and Onana, A.A. (**2016**). Phosphorus adsorption isotherms in relation to soil characteristics of some selected volcanic affected soils of Foumbot in the West Region of Cameroon. International Journal of Soil Science, 11: 19-28.*
6. *Ingole, S.P. (**2015**). A Review on Role of Physico-Chemical Properties in Soil Quality. Int. J. Chem. Stud. 3:29-32.*
7. *Sde, N., Jvande, S., Hartmann, R. and Hofman, G. (**2000**). Using time domain reflectometry for monitoring mineralization of nitrogen from soil organic matter. Eur. J. Soil Sci. 51:295-304.*
8. *Muhammad Aqeel Ashraf, Mohd. Jamil Maah and Ismail Yusoff, Chapter - Soil Contamination, Risk Assessment and Remediation, 2014, Book - Environmental Risk Assessment of Soil Contamination, DOI: 10.5772/57287*
9. *S. De Alba, D. Torri, L. Borselli, M. Lindstrom, Degradación del suelo y modificación de los paisajesagrícolas por erosiónmecánica (Tillage erosion)J. Soil Sci., 10 (3) (**2003**), pp. 93-101,View Record in Scopus Google Scholar*
10. *Y. García, W. Ramírez, S. SánchezIndicadores de la calidad de los suelos: una nuevamanera de evaluaresterecursoPastosForrajes, 35 (2) (**2012**), pp. 125-138, View Record in Scopus Google Scholar*
11. *E.A. Martínez-Mera, A.C. Torregroza-Espinosa, A. Valencia-García, L. Rojas-Gerónimo Distribution of nitrogen fixing bacterial isolates and its relationship to the physicochemical characteristics of southern agricultural soils of the Atlántico department, Colombia Soil Environ., 36 (2) (**2017**), pp. 174-181, View Record in Scopus Google Scholar*
12. *W. Jiao, W. Chen, A.C. Chang, A.L. Page, Environmental risks of trace elements associated with long-term phosphate fertilizer applications: a review Environ. Pollut., 168 (**2012**), pp. 44-53, View Record in Scopus Google Scholar*

(*K.Chitra)

13. *M. Jaurixje, D. Torres, B. Mendoza, M. Henríquez, J. Contreras, Propiedadesfísicas y químicas del suelo y surelación con la actividadbiológica bajo diferentesmanejosen la zona de Quíbor, Estado Lara, Bioagro, 25 (1) (**2013**), pp. 47-56*
14. *A .Kabata-Pendias, Trace Elements in Soils and Plants(fourth ed.), CRC, Press, Boca Ratón, FL, USA (**2011**), p. 505p Google Scholar*
15. *M. Marković, C. Cupać, R. Đurović, J. Milinović, P. Kljajić, Assessment of heavy metal and pesticide levels in soil and plant products from agricultural area of Belgrade, Serbia, Arch. Environ. Contam. Toxicol., 58 (2) (**2010**), pp. 341-351, Cross RefView Record in Scopus Google Scholar*
16. *G. Wu, J.Y. Wu, H.B. Shao, Hazardous heavy metal distribution in dahuofang catchment, fushun, liaoning, an important industry city in China: a case study, Clean. - Soil, Air, Water, 40 (12) (**2012**), pp. 1372-1375, Cross RefView Record in Scopus Google Scholar*
17. *B.J. Alloway, Sources of heavy metals and metalloids in soils Heavy metals in soils B.J. Alloway (Ed.), Trace Metals and Metalloids in Soils and Their Bioavailability (third ed.), Springer (**2013**), pp. 11-50*
18. *G. Rueda-Saá, J.A. Rodríguez-Victoria, R. Madriñán-Molina, Methods for establishing baseline values for heavy metals in agricultural soils:prospects for Colombia AcAg, 60 (3) (**2011**), pp. 203-218, View Record in Scopus Google Scholar*
19. *Jiao, W., Chen, W., Chang, A.C., Page, A.L. (**2012**). Environmental risks of trace elements associated with long-term phosphate fertilizer applications: a review. Environ. Pollut., 168, 44-53. https://doi.org/10.1016/j.envpol.2012.03.052.*
20. *S. Khan, Q. Cao, Y. M. Zheng, Y. Z. Huang, and Y. G. Zhu, "Health risks of heavy metals in contaminated soils and food crops irrigated with wastewater in Beijing, China," Environmental Pollution, vol. 152, no. 3, pp. 686–692, (**2008**).View at: Publisher Site | Google Scholar*
21. *M. K. Zhang, Z. Y. Liu, and H. Wang, "Use of single extraction methods to predict bioavailability of heavy metals in polluted soils to rice," Communications in Soil Science and Plant Analysis, vol. 41, no. 7, pp. 820–831,(**2010**).View at: Publisher Site | Google Scholar*
22. *Sat Pal Sharma and J. S. Brar, (**2008**), NUTRITIONAL REQUIREMENTS OF BRINJAL (SOLANUM MELONGENA L.) - A REVIEW, Agric. Rev., 29 (2):79 – 88.*
23. *Shanmuganathan M, Rajendran A, (**2018**). Soil Fertility Analysis for the Cultivation of Sugarcane and Rice in Thiruvarur Area. Curr Agri Res; 6(3).*
24. *Wu J, Nofziger DL. Incorporating temperature effects on pesticide dug radiation into a management model. J environment Quali. (**1999**); 28:92–100.*
25. *Probert RJ. The role of temperature in the regulation of seed dormancy and germination. In Fenner editor. Seeds: the ecology of regeneration in plant communities. England: CABI publishing; (**2000**). p. 261–292.*
26. *T.A.Adagunodo[a]L.A.Sunmonu[b]M.E.Emetere[a], Heavy metals' data in soils for agricultural activities, Data in Brief, Volume 18, June (**2018**), Pages 1847-185*

(*K.Chitra)