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Estimation of Metal Ions in Various Soil Samples in Relation to Crop Production (Wheat, Mustard, Barley) at Different Region of Dehradun India

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Abstract

Metals in the form of salts or as such have a profound effect on development and growth of crops. Various soil samples at different regions of Dehradun (India) have been analysed analytically for the concentration of various metal ions in relation to the growth and development of wheat, mustard and barley. The various metal ions have been found in a good concentration range at which the concerned crops could show maximum growth and development. The concentration of various salts like phosphate ion as determined spectrophotometrically was found to be in between 0.732 to 1.610, for NO_3^- the concentration was found in between 0.210 to 0.998 mg/kg, and the concentration of NO_2^{2-} was found to be 0.138 to 0.475 mg/kg. The metal ions were determined analytically and the concentration of various metals like Pb^{2+} was found in the range of 0.101 - 0.265 mg/kg, Zn in the range of 0.047 – 0.175 mg/kg, Cu in the range of 0.015 – 0.101 mg/kg and the concentration of Fe was found in the range of 0.120 – 0.462 mg/kg. Na, K, Li and Ba were analysed by flame-photometry and the concentration of Na was found in the range 0.10- 0.47 ppm, K in the range of 0.70 – 2.4 ppm, Li 0.00 – 0.01 ppm and the Ba in the range of 0.00 – 0.03 ppm. Also the data reveals the distributions of heavy metals in the agricultural land of the concerned region and can be used to estimate the risks associated with the consumption of crops grown on such soils. So the soil samples which have been examined can be opted for the production of various crops as the soil samples show a good quality and quantity of various mineral ions. The Dehradun in total bears a good range of forests and soil is rich of various types of mineral salts so could be used for the growth of multiple crops.

Keywords: Metal Ions, Wheat, Mustard, Barley, Flame-photometry, Analytical

1 Introduction

Environment is sum total of surroundings within which humans exist. The environment is made up of: the land, the water and the atmosphere of the earth; microorganisms, plant and animal life. The combination of the items on this list and the interrelationships among and between them, the physical, chemical, aesthetic and cultural properties and conditions of the foregoing that influence the human health and well-being does come under the study of environment. The environment is also characterised by the number of spheres that influence its behavior and intrinsic value, among which the most important sphere is biosphere because it harbours the living organisms. This is the sphere where you find living organisms (plants and animals) interacting with each and their nonliving environment (soil, air and water).

Metals in both in aquatic and terrestrial environment are important for the growth and development of all types of plants (1, 2 & 3). However, at some locations the soil gets contaminated with various non-essential metals by humans (4). The toxic concentration of various heavy metals is not confirmed in various soils, but land disposal of wastes in the soil effects the crop production due accumulation of heavy metals (5, 6). Livestock manure is a good organic fertilizer that contains all types of nutrients such as amino acids, nucleic acids, sugars, and vitamins, in addition is a good source of organic matter, nitrogen, phosphorus, potassium, and some micronutrients (1, 7). The soil fertility can be increased by recycling of livestock manure which leads to increase in the productivity of crops (2, 8) by improving the soil properties (9), enhancing the ability of nutrients and their retention (10), and by step to step improvement in the soil nutrients (11), which also leads to the availability of manure to plants (12).

Presently the agricultural system the use of manures has attracted more attention for its sustainable development (13). Researchers have mentioned that together use of organic manure and chemical fertilizers could have more results for combating nutrient depletion and for crop production (14). Jiang et al. (15) mentioned that direct application of manure increases the crop

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production as well as improves the quality of the soil. Abbasi and Tahir (16) demonstrated that farmyard manure/poultry manure and also organic substrates either singly or in combined manner with other inorganic fertilizers shows more pronounced effects on wheat and barley production. Long-term use of organic fertilizers using manure or manure plus NPK fertilizer considerably increases the soil carbon content, inorganic nitrogen and sulphur content (17), and available P levels (11). The availability of Zn, Fe, and Mn in the soil has been found to increase the absorption of organic matter significantly (18). As per reports, the presence of PO_4^{2-}, $H_2PO_4^-$, or HPO_4^{2-} anions in soil solutions leads to the precipitation of $Zn_3(PO_4)_2$ with Zn ions, thereby immobilizing Zn and decreasing the zinc content in the soil with increasing manure application (13,16). Ju et al. (19) showed that the average Cd concentration in soils where vegetables are grown was found 2.8 times higher than in soils where wheat-maize are grown in rotations which occurs mainly due to the excessive application of fertilizers and manures during greenhouse vegetable production in northeast China. Rezig et al. (17) showed that the recycling of carbon containing minerals, mostly bio-solids (e.g., livestock manures), should be conducted carefully in order to avoid the accumulation of toxic elements. Dong et al. (20) stated that manure are the main source of Cu, Zn, Cd, Ni, Pb, and Cr in a wheat-maize field soils in north China, where the composition accounts for about 86.1%, 83.8%, 76.6%, 72.5%, 64.3%, and 46.3% of the total external input for these heavy metals, respectively.

2 Materials and Methods

2.1 Study area and Soil Sampling

The soil samples for the analysis of various metal ions were collected from two outer regions of Dehradun (ISBT Region and Sahasthdhara Region) in which different sites were taken into consideration. Sites from ISBT region include - ISBT Main, Chanderbani, GMS Road, Azad Colony, Kandoli, Lalpull, and sites from Sahasthdhara Region include - Kulhan, Tehrigaon, T. Colony, Gujrara, Danda, Mandi) (Figure 1). The soil samples were collected in the morning time in air tight bottles in desiccators under normal room temperature conditions.

2.2 Soil Sample Preparation

The Soil samples were dried at 50°C in cardboard boxes. The dried soil samples were grounded by mortar and pestle and passed through a 12-mesh (approximately 2 mm) screen. The soil samples, at the time they were collected, were recorded and placed in trays holding five rows of ten boxes each (boxes are 2.5” x 3” x 3” deep), making a total of 06 samples. The soil samples were sieved and weighed each time, put in a beaker, mixed with (6 ml HNO_3) (3 ml HCl) (0.25 ml H_2O_2) and then heated. The digested sample solution was diluted to 50 ml with de-ionized water and filtered through a 0.45 µm microporous membrane. Finally, 1.0 ml filtered solution was diluted to 10 mL for estimation of various salt ions.

3 Results and Discussion

The concentrations of various metals in soil and their impact on environment and society can be influenced by many factors, such as parent material, climate and anthropogenic activities (21). The metals can be added in various ways to soils as in the form of agricultural fertilizers and pesticides, soil amendments (e.g., lime and gypsum), or organic fertilizers (e.g., manures and composts) (22). Correlation analysis between the soil heavy metals and fertility parameters may help to trace the levels of heavy metals in soil. The concentration of phosphate ion in various soil samples (both agricultural and forest) were found within the appreciable limit. Among all the agricultural soil samples the highest concentration was found in the soil sample collected from (GMS Road) followed by (Azad Colony). The least concentration of Phosphate was found present in the soil sample (Chanderbani). Among the forest soil samples the highest phosphate ion concentration was found in the (Tibetan Colony) followed by soil collected from Gujrara. The least concentration of phosphate ion among all the forest soil samples so for collected was found in the Kulhan. Although the phosphate ion concentration in both forest as well as agricultural soil samples run side by side, having less ion difference so for as observed. Among all the soil samples the agricultural soil samples were found to have higher phosphate ion concentration than the forest soil samples. The nitrate ion concentration was found highest (Mandi) followed by (Chanderbani). The least concentration of nitrate was found in the (Azad Colony). The nitrate ion concentration in the agricultural soil samples were found in between (0.210-0.998 mg/kg). The concentration of nitrite ion in various forest samples were found in a range (0.121 – 0.475 mg). The highest concentration of nitrite ion was found in the Danda of the region 1 followed by Kulhan. The least concentration of nitrite was found in the Gujrara of region 1. The nitrite ion concentration was found highest in the (Mandi) among all the agricultural soil samples, followed by Chanderbani. The least nitrite ion concentration was found in the Lalpull soil sample.

Figure 1: The map showing the area of sampling

The nitrite ion was found highest in the Tibetan Colony followed by Danda. The least nitrite ion was found in the Kandoli site of the soil sample. The concentration of nitrate in all the above samples shows within the range of its accessibility, although it is low, but other forms of nitrogen may account for the availability of nitrogen (23).

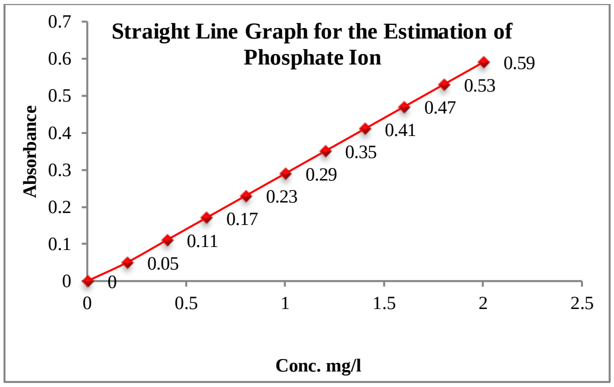

Figure 1: Standard Graph for the estimation of PO_4^{2-}

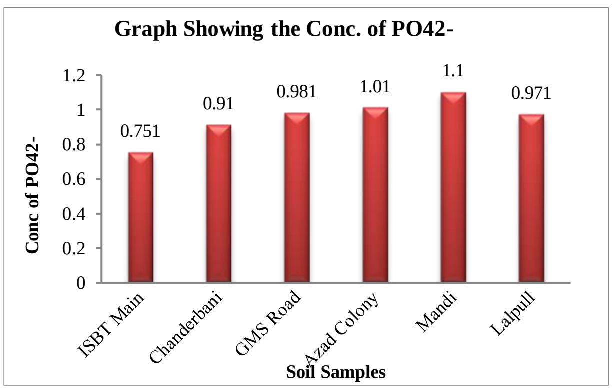

Figure 2: PO_4^{2-} ion in Various Soil Samples at Region 1

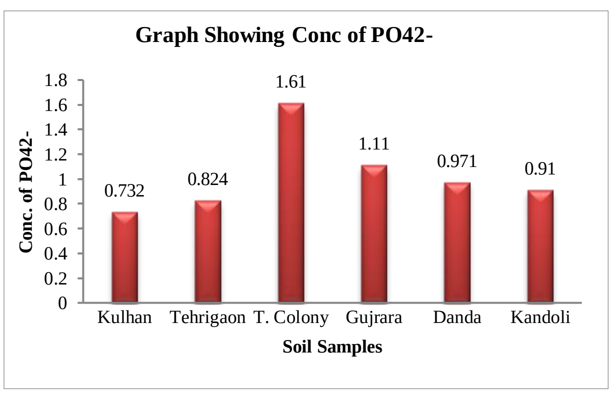

Figure 3: PO_4^{2-} ion in Various Soil Samples at Region 2

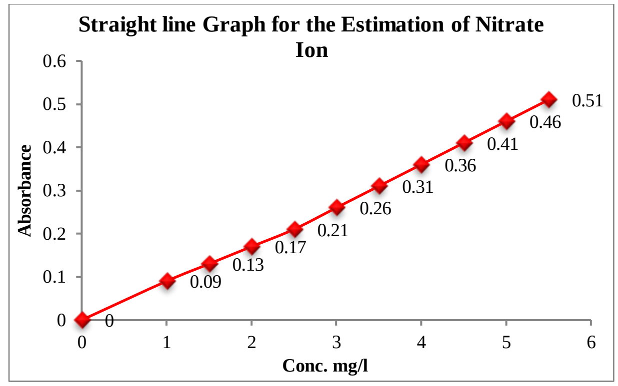

Figure 4: Standard Graph for the estimation of Nitrate Ion

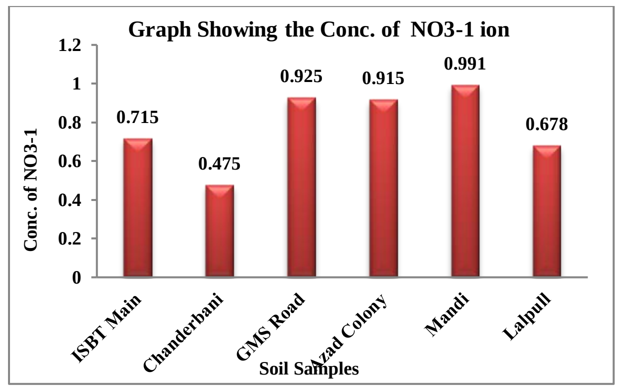

Figure 5: NO_3^{1-} ion in Various Soil Samples at Region 1

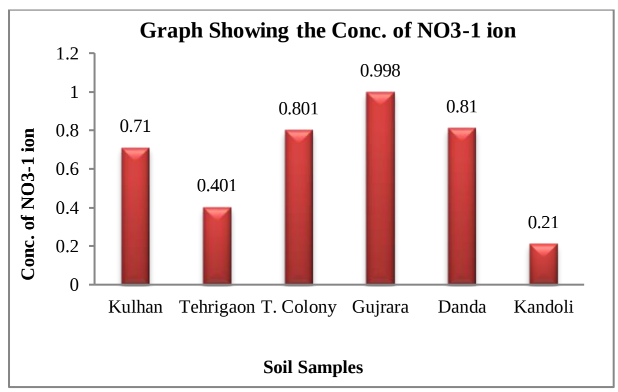

Figure 6: NO_3^{1-} ion in Various Soil Samples at Region 2

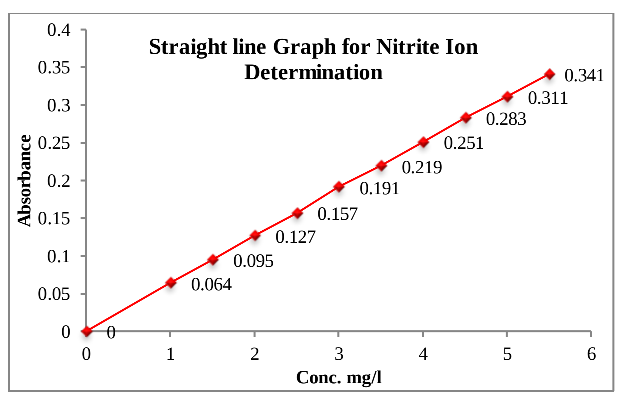

Figure 7: Standard Graph for the estimation of Nitrite Ion

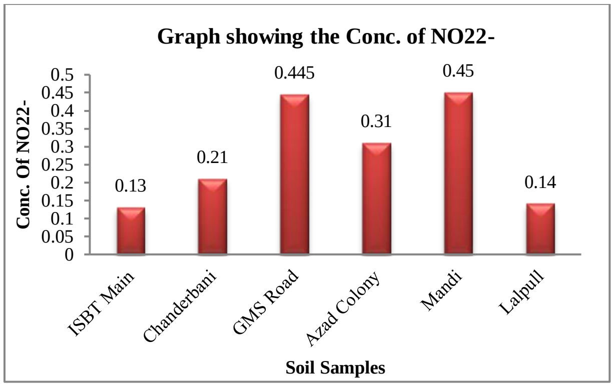

Figure 8: NO_2^- ion in Various Soil Samples at Region 1

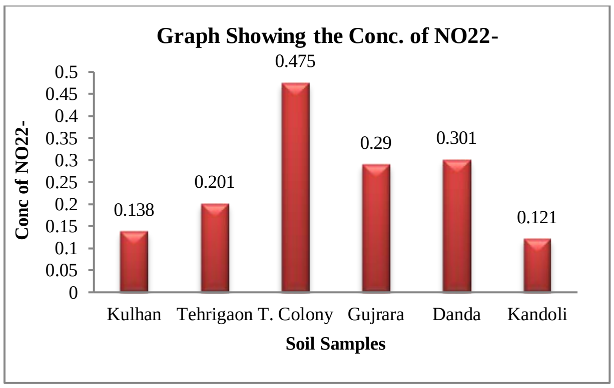

Figure 9: NO_2^- ion in Various Soil Samples at Region 2

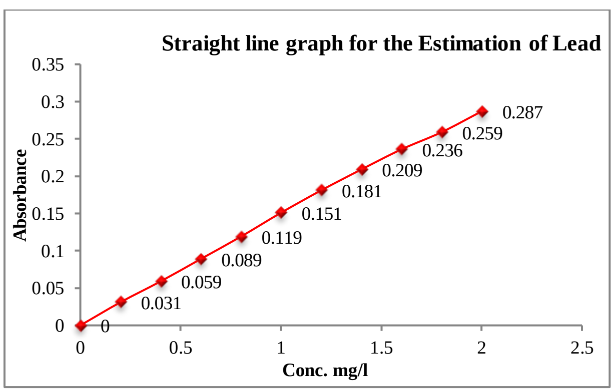

Figure 10: Standard Graph for the estimation of Lead

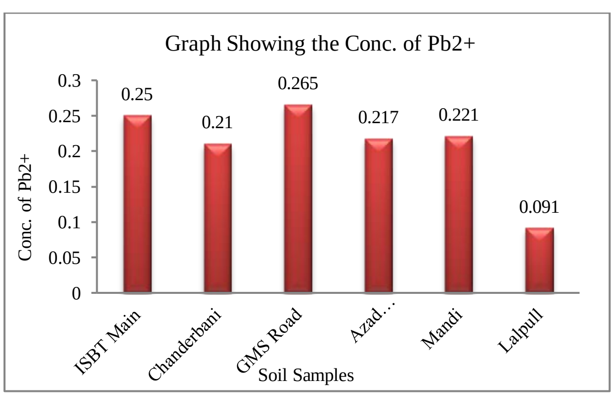

Figure 11: Pb^{2-} ion in Various Soil Samples at Region 1

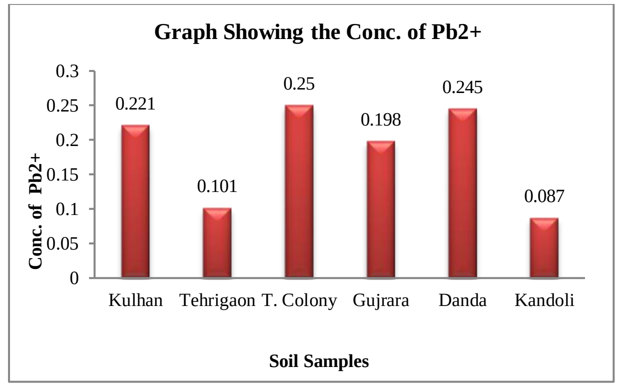

Figure 12: Pb^{2-} ion in Various Soil Samples at Region 2

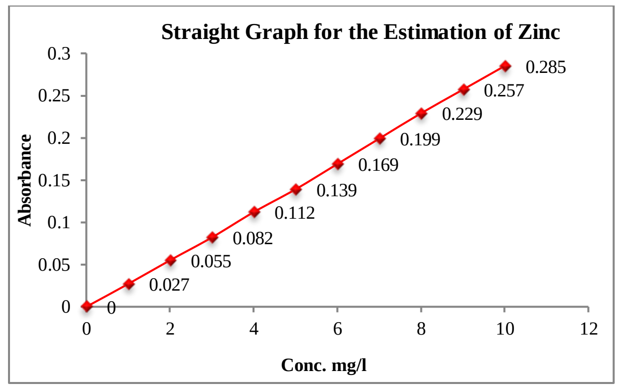

Figure 13: Standard Graph for the estimation of Zinc

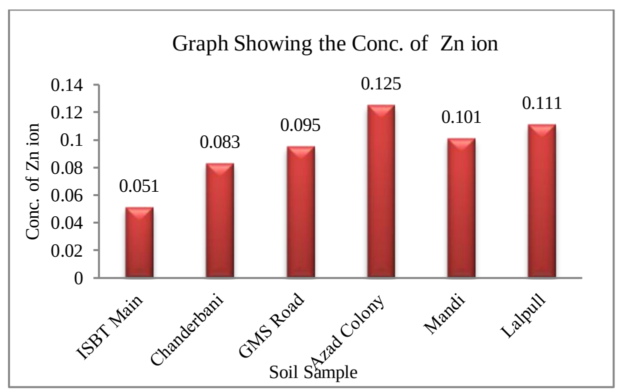

Figure 14: Zn^{2-} ion in Various Soil Samples at Region 1

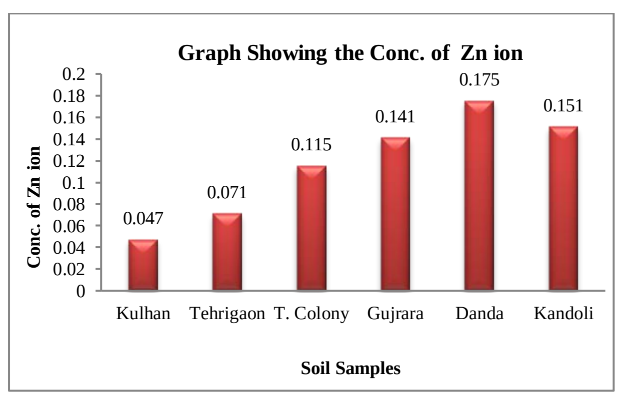

Figure 15: Zn^{2-} ion in Various Soil Samples at Region 2

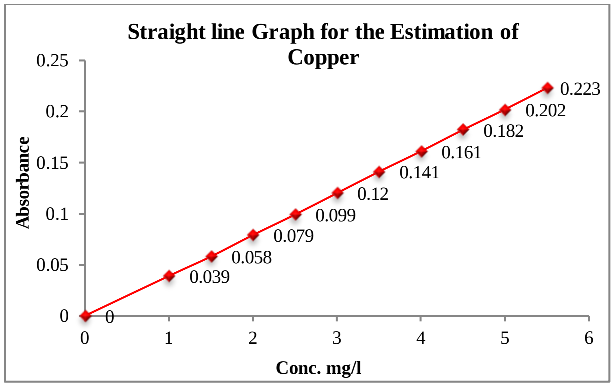

Figure 16: Standard Graph for the estimation of Copper

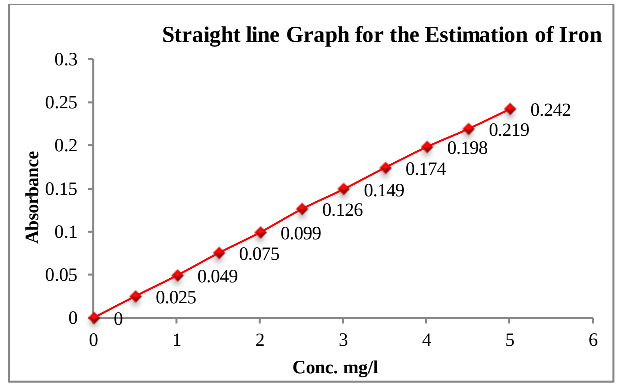

Figure 19: Standard Graph for the estimation of Fe

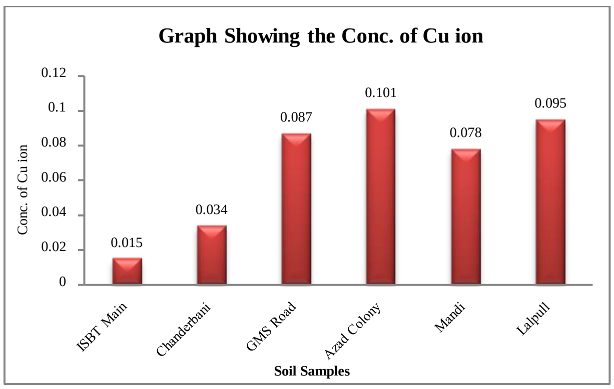

Figure 17: Cu^{2-} ion in Various Soil Samples at Region 1

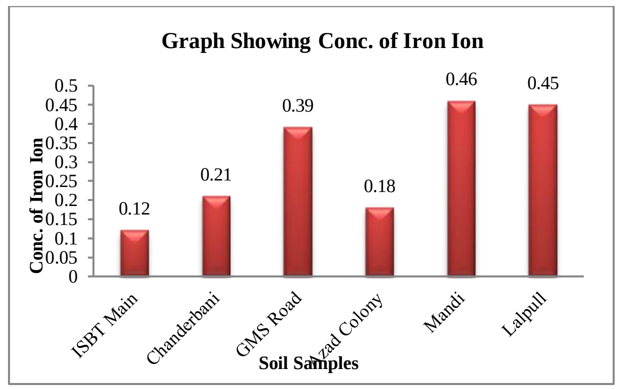

Figure 20: Fe ion in Various Soil Samples at Region 1

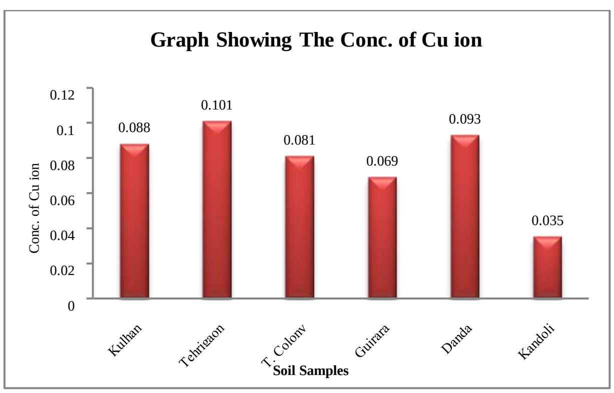

Figure 18: Cu^{2-} ion in Various Soil Samples at Region 2

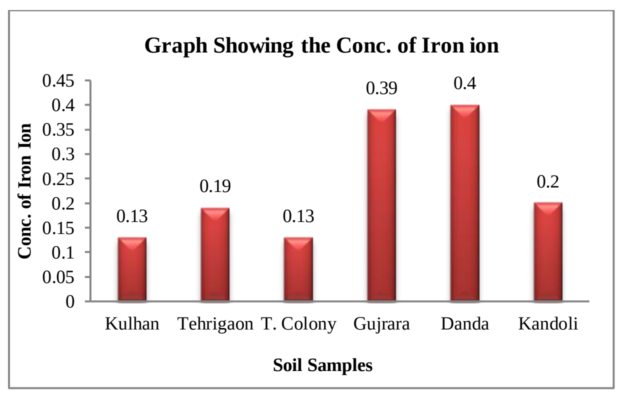

Figure 21: Fe ion in Various Soil Samples at Region 2

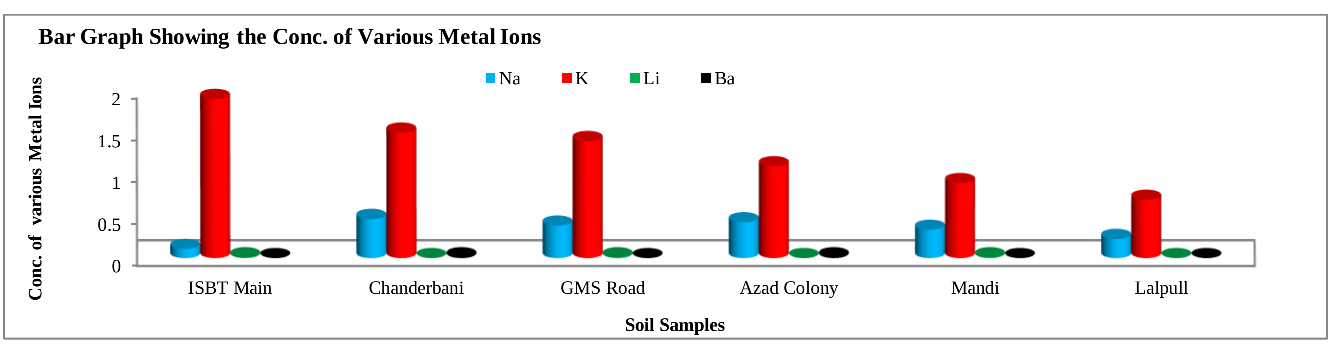

Figure 22: Showing the concentration of (Na, K, Li, Ba) in various soil samples of Region1

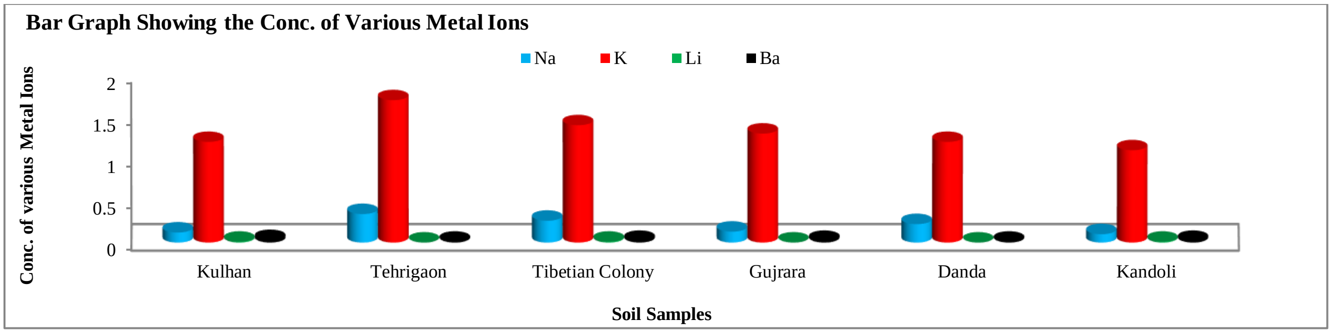

Figure 23: Showing the concentration of (Na, K, Li, Ba) in various soil samples of Region 2

The lead ion was found highest in the GMS road soil sample followed by the Chanderbani. The least lead ion concentration was found in the Lalpull. The lead ion concentration was found in the range (0.087 – 0.250 mg/kg). The highest lead ion concentration was found in the Tibetan Colony. The least ion concentration was found in the Kandoli forest soil samples. Cu and Zn are among the most abundant metals in wheat and other grains, as they are the essential micronutrients for plants (24). The concentration of zinc and Cu in the concerned soil samples is much abundant for the cultivation of various crops, like wheat barley etc. ion in various agricultural soil samples were found in the range (1.8 – 3.7mg). The highest zinc ion was found in the Azad Colony and the least ion was found in the Chanderbani. The least zinc ion concentration was found in Kulhan soil sample. The copper ion concentration in various soil samples were found in the range (0.035-0.161mg/kg), the highest being found in the Azad Colony followed by Danda. Among the two regions the highest concentration of copper ion was found in the region 1 soil samples. According to Campbell (25), the concentration of Fe in wheat grown soil is 25 mg kg^{-1}, and the higher concentration range for Fe in wheat growing soil in grain-filling stage is 30–200 mg kg–1. The results obtained in our study get aligned with the above results. The iron content in the soil samples was found in the range (0.120 – 0.462), the highest iron content being found in the Lalpull site, followed by Mandi. The least concentration of iron was found in the Chanderbani soil site. The iron content among the soil samples of region 2 was found highest in the Kulhan, followed by Danda. The least iron content was found in the Tehrigaon. The concentration of potassium was found marginally high in all the soil samples, followed by sodium ion. The lithium and barium content were found present in few soil samples.

Considering that toxic heavy metals carried by food causes many related health effects in human, few studies have recommended dietary supplements for people at risk of Cd and Pb exposure (26). High concentration of heavy metals in vegetables gets transferred to food wed and cause serious health issues to humans. Metals (e.g., Zn, Cd, Pb and Cu) causes mutagenesis and other diseases, as carcinogenesis, immune system weakness, also inhibit growth and fertility (27, 28, and 29).

5 Conclusion

Soil analysis provides complete information about the importance of maximizing nutrient use efficiency and agricultural productivity. Soil plays a central role in food safety as it determines the possible composition of food and feed at the root of the food chain. However, the quality of soil resources as defined by their potential impact on human health by propagation of harmful elements through the food chain. A historical record of soil properties provided by long-term soil testing is useful for determining the effectiveness of fertilizer management strategies in maintaining soil fertility and sustainable agricultural productivity. Soil testing is also a useful tool for identifying the causes of nutrient related plant growth problems. In conclusion it could be concluded that all the salt minerals and the metals are under suitable range for the optimal growth of maize barley and wheat. So the soil samples which have been examined can be opted for the production of various crops as the soil samples show a good quality and quantity of various mineral ions. The Dehradun in total bears a good range of forests and soil is rich of various types of mineral salts so could be used for the growth of multiple crops.

Ethical issue

Authors are aware of, and comply with, best practice in publication ethics specifically with regard to authorship (avoidance of guest authorship), dual submission, and manipulation of figures, competing interests and compliance with policies on research ethics. Authors adhere to publication requirements that submitted work is original and has not been published elsewhere in any language.

Competing interests

The authors declare that there is no conflict of interest that would prejudice the impartiality of this scientific work.

Authors' contribution

All authors of this study have a complete contribution for data collection, data analyses and manuscript writing.

References

1. Lepp, N.W. 1981; Effects of Heavy Metals on Plants. Vol. I and II, Applied Science, London.
2. Alloway, B.J. 1995; Heavy Metals in Soils. Blackie Academic and Professional, Glasgow.
3. Hall, J.L. and L.E. Williams. 2003; Transition metal transporters in plants. J. Expt. Bot., 54: 2601- 2613.
4. Naidu, R., R.S. Kookuna, D.P. Oliver, S. Rogers and M.J. McLaughlin. 1996; Contaminants and the soil environment in the Australasia-Pacific Region, Dordrecht Kluwer Acad. Publ.
5. Nriagu, JO, and JM, Pacyna. Quantitative assessment of worldwide contamination of air, water and soil by trace-metals. Nature, 1988; 333: 134-139.
6. Younas, M. and F. Shahzad. Assessment of Cd, Ni, Cu, and Pb pollution in Lahore, Pakistan. Environ. Intern. 1998; 24: 761-766.
7. Berry PM, Stockdale EA, Sylvester-Bradle. N, P and K budgets for crop rotations on nine organic farms in the UK. Soil Use and Management. 2003; 19: 112–118. doi: 10.1079/sum2003176
8. George S, Wright DL, Marois J J. Impact of grazing on soil properties and cotton yield in an integrated crop-livestock system.

Soil & Tillage Research. 2013; 132: 47–55. doi: 10.1016/j.still.2013.05.004
9. Mac Rae RJ, Mehuys GR. The effect of green manuring on the physical properties of temperate-area soils. Advances in Soil Science. 1985; 3: 71–94. doi: 10.1007/978-1-4612-5090-6_2
10. Drinkwater LE, Wagoner P, Sarrantonio M. Legume-based cropping systems have reduced carbon and nitrogen losses. Nature. 1998; 396: 262–265. doi: 10.1038/24376
11. Rezig FAM, Mubarak AR, Ehadi EA. Impact of organic residues and mineral fertilizer application on soil-crop system: II soil attributes. Archives of Agronomy and Soil Science. 2013; 59: 1245–1261. doi:10.1080/03650340.2012.709623
12. Rutkowska B, Szulc W, Sosulski T, Stepien W. Soil micronutrient availability to crops affected by long term inorganic and organic fertilizer applications. Plant Soil and Environment. 2014; 60: 198–203.
13. Zhang FS, Chen XP, Ma WQ. Discussion on fertilizer in an area of modern agriculture. Phosphate Compound Fertilizer. 2003; 18: 1–3.
14. Paul G C, Mannan M A. Integrated nutrient management in sugarcane to enhance sugar productivity. In: Proceedings, International Symposium on Technologies to Improve Sugar Productivity in Developing Countries. Guilin: People's Republic of China; pp. 108–121.
15. Jiang D, Hengsdijk H, Dai TB, de Boer W, Qi J, Cao WX. Long-term effects of manure and inorganic fertilizers on yield and soil fertility for a winter wheat-maize system in Jiangsu, China. Pedosphere. 2006; 16: 25–32. doi: 10.1016/s1002-0160(06)60022-2
16. Abbasi MK, Tahir MM. Economizing nitrogen fertilizer in wheat through combinations with organic manures in Kashmir, Pakistan. Agronomy Journal. 2012; 104: 169–177. doi: 10.2134/agronj2011.0264.
17. Li BY, Zhou DM, Cang L, Zhang HL, Fan XH, Qin SW. Soil micronutrient availability to crops as affected by long-term inorganic and organic fertilizer applications. Soil & Tillage Research. 2007; 96: 166–173. doi: 10.1016/j.still.2007.05.005
18. Ai C, Liang GQ, Sun JW, Wang XB, Zhou W. Responses of extracellular enzyme activities and microbial community in both the rhizosphere and bulk soil to long-term fertilization practices in a fluvo-aquic soil. Geoderma. 2012; 173: 330–338. doi: 10.1016/j.geoderma.2011.07.020
19. Ju XT, Kou CL, Christie P, Dou ZX, Zhang FS. Changes in the soil environment from excessive application of fertilizers and manures to two contrasting intensive cropping systems on the North China Plain. Environmental Pollution. 2007; 145: 497–506. doi: 10.1016/j.envpol.2006.04.017 PMID: 16777292
20. Dong TX, Yang HX, Li HF, Qiao YH, Su DS. Accumulation Characteristics of Heavy Metals in the Soil with Wheat-corn Rotation System in North China. Journal of Agricultural Resources and Environment. 2014; 4:355–365. doi: 10.13254/j.jare.2014.0131
21. Zarcinas BA, Ishak, CF, McLaughlin, MJ. Cozens, G. Heavy metals in soils and crops in southeast Asia. 1. Peninsular Malaysia. Environ. Geochem. Health. 2004; 26: 343-357.
22. Petrikova V, Ustjak, S. Roth, J. Heavy-metals contamination of agricultural crops and soils in 5 regions of the czech-republic with different immission pollution load. Rostlinna Vyroba. 1995; 41: 17-23.
23. Bagshaw J, Moody P, and Pattison T. Soil health for vegetable production in Australia—Part 4: Measuring soil health. The State of Queensland, Department of Employment, Economic Development and Innovation, 2010.
24. Sridhara Chary, N. Kamala, CT, Samuel Raj. Assessing risk of heavy metals from consuming food grown on sewage irrigated soils and food chain transfer. Ecotoxicol. Environ. Safety. 2008; 69; 513-524.
25. Udom BE, Mbagwu JSC, Adesodun, JK Agbim. N. N. Distributions of zinc, copper, cadmium and lead in a tropical ultisol after long-term disposal of sewage sludge. Environ. Int. 2004; 30:467-470.
26. Zhai Q, Narbad A, Chen W. Dietary Strategies for the Treatment of Cadmium and Lead Toxicity Nutrients. 2015; 7(1):552-571. doi:10.3390/nu7010552.
27. Swarup D, Dwivedi SK. Environmental pollu-tion and effects of lead and fluoride on animal health. New Delhi: Indian Council of Agricultural Research. 2002; 160p.
28. Alonso ML, Benedito JL, Miranda M, Castillo C, Hernández J, Shore RF. Interactions between toxic and essential trace metals in cattle from a region with low levels of pollution. Contamination and Toxicology. 2002; 42(2):165–172.
29. Mahajan VE, Yadav RR, Dakshinkar NP, Dhoot VM, Bhojane GR, Naik MK, Shrivastava P, Naoghare PK, Krishnamurthi K Influence of mercury from fly ash on cattle reared nearby thermal power plant. Environmental Monitoring and Assessment. 2012; 184(12):7365–7372.