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ASSESSMENT OF THE PHYSICOCHEMICAL PARAMETERS AND HEAVY METALS CONCENTRATIONS OF SOILS AROUND HOSTELS IN BENUE STATE UNIVERSITY, MAKURDI, NIGERIA

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ABSTRACT
The physicochemical properties and heavy metal concentrations of soil samples collected behind various hostels in Benue State University, Makurdi were analyzed and results compared to FAO standards. The hostels used for the study were boys' hostel (First Camp), girls' hostel (First Camp), girls' hostel (Second Camp) and boys' hostel (Second Camp). The physicochemical parameters analyzed were pH, temperature, nitrate concentration, electrical conductivity, organic matter content, phosphate levels, and cation exchange capacity (CEC) while the heavy metals were Pb, Cu, As and Cd. Results of these analyses showed that pH was in the range of 6.90 - 8.25, temperature (30.20–30.30 ºC), conductivity (174.00–795.50 µScm^{-1}), organic matter (72.66–89.12 %), CEC (23.82–37.14 cmol/kg), PO_3^- (0.069–0.281 mg/L), NO_3^-(0.89–0.92 mg/L). The concentrations of the heavy metals (in mg/kg) were: Pb (23.7250 - 23.7250), Cd (27.6600 - 29.0200), As (0.7750-0.8450), Cu (62.1200 -78.3300). These results proved that the soils around these hostels are not contaminated as all the parameters measured were found to be within the permissible limit set by FAO. The results of this study showed that the soil around the hostels were not contaminated since most the studied parameters were within the accepted limit set by the FAO/WHO hence does not pose health risk.

Keywords: Heavy metals, Soil, Concentration, Contamination, Hostels

INTRODUCTION
Soil is one of the priceless natural resources which form the uppermost layer of the earth surface. It plays a crucial role in supporting life in plants and animals (Kumari *et al*., 2023; Selvi *et al*., 2023). However, human activities such as agriculture, industrial activities, waste disposal and urban development etc alter soil composition leading to contamination of soils. Soil contamination in recent times is a serious environmental threat and challenge worldwide (Chen *et al*., 2023; Sani *et al*., 2012). Contaminated soils are characterized by the presence of pollutants such as pesticides and herbicides, plastic wastes, oil spills, fertilizers, radioactive materials and excess heavy metals (Okoh and Zakpaa, 2024). The physicochemical properties of such soils such as pH, redox potentials, organic matter content, texture etc are altered due to the presence of pollutants. Most common among these contaminants are the heavy metals. Soil pollution by these potentially toxic elements is one of the most pressing public concerns, since it could directly affect and cause irreplaceable damage not only the environment but also human beings (Jency *et al*., 2023). This is because they can accumulate and persist in soils, affecting ecosystem functions, compromising soil quality and the balance of ecosystem communities (Meena *et al*., 2020). For example, the presence of heavy metals in the soil tends to reduce soil fertility, damage the soil ecological environment and reduce crop yield (Edwin *et al*., 2022).

Generally, heavy metals are present in the soil in form of cations which form chemical bond with inorganic and organic ligands. Unlike organic pollutants, heavy metals do not degrade or decompose over time, making contamination persist and often irreversible. Heavy metals find their way into human body through food chain via soil-plant system and endanger human health (Kosakivska *et al*., 2020). In recent times, heavy metals with high attention can be classified into three categories; macro nutrients example Co and Mg, micro nutrients example Fe, Cu, Mn and highly toxic elements such as Pb, Hg, As and Zn, As and Cd. The micro and macro nutrients also called the essential nutrients play important role in the growth and development of plants and animals. However, their negative effects are seen when their concentrations exceed the FAO/WHO permissible limit. For the highly toxic elements such as As, Cd etc, their toxicity occurs even at very low concentrations (Mohammad *et al*., 2024).

MATERIALS AND METHODS
The geographical coordinates of Benue State University (BSU) Makurdi, Nigeria are approximately Latitude: 7.72849° N, Longitude: 8.55395° E. It is located near the southern bridgehead of the Benue River and it sits on sandy alluvial formations. The campus spans approximately 6 km², between Gboko Road and the River Benue, roughly 1.5 km wide and 4 km long. It slopes gently from Gboko Road toward the river with gradients ranging from 0 to 50, resulting in generally well-drained terrain, though some areas are hydromorphic (Wikipedia – Benue State -Geology section; Osujieke, *et al*., 2019).

Sample Collection
The soil samples (10 g each) were collected from four different locations behind the boys and girls hostels in the first and second campuses of Benue State University, Makurdi. The Soil to be sampled in each location were divided into four quadrants, the refuse waste soils were collected from drainages in various hostel in Benue State University, Makurdi campus with the aid of a clean spatula. The soil samples were placed in polythene bags, labeled and taken to the laboratory for treatment and analysis.

Samples Pre-Treatment
The collected soil samples were homogenized and air-dried in an oven at 30 ºC overnight and then passed through a 2 mm sieve to remove unwanted materials. The sieved soils were placed in polythene bags ready for further analysis.

Determination of pH

About 10 g of each oven-dried soil was weighed into 50 mL beaker and 50 mL of distilled water was added. It was stirred with a glass rod and allowed to stand for 30 minutes. The electrode of calibrated pH meter was inserted into the solution and the pH was recorded. The process was repeated 3 times for each sample and the results obtained were recorded (Ghare and Kumbhar, 2022; Oyeyiola and Agbaje, 2013).

Determination of Electrical Conductivity

The air dried soil samples were sieved through a 2 mm sieve to remove stones and other debris. Exactly 20 g of the sample was weighed into a beaker and made to a soil/water suspension ratio of 1:2. This was stirred for 30 minutes and then left to stand for about 10 minutes for it to settle. The electrical conductivity meter was calibrated at 25 ⁰ C. The cell of the meter was lowered into the mixture and moved up and down devoid of any disruption of the settled sediments. The readings were noted after the electrical conductivity meter had stabilized (Oyibo, 2013).

Determination of Organic Matter

About 10.0 g sieved (2 mm) soil sample was weighed into an ashing vessel. The vessel was placed in a drying oven set at 105 °C and dried for 18 hours. After which the ash vessel was removed and cooled in a dry atmosphere. When it was completely cooled, 5 g (W_1) of the sample was placed the ashing vessel and inserted into a muffle furnace for 24 hours. The ashing vessel from the muffle furnace was removed and cooled in dry atmosphere and weighed (W_2). The percent of organic matter was calculated using the formula:

$\%\ \text{ash} = \frac{W_1 - W_2}{W_1} \times 100\ \%$ (Ghare and Kumbhar, 2022).

Determination of Nitrate

Nitrate content in the soil samples was determined calorimetrically using a UV-Visible spectrophotometer. This method is based on the reaction of nitrate with sodium salicylate to form a yellow-colored complex, which can be measured at a specific wavelength. In the procedure, a 5.0 g of air-dried, sieved (<2 mm) soil was extracted using 2 M potassium chloride (KCl) solution in a soil-to-extractant ratio of 1:5. The mixture was shaken for 30 minutes to facilitate the release of nitrate ions from the soil matrix into the solution. The suspension was then filtered to obtain a clear extract. An aliquot of the soil extract was treated with sodium salicylate under acidic conditions, resulting in the formation of a nitrosalicylic acid complex. After the reaction was complete, the mixture was neutralized and the absorbance was measured using a spectrophotometer at a wavelength of 410 nm. A standard calibration curve, prepared using known concentrations of nitrate, was used to determine the nitrate content of the samples (Ghare and Kumbhar, 2022).

Extraction of the nitrate from the soil

Soil-$NO_3^- + KCl$ Soil-$Cl^- + KNO_3$ (in the extract)

Reaction of nitrate with sodium salicylate under acidic conduction

$NO_3^- + 2H^+ \quad NO_2^+ + H_2O$

Then

$C_7H_5O_3^- + NO_2^+ \quad C_7H_4NO_4^- + I$

i.e sodium salicylate + nitronium ion 3-nitrosalcylic acid (yellow)

Neutralization step

$C_7H_4NO_4OH + NaOH \quad C_7H_4NO_4Na + H_2O$

Overall reaction

$NO_3^- + C_7H_5O_3Na \quad C_7H_4NO_4Na + H_2O$

Determination of Phosphate

Available phosphate in the soil samples was determined using the molybdenum blue colorimetric method. About 2.5 g of the air-dried, sieved (<2 mm) soil was added to 50 mL of 0.5 M sodium bicarbonate ($NaHCO_3$) solution at pH 8.5. The mixture was shaken for 30 minutes to facilitate the release of phosphate ions into solution. After shaking, the suspension was filtered to obtain a clear extract for analysis. An aliquot of the extract was then reacted with a mixed reagent containing ammonium molybdate, potassium antimonyl tartrate and ascorbic acid in an acidic medium. In the presence of phosphate, a blue-colored phosphomolybdenum complex was formed, which was subsequently reduced by ascorbic acid to produce molybdenum blue. The intensity of the blue color, which is directly proportional to the phosphate concentration, was measured using a UV-Visible spectrophotometer at a wavelength of 880 nm. A calibration curve prepared from standard phosphate solutions was used to determine the phosphate concentration in the soil extract. The results were expressed in milligrams of phosphorus per kilogram of soil (mg/kg) for all soil samples (Utange *et al*., 2021; Olsen and Sommers, 1982).

Extraction of phosphate from the soil using 0.5M $NaHCO_3$ solution

$Ca(PO4)_2$ (s) + 3$NaHCO_3$ (aq) 2Na_3PO_4 (aq) + 3$CaCO_3$ (s)

Formation of phosphomolybdic acid (heteroploy acid complex)

$PO_4^{3-} + 12MoO_4^{2-} + 24H^+ \quad H_3[P(Mo_{12}O_{40})] + 12H_2O$

Reduction to molybdenum blue by ascorbic acid

$H_3[P(Mo_{12}O_{40})] + C_6H_8O_6$ reduced molybdenum blue complex + $C_6H_6O_6 + H_2O$

The potassium antimonyl titrate acts as a catalyst

$PO_4^{3-} + 12MoO_4^{2-} + Sb^{3+} + 24H^+ \quad H_3[PSb(Mo_{12}O_{40})] + 12H_2O$

Digestion of Soil Samples

Exactly 1.0 g of the air dried soil samples were weighed into a crucible; 20 cm^3 of HCl and HNO_3 were added in a ratio of 3:1 followed by 10 cm^3 of hydrofluoric acid. The whole mixture was heated in a fume cupboard at 100 ºC until a clear solution was obtained. The solution was then cooled in a desiccator and transferred into a 250 cm^3 plastic volumetric flask and stored for heavy metal analysis (Edwin *et al*., 2022).

Determination of Heavy Metals Present in the Soil Samples

The heavy metals (lead (Pb), Arsenic (As), cadmium (Cd) and copper (Cu)) were determined with Atomic Absorption Spectrophotometer (AAS) (Pasco spectrometer PS2600).

RESULTS AND DISCUSSION

Table 1: The Physicochemical Analysis of Soil Samples

Samples	pH	Temperature (°C)	Conductivity (μScm^{-1})	Organic matter (%)	CEC cmol/kg	PO_4^{3-} (mg/kg)	NO_3^- (mg/kg)
A	$6.90^a \pm 0.28$	$30.20^a \pm 0.00$	$200.50^b \pm 9.19$	$89.12^d \pm 0.01$	$25.00^{ab} \pm 1.66$	$0.075^a \pm 0.002$	$0.89^a \pm 0.008$
B	$7.60^b \pm 0.282$	$30.30^a \pm 0.00$	$795.50^d \pm 71.41$	$81.28^b \pm 0.00$	$23.82^a \pm 0.00$	$0.094^b \pm 0.008$	$0.92^b \pm 0.012$
C	$7.90^{bd} \pm 0.14$	$30.30^a \pm 0.14$	$174.00^a \pm 1.41$	$87.54^c \pm 0.00$	$29.71^{ab} \pm 8.33$	$0.281^c \pm 0.003$	$0.89^{ab} \pm 0.008$
D	$8.25^d \pm 0.07$	$30.25^a \pm 0.07$	$541.00^c \pm 66.46$	$72.66^a \pm 0.00$	$37.14^b \pm 2.18$	$0.069^a \pm 0.007$	$0.89^a \pm 0.003$
FAO	6.0-7.5	20-30 °C	2 dS/m – 4 dS/m	min of 3-5%	Not specified	20-30 mg/kg	Not specified

Values within the same column with the same superscript are not significantly different at $p > 0.05$

Table 2: The Concentration of Heavy Metal in Soil Samples

Samples	Pb (mg/kg)	Cd (mg/kg)	As (mg/kg)	Cu (mg/kg)
A	$23.7250^a \pm 0.0212$	$27.6600^a \pm 0.0000$	$0.7750^a \pm 0.0071$	$78.3300^d \pm 0.0141$
B	$29.6250^d \pm 0.0071$	$29.0200^d \pm 0.0141$	$0.8450^b \pm 0.0071$	$77.4800^c \pm 0.0141$
C	$27.0750^b \pm 0.0071$	$28.4600^b \pm 0.0141$	$0.7750^a \pm 0.0212$	$62.1200^a \pm 0.0141$
D	$28.3400^c \pm 0.0141$	$28.5600^c \pm 0.0141$	$0.7750^a \pm 0.0212$	$69.1250^b \pm 0.0071$
WHO/FAO, 2001	50 mg/kg	0.3 mg/kg	20 mg/kg	100 mg/kg

Values within the same column with the same superscript are not significantly different at $p < 0.05$

Key: A= Boys' hostel first campus, B = girls' hostel first campus, C = girls' hostel second campus, D = boys' hostel second campus

Discussion

Physicochemical parameters of the soil samples

The results of the measured physicochemical parameters of the soil samples are presented on Table 1. Results of the pH analysis showed that the pH of the soils was in the range of 6.90 – 8.25 and this was within the 6.0-7.5 recommended by FAO (FAO, 2020) apart from D which was slightly higher (8.25). Most of the soil samples were slightly alkaline apart from A which was slightly acidic. The high pH values of these soils could be as a result of the minerals present in the soils. The pH of soils play an important role on soil nutrient availability, plant uptake, growth, productivity and phytochemical content (Jia *et al*., 2024; Prabhudev *et al*., 2023; Shareef *et al*., 2019). Generally, the availability of most micronutrients such as iron, manganese, zinc, copper and boron are strongly influenced by soil pH (Kennedy, 2022). In acidic soils, these micronutrients are more soluble and readily available. However, in alkaline soils, they tend to form insoluble hydroxides and carbonates, thus reducing their availability to plants (Menna, 2022).

As the pH approaches 8, the availability of micro nutrients such as B, Cu, F, Mn, Ni, Zn decrease, hence soils from B, C and D are likely to have less of these nutrients. In acidic conditions, high levels of Al and Mn can prevent the elongation and proper functioning of roots (Mandić *et al*., 2023; Rahman *et al*., 2018). However, in alkaline conditions, the reduced availability of essential nutrients can impair root elongation thus affecting plant growth and productivity. It has also been proved that soil pH affects the composition and activity of microbes which in turn influences nutrient availability.

Most bacteria operate optimally at pH of 6.5 -7.5 while fungi operate within the pH of 4-6. The activities and diversity of microorganisms (bacteria) tends to be lower in acidic soils thus affecting the decomposition of organic matter and nitrogen fixation. Contrary, neutral to slightly alkaline soils generally support a more diverse and active microbial community (Kennedy, 2022). The pH of these soil samples (6.90 – 8.25) shows that the soils will be suitable for crop production and the microbial community of the soil will not be affected (Yusuf *et al*., 2024). Thus soils can be used to cultivate different crops depending on the pH requirement of the crops. Different crops require different pH values for optimum yield. Sample A with pH of 6.90 can be used to cultivate crops like beans, broccoli, cabbage, cucumber and okra etc since these crops do well in acidic soils because in this acidic pH, these nutrients are more soluble and available for the crops than in alkaline condition (Dewangana *et al*., 2023; Barrow and Hartemink, 2023).

Soil temperature refers to the hotness or coldness of the soil. It is determined by various factors such as solar radiation, soil composition, moisture content, depth of the soil (Onwuka, 2016). All the soil samples studied had almost similar temperature (30.20-30.30 °C) which are comparable to the maximum temperature recommended by FAO (20 -30 °C) for crop cultivation. Above and below this temperature range, plant growth/ productivity decline considerably. This result showed that these soils can be used to cultivate a wide variety of crops as their seed germination, photosynthesis, root development, soil nutrients availability and uptake growth and productivity will not be affected by temperature. This is because the physical, chemical and biological processes, rate of organic matter decomposition and mineralization of organic matter and retention ability of the soils will not be affected by this temperature range. This temperature range also favours the activities of microorganisms.

The conductivity obtained for the soil samples was in the range of 174.00–795.50 μScm^{-1} (0.174-0.7955 dS/m) while the maximum recommended FAO conductivity is 2 dS/m – 4 dS/m. The results showed that the conductivity of the sampled soils were moderate and thus can be used to cultivate a wide variety of crops. Electrical conductivity gives an idea of the soluble salt content, charged particles, soil fertility, salinity, nutrient content and overall soil condition. The higher the number of ions or charged particles in the soil, the higher the salinity and hence the higher the soil conductivity (Dandwate, 2020). Thus sample B has the highest conductivity (795.5 μS/cm) indicating a higher concentration of dissolved salts, salinity, and hence could be more fertile. Sample C has the lowest conductivity (174 μS/cm), which shows it has lower salinity level and potentially fewer dissolved nutrients or salts and hence could be less fertile. Soil A and C with low conductivities (0- 200 μS/cm or 0-0.2 dS/m) have low salinity and hence may be deficient in essential nutrients. These soils are suitable for crops like vegetables and legumes. Soil B (795 μS/cm) and D (541 μS/cm) with moderate conductivity (200

– 1000 µS/cm or 0.2-1.0 dS/m) will favour production of most crops such as cereals, fruits and vegetables because of the balanced level of nutrients. However, soils with high conductivity (1000-2000 µS/cm or 1.0-2.0 dS/m) have high salinity and this may affect nutrient up take and prevent plant growth (Zaiad, 2010). Such soils can be used to cultivate crops such as barley, cotton and certain wheat. At above 2000 µS/cm or 2.0 dS/m, the crops may suffer from weak nutrient imbalance and salt toxicity. Factors that affect soil conductivity include: temperature, pH, soil texture, water content and ion concentration. Soils with fine particles such as clay tend to have high conductivity because they can retain more water an ions (Ghare and Kumbhar, 2022).

Soil organic matter content is the fraction of the soil that is made up of organic matter such as plants and animal residue at various stages of decomposition. Soil organic matter is crucial for enhancing soil structure, water retention and nutrient supply and soil biodiversity (Sisay and Feleke, 2024). Sample A had the highest amount of organic matter (89.12 %) while Sample D has the lowest at 72.66 %. Higher organic matter content in sample A suggests better soil structure, higher water retention capacity and enhanced microbial activity and more fertility which are beneficial for plant growth.

The cation exchange capacity (CEC) is measure of how well a soil can retain and exchange positively charged ions (Williams, 2023). These cations most numerous on exchange site of soils include essential nutrients such as Na^{+}. K^{+}, Ca^{2+}, Mg^{2+} (Haruna, 2023; Hashimi *et al*., 2020). Sandy soils have low cation exchange capacity (1-20 cmol/kg), loamy soils have moderate (10-25 cmol/kg) and for clay soils it is high within the range of 20 – 40 cmol/kg. A high cation exchange capacity indicates that the soil can hold or retain more cations and therefore makes the nutrients available for the crops (Kome *et al*., 2019). Soils with high clay content generally have higher cation exchange capacity value while sandy soils have lower cation exchange capacity because they quickly loss nutrients to leaching. Soils with high organic matter content such as peat have very high cation exchange capacity of 30-50 cmol/kg due to the presence of humus (decomposed organic matter) and are very fertile (Ciric *et al*., 2023). Results of this research showed that the cation exchange capacity was between 23.82–37.14 cmol/kg showing that none of the soil was sandy soil thus may not need frequent fertilizer application. Sample D have the highest cation exchange capacity (37.14 cmol/kg) which means it will have a greater ability to hold and exchange cations/nutrients and make it available for the crops thus it is expected to be more fertile. Sample C also has a relatively high CEC of 29.71 cmol/kg, suggesting good nutrient-holding capacity. Sample A has a moderate CEC value of 25 cmol/kg, while Sample B has the lowest, potentially indicating less fertile soil compared to the other samples studied. Thus may loss nutrients faster than A, C and D and may need application of fertilizer.

The nitrate concentration obtained from the soils was between 0.89-0.92 mg/kg. Nirogen occur in the soils in form of nitrates, ammonium, nitrogen gas and organic nitrogen (Kanthle *et al*., 2019). Therefore this nitrate concentration of 0.89-0.92 mg/kg represents the nitrogen content of the soil which is an essential nutrient for plant growth. Nitrates are soluble in water and therefore will make the nitrogen available for plant absorption. Nitrates in the soils are also produced when the bacteria (nitrosomonas and nitrobacter) convert ammonium to nitrates in the process called nitrification. Excess nitrates in the soil can lead to nutrient imbalance, ground water pollution and cause production of excess leafy growth without fruits or roots. Fertilizers, animal manure and atmospheric deposition of nitrogen compounds from air, decomposition of organic matter and biological nitrogen fixation by legumes contribute to increase in soil nitrogen levels. When plants absorb nitrates ions, the nitrates are converted to ammonium ions within the plant cells. The ammonium is incorporated into amino acids and other nitrogen containing compounds for proper chlorophyll formation and plant growth (Kanthle *et al*., 2019).

Results of the analysis showed that the phosphate concentration in all the soil samples (0.069 – 0.28 mg/L) were below the maximum limit specified by FAO (0.1 -10 mg/L). The presence of phosphates in the soil is an indication of the presence of phosphorus (Mardamootoo *et al*., 2021). These phosphate concentrations were low thus crops grown on these soils may have stunted growth, dark green leaves or purplish leaves and poor root development associated with deficiency of phosphates/phosphorus in the soil. Thus for good crop yield, phosphates containing fertilizers should be applied on these soils. However, excess phosphates in the soil can lead to eutrophication of water. Phosphorus, also called the master key element in soil quality is an essential nutrient in plants which is responsible for growth. It is a key component of DNA, RNA and ATP which are responsible for energy transfer, cell division and other vital processes (Edwin *et al*., 2022; Dandwate, 2020). Phosphates occur in soils in the form of inorganic and organic phosphates; the inorganic phosphates occur as minerals or in soluble forms. They are usually bonded to metals such as Ca, Fe and Al, forming insoluble phosphates thereby making them unavailable for plant absorption (Dandwate, 2020; Abolfazli *et al*., 2012). The organic phosphates are obtained from organic matter such as decaying plant and animal residues. The microbes in the soil convert these to inorganic phosphates for easy absorption by plants. The availability of phosphates in the soil is influenced by pH, soil texture and microbial activities (Annappa *et al*., 2024).

Heavy Metal Concentration of the Soil Samples

The lead concentration in the soils was found to be in the range of 23.750-29.625 mg/kg and below the FAO recommended value of 50.0 mg/kg. This result shows that the crops grown and cultivated on these soils will pose no harm to humans in terms of lead concentration. Elevated lead concentration in soils and foodstuff is a critical environmental issue as it poses health risk to both children and adults. In children, it can limit brain development, learning disability and developmental delays. In adults, exposure to excess lead may cause kidney damage, hypertension, neurological effects, cardiovascular and reproductive issues. Lead enter the soil through various pathways such as industrial emission, contaminated waste disposal lead based paints (Nyiramigisha *et al*., 2021; Yandav *et al*., 2018).

The concentration of the Cd in the soils was in the range of 28.4600-29.0200 mg/kg. This concentration was far above the 0.3 mg/kg recommended by FAO in soils. Therefore crops cultivated from these soils could accumulate high concentration of Cd in their tissues. Cadmium is toxic to both plants and animals when it accumulates to significant concentrations in tissues. It gets into the soil through natural processes and human activities such as industrial emission, mining, agricultural practices such as application of phosphate fertilizers. When in soil, cadmium binds to organic matter and clay minerals. Its mobility in the soils influenced by pH, organic matter content, and presence of other ions. The presence of cadmium in the soil is of great concern because it persists and accumulates in food chain. Long term exposure to cadmium can cause health problems such as kidney damage, bone disease and increased risk to cancer (Hamsa *et al*., 2017).

Results of the analysis showed that the concentration of copper (62.1200-78.3300 mg/kg) was below the maximum limit given by FAO (100 mg/kg). Thus crops cultivated on these soils will not accumulate high concentrations of copper in their tissues and thus will not have detrimental effects on the consumers. The crops will not show yellowing of leaves (chlorosis), stunted growth and poor root development associated with deficiency of copper in the soils. Deficiency of copper is often seen in soils with high pH or those that are heavily leached. Copper is an essential trace element that plays important roles in several biological processes such as respiration, photosynthesis and protein synthesis. It gets into the soil through atmospheric deposition, decomposition of plants and animal materials, agricultural practices, industrial activities and from irrigation water (Hamsa *et al*., 2017).

The arsenic concentration was found to be between 0.7750 – 0.8450 mg/kg and far below the maximum limit of 20 mg/kg set by the WHO/FAO. Arsenic occurs naturally but can by toxic to humans when ingested, inhaled or absorbed in significant quantities. Arsenic is known to cause cancer, high blood pressure and increased risk of heart disease, stroke and miscarriages.

CONCLUSION

The findings of this study revealed that the soil around the hostels were not contaminated as most the parameters analyzed were within the accepted limit established by the FAO/WHO Therefore it does not pose an environmental or health risk.

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