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Original Article

Effect of Thermal Treatments on Physicochemical Properties and Heavy Metal Concentrations in Lead Polluted Soil from Madakka, North Central, Nigeria

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ABSRACT

The study investigated effect of sterilization on physicochemical properties of Lead polluted soil from Madakka. Two samples each were collected from Madakka and Botanical Garden of Ahmadu Bello University, Zaria. The sterilized and non sterilized soil from the garden were used as positive and negative control respectively, making a total of four samples. The sterilization was done using laboratory autoclave at 82°C for 30 min. Soil physico-chemical parameters and heavy metals were determined using standard procedure for some parameters and Microwave Plasma Atomic Emission Spectroscopy (MPAES) for the minerals and heavy metals Significant ($p<0.05$) differences were observed in Org. C%, Org. M,P, Mg, Ca, K, Na, EC, sand, silt, and clay in the following ranged, Org. C% (1.47±0.584.49±1.00) from MTUS and GUS, %Org. M (1.61±0.62—8.10±0.57) from MTUS and GUS, P (0.53±0.07—0.9±40.12) from GST and MTUS, Mg (8.96±0.74—24.80—0.60) from MTST and GS, Ca (197.02±5.54—436.58±38.58) from MTUS and GST, K (9.07±2.07—35.27±1.88) from MTUS and GST, Na (0.18±0.11—2.03±0.05) from MTUS and GST, EC (185.10±1.00—626.00±0.00) from MTUS and GST, sandy (74.20±0.61—85.95—0.55) from GST and MTUS, silt (5.50±0.61—14.10±0.52) from MTUS and MTST, clay (2.83±0.67—15.17±1.27) from MTST and GST. In As, Cr, Fe, and Pb with their values ranged from; As (0.00±0.00—2.00±0.00) from GUS, MTST, and MTUS, Cr (0.00±0.00—1.33±0.58) from GST and MTSU, Fe (0.00±0.00—88.67±1.15) from GUS and MTST, Pb (0.00±0.00—582.00±23.81) from GUS and MU TUS. Significant ($p<0.05$) differences were found in organic carbon (Org. C%), organic matter (%Org. M), phosphorus (P), magnesium (Mg), calcium (Ca), potassium (K), sodium (Na), electrical conductivity (EC), sand, silt, and clay. However, concentrations of arsenic (As), chromium (Cr), iron (Fe), and lead (Pb) in garden soil and mine tailing statistically differ.

Keywords: Garden Soil, Mine Tailing, Sterilized, Non-sterilized and Heavy Metals.

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INTRODUCTION

Soil contamination by heavy metals poses a significant environmental and public health risk, particularly in regions with extensive agricultural activities and industrial pollution (1). Madakka, an area known for its artisanal mining activities, has been identified as having soils contaminated with various heavy metals, most especially lead (Pb) (2). This contamination not only affects soil quality but also poses a threat to plant growth and, consequently, food safety (3). Understanding the physicochemical properties of soils and how they are influenced by different treatment methods is crucial for developing effective remediation strategies (4).

Thermal treatments have emerged as a promising approach to mitigate heavy metal contamination in soil (5). These treatments involve the application of heat to soil, which can alter its physical and chemical properties, potentially reducing the mobility and bioavailability of heavy metals (6). The effectiveness of thermal treatments depends on various factors, including temperature, duration, and the specific characteristics of the soil being treated (7). However, this process can also impact the soil's physicochemical properties, such as pH, organic matter content, cation exchange capacity (CEC), and texture, which are critical for maintaining soil fertility and structure.

This study focuses on the effect of thermal treatments on the physicochemical properties and heavy metal concentrations in lead-polluted soil from Madakka. Understanding these effects is essential to evaluating the potential of thermal remediation as a sustainable approach for reclaiming contaminated soils. The research aims to determine how thermal autoclave thermal treatment can influence the retention or release of lead and other associated heavy metals, providing insights into optimizing remediation strategies for polluted environments.

MATERIALS AND METHODS

Soil Samples Collections and Study Site

Madaka, which is situated in Rafi Local Government Area, Kagara, Niger State, Nigeria, as seen in figure 1, is a place where mined soil samples were collected. While, Soil from Botanical Garden of Ahmadu Bello University, Zaria was used as control site, which is located around latitude 11^0 06’ 40.61” N (11.14306) and longitude 7^0.43’ 21.72” (7.654167). Madaka is a town that is contaminated with lead. The research region is located between latitudes 10°00' N (10.00908) and 10°04' N (6.456607) of the Greenwich meridian, and it is a section of Tegina sheet 142SE and Alawa sheet 143SE. The Minna-Kagara Road and various smaller roads provide access to the region. There are two different seasons in the research area: the rainy season and the dry season. The region has minimum and maximum temperatures of 26°C and 34°C, respectively, with an average of 1200 mm of rainfall each year. Typically, the vegetation is Guinea savannah, which is distinguished by long grasses that are dotted with different kinds of trees.

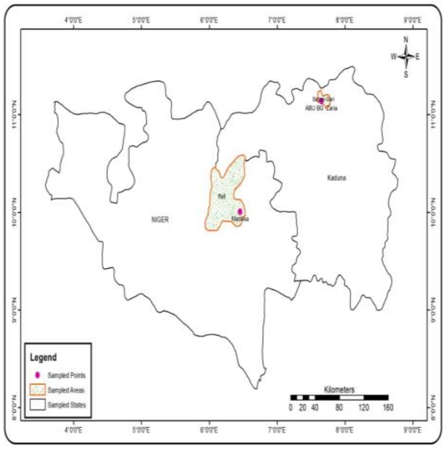

Fig 1 Map of Madakka under Rafi L.G.A of Niger State and Botanical Garden of Ahmadu Bello University, Zaria where Mine Tailing and Garden Soil were Obtained

Soil Thermal Treatment Using an Autoclave

The soil samples were air-dry partially to prevent excessive clumping during sterilization; the soil was saved through a sieve to remove large debris and achieve a uniform texture. The container was Setup, and the soil was placed in the autoclave-safe containers with specialized bags perforated for steam penetration. The autoclave's water reservoir was filled with of distilled water to ensure consistent steam generation and preheated, temperature and Pressure was set in the autoclave to 121°C (250°F) and pressure se at of 15 psi (pounds per square inch) was maintained, the soil was left in the autoclave for a standard for 60 minutes. This method has been employed by many researchers, among who are; (8, 9, 10).

Experimental Design and Soil Homogenization

Homogenized mine tailing and garden soil sterilized were allowed to cool for 30 minutes in accordance with the method described by (11), while non-sterilized mine tailing and garden were also collected after homogenization, two per each were sampled totaling four (4) treatments

Digestion of Soil Sample

The soil sample collected was digested with the following acids, nitric acid 10ml, perchloric acid 2ml and sulphuric acid 1ml. A gram of grinded sieve soil was weighed into a 100ml beaker, 10ml of concentrated nitric acid was added to it, 2ml of concentrated perchloric acid and 1ml of concentrated sulphuric acid all were added. The samples were heated to digest for 10-15 minutes and allowed to cool at room temperature and later dilute with distil water to 50ml volume (11) Ryan *et. al.,* 2001).

Determination Physico-Chemical Properties

Soil pH

The soil sample was dried slightly, 100 grams of soil was placed in a clean container and distilled water to the it at a 1:1 ratio (i.e., equal parts of soil to water). The mixture was stirred thoroughly to create a slurry and was allowed to stay for few minutes to get fully saturated and the particles to settle. The pH meter was calibrated for accurate readings in accordance with method employ by (12) . The electrode was rinsed of the pH meter with distilled water to remove any previous soil or solution residue and inserted into soil-water slurry. The pH meter was allowed to stabilize and display the reading, the pH value displayed by the meter was recorded.

Total organic carbon content

Soil samples were Air-dry and grinded to pass through a fine sieve. The soil was mixed with potassium dichromate ($K_2Cr_2O_7$) solution and sulfuric acid (H_2SO_4). The dichromate oxidizes the organic matter, releasing CO_2. The sample was titrated with Black-titrate dichromate and ferrous ammonium sulfate (FAS) to determine the amount of organic carbon oxidized. stoichiometric relationships were used to calculate the total organic carbon content according to the (13)

$$\text{Percentage organic carbon} = \frac{\text{m.e K2Cr207} - \text{m.eFeSO4)} \times 0.003 \times F \times 10}{\text{Oven} - \text{dry weight of the soil}}$$

Soil Organic Matter Content

One (1g) of soil sample was weigh into a flask, 10ml of potassium dichromate ($K_2Cr_2O_7$) solution (0.167N) was added to the sample, concentrated Sulphuric acid (H_2SO_4) was also added to the mixture to oxidize the organic matter. The mixture turns dark, indicating the oxidation of organic carbon. After the reaction, the samples were titrated with dichromate and a standard ferrous ammonium sulfate (FAS) solution. Organic carbon content was calculated Using the volume of titrant consumed based on the formula. (13), adopted this same method.

Soil Total Nitrogen content

One (1gram) of the dry soil sample was weigh and placed in the digestion flask and concentrated sulfuric acid (H_2SO_4) and catalyst (such as selenium or copper) were added to it. The sulfuric acid breaks down the soil organic matter and converts nitrogen into ammonium sulfate $(NH_4)^2SO_4$. The mixture was subjected to heating at (40°C) until it reached boiling point. The reaction typically lasts for 3 hours. The mixture was allowed to be cooled and then neutralized with sodium hydroxide (NaOH). This process releases ammonia (NH_3) from the ammonium ions. The ammonia was distilled into a solution containing concentration of boric acid (H_3BO_3). This captures the ammonia in the solution. The ammonia solution was titrated with a standard acid, hydrochloric acid (HCl), to determine the amount of ammonia present. The nitrogen content was calculated based on the amount of ammonia recovered and the known factors in the digestion and distillation process. The nitrogen concentration was measured following the Kjeldahl method (14), as determined by Bray 1 method. Using the below formula

$$\text{Percentage N} = \frac{\text{ml H2SO4 x Normality of acid x 0.014 x 100}}{\text{oven} - \text{dried weight of the soil}}$$

Soil Electrical Conductivity

Twenty (20 grams) of soil was placed in a clean container (glass cup). Distilled water was added to the soil, to a common dilution ratio of 1:1 (1-part soil to 1-part water), the mixture was stirred to create a homogeneous slurry. The soil-water mixture was allowed to sit for about 30 minutes.

The EC meter was calibrated with a standard solution of 1413 µS/cm (microsiemens per centimeter), the EC meter was rinse probe with distilled water before use to avoid cross-contamination. The EC reading was taking in microsiemens per centimeter (µS/cm), as describe by (15).

Determination of soil macro-elements

The digested sample were also used to determine the concentration of the following mineral elements; Phosphorous, Magnesium, Calcium, Potassium and Sodium using Microwave Plasma Atomic Emission (Spectroscopy (MP-AES), Agilent 4100), in the following wave length, P 213.62(nm), Mg 285.21(nm), Ca 422.67 (nm), K 766.49 (nm) and Na 589.59 (nm), as adopted by (16).

Determination of Sandy Property in Soil

The methods employed by (16) were adopted. The soils sample was Air-dry to remove moisture and prevent clumping. A stack sieves with mesh sizes 2 mm and 0.2 mm were used in sieving the mine tailing and garden soil, since tailing appeared coarse sand and garden soil fine sand. Hundred grams (100g) of soil was Weigh from each sieve to determine the proportion of sand. The sedimentation was used to analyze soil particle size by suspending soil in water with a dispersing agent and measure the rate at which sand particles settle since larger particles (sand) settle faster than silt or clay. The sand content was determined using the percentage of the total soil weight as seen the formula below.

$$\text{Percentage of Sand} = \frac{\text{Oven} - \text{dry Weigth of Soil Sample} - \text{Hyrometer Reading at 40second}}{\text{Oven} - \text{dry weigth of Soil sample}} \times 100$$

Percentage of Sand = Oven-dry Weight of Soil Sample (Oven-dry Weight of Soil Sample - Hydrometer R eading at 40 seconds) ×100

Where:

- Hydrometer Reading at 40 seconds: The hydrometer measures the concentration of suspended finer particles (silt and clay) after sand particles have settled.
- Oven-dry Weight of Soil Sample: The weight of the soil sample used for the test.

Determination of Clay Property in Soil

Soils samples were air-dry and crushed clumps using a pestle and mortar, and sieve through a 2mm to remove large particles. Fifty (50g) soil was dispensed into water with sodium hexametaphosphate as dispersing agent the mixture was stirred thoroughly to separate particles. The settling rate was measured using a hydrometer at 1, 2, 5, 10, 20 minutes to observe the rapid changes in sedimentation rates, especially in saline conditions in accordance with the procedure used by (16). The percentage of clay in the soil was calculated using the formula.

$$\text{Percentage of Clay} = \frac{\text{Oven} - \text{dry Weigth of Soil Sample}}{\text{Hydrometer Reading at 24 hours}} \times 100$$

Determination of Silt Property in Soil

Soils samples were air-dry and crushed clumps using a pestle and mortar, and sieve through a 2mm to remove large particles. Fifty (50g) of soil was dispense into water with sodium hexametaphosphate as dispersing agent the mixture was stir thoroughly to separate particles. The hydrometer readings were taken at 0, 1, 2, 4, 8, 15, and 30 minutes after the suspension is prepared following the methods adopted by (17). The percentage of silt based on the difference between sand and clay proportions was Calculated using the formula below.

$$\text{Percentage of Silt} = \left(\frac{\text{H2} - \text{H1}}{\text{W}}\right) \times 100$$

Where:

- $H2_{==}$ Hydrometer reading at the silt sedimentation time (usually 40 seconds).
- $1H1_{==}$ Hydrometer reading at the clay sedimentation time (usually 2 hours).
- W: Oven-dry weight of the soil sample (in grams).

Determination of Heavy Metals Accumulation in Soil

The following heavy metals; As, Cr, Fe and Pb, were all determined from the digested samples using Microwave Plasma Atomic Emission (Spectroscopy (MP-AES), Agilent 4100) at the following wavelength, As 253.65(nm), Cr 357.87 (nm), Fe 259.94 (nm) and Pb 405.78 (nm).

Data Analysis

Data obtained were analyzed using Statistical Package for Social Sciences (SPSS) version 23.0, the statistical significance was tested using One-way Analysis of Variance and Duncan's Multiple Range Tests (DMRT) at $P \leq 0.05$.

RESULTS

Soil Chemical and Physical Properties of Sterilized and Unsterilized Mine Tailing and Garden Soil from Madaka before planting.

The results in table 1 show the chemical and physical properties of mine tailing and garden soil after sterilization, prior to plant. There was no significant ($p<0.05$) difference in the soil pH of both the sterilized and unsterilized mine tailing and garden soil, but the pH recorded from unsterilized mine tailing appear with the highest value of 7.97±0.81 while the least value of 6.93±0.06 taken from sterilized garden soil. Significant ($p> 0.05$) difference was observed in the % Organic carbon, unsterilized garden soil gave the highest value of 4.49±1.00 and least value of 1.47±0.58 taking from unsterilized my tailing. In %Organic matter, significant ($p<0.05$) difference was observed with the highest value of 8.10±0.57 obtained from unsterilized garden soil while 1.61±0.62 taken from unsterilized mine tailing. There was no significant ($p>0.05$) difference in percentage Nitrogen thus, 0.61±0.79 was recorded as the highest value while the least value of 0.06±0.04recorded from that of mine tailing. The Phosphorous content appeared with significant ($p<0.05$) difference, unsterilized mine tailing show, highest value of 0.94±0.12 and while 0.53±0.07 was obtained from the sterilized garden soil. There was significant ($p> 0.05$) difference recorded in Magnesium contents of the treatments with the highest value of 8.96±0.74 recorded from the sterilized mine tailing as least value. Calcium on the other hand, also showed significant ($p> 0.05$) difference with the sterilized garden soil haven the highest value of 436.58±38.58 and 197.02±5.54 for unsterilized mine tailing Significant ($p<0.05$) difference was seen in Potassium concentration, sterilized garden soil gave the highest value of 35.27±1.88 and 9.07±2.07 was recorded as the least value from unsterilized mine tailing. There were significant ($p<0.05$) sodium contents with the highest value of 2.03±0.05 documented from sterilized garden soil and the least value of 0.18±0.11 taken from the unsterilized mine tailing. There was significant ($p<0.05$) difference in Exchangeable Cation, with 626.00±0.00 as the highest value from sterilized garden soil, while unsterilized mine tailing gave the least value of 185.10±1.00. There was significant ($p<0.05$) difference in sandy properties of the soils with 85.97±0.55 taken as the highest value from unsterilized mine tailing and 74.20±0.61 as the least for sterilized garden soil. The silt components of garden soils appeared with statistical ($P<9.05$) difference, sterilized mine tailing gave the highest value of 14.10±0.52, while unsterilized mine tailing possess the least value of 5.50±0.61. The clay contents of the soils appeared significantly ($p>0.05$) difference, with 13.50±1.10as the highest from unsterilized garden soil and 2.83±0.67as the least from unsterilized mine tailing.

Table 1: Soil Chemical and Physical parameters of Sterilized and Unsterilized Mine Tailing and Garden Soil from Madaka, before planting.

	Treatments			
Parameters	GUS	GST	MTUS	MTST
pH	7.27±0.55[a]	6.93±0.06[a]	7.97±0.81[a]	7.20±0.36[a]
Org.C (%)	4.49±1.00[a]	2.15±0.58[b]	1.47±0.58[b]	1.87±0.86[b]
Org.M(%)	8.10±0.57[a]	3.70±0.73[b]	1.61±0.62[c]	1.74±0.89[c]
N(%)	0.61±0.79[a]	0.14±0.00[a]	0.06±0.04[a]	0.10±0.11[a]
P(ppm)	0.70±0.10[b]	0.53±0.07[c]	0.94±0.12[a]	0.77±0.01[b]
Mg(ppm)	13.02±2.20[b]	24.80±0.60[a]	11.58±1.23[b]	8.96±0.74[c]
Ca(ppm)	276.47±14.07[b]	436.58±38.58[a]	197.02±5.54[c]	209.87±8.62[c]
K(ppm)	18.69±2.02[b]	35.27±1.88[a]	9.07±2.07[c]	12.10±1.85[c]
Na(ppm)	0.51±0.11[c]	2.03±0.05[a]	0.18±0.11[d]	1.01±0.02[b]
EC (mS/cm)	553.33±5.77[b]	626.00±0.00[a]	185.10±1.00[d]	460.33±0.58[c]
Sand%	75.50±0.61[c]	74.20±0.61[d]	85.97±0.55[a]	83.77±0.12[b]
Silt%	12.40±1.21[b]	11.43±0.64[b]	5.50±0.61[c]	14.10±0.52[a]
Clay%	13.50±1.10[a]	15.13±1.27[a]	8.23±0.38[b]	2.83±0.67[c]

Means ± standard deviation with different superscripts in a row vary significantly at P=0.05 Where: GST= Garden Soil Sterilized, GUS=Garden Soil Unsterilized, MT= Mine Tailing Sterilized, MT= Mine Tailing Unsterilized,

Heavy Metals Content of Unsterilized and Sterilized Garden Soil and Mine Tailing from Madaka before Planting.

Table 2 shows the results of heavy metals presence in unsterilized and sterilized mine tailing and garden soils before the commencement of the research. However, significant ($p<0.05$) difference was observed in Arsenic (As) concentration, with 2.00±0.00 recorded from both sterilized and unsterilized mine tailing while 1.00±0.00 was documented as the least value from sterilized garden soil. Cromiun (Cr) content also appeared with statistical ($p<0.05$) difference, 1.33±0.58 was recorded as the highest value from mine tailing and least value of0.00±0.00 obtained from sterilized garden soil. The Fe concentration also appeared with statistical ($p < 0.05$) difference, with sterilized mine tailing haven the highest concentration of 88.67±1.15 and least value of 0.00±0.00 documented from unsterilized garden soil. The lead (Pb) concentration of the two soils shows significant ($p<0.05$) difference, with high concentration of 582.00±23.81 obtained from unsterilized mine tailing and 0.00±0.00 recorded as the least value from unsterilized garden soil.

Table. 2: Heavy Metals Content of Unsterilized and Sterilized Garden Soil and Mine Tailing from Madaka, before Planting.

	Parameters (ppm)			
Treatments	As	Cr	Fe	Pb
GST	1.00±0.00[b]	0.00±0.00[b]	1.00±0.00[b]	1.00±0.00[c]
GUS	0.00±0.00[b]	1.00±0.00[a]	0.00±0.00[b]	0.00±0.00[c]
MTST	2.00±0.00[a]	1.00±0.00[a]	88.67±1.15[a]	52.33±1.53[b]
MTUS	2.00±0.00[a]	1.33±0.58[a]	88.00±1.73[a]	582.00±23.81[a]

Means ± standard deviation with difference superscript letters in column vary significantly at $p < 0.05$ Where is: GST= Garden Soil Sterilized, GUS= Garden Soil Unsterilized, MT= Mine Tailing Sterilized, MT= Mine Tailing Unsterilized,

DISCUSSION

The result in table 1 shows the chemical and physical properties of soil, collected from the mining and garden site, prior to planting, of which part was subjected to sterilization before inoculation with *G intraradices*. The pH value obtained from sterilized and unsterilized garden and mine tailing soil do not differ statistically. The statistical difference in %Org. C might have been attributed to lack of heat treatments on unsterilized soil (GUS), the same heat treatments might have been source of reduction in the sterilized garden soil i.e (GST). More also, silt and clay content of this soil might have contributed to this change, since the soil type also determined the amount and level at which this organic compound can be bind to the soil particle, part of the nutrients that make up the organic carbon might have been depleted in the heat-treated soil. (18). confirm the effects of thermal treatments on soil properties. The litter of the leaves of this untreated garden soil might have also been a source of organic carbon to this soil; similar report was, reported by (19) that soil organic carbon is usually improved by leave litter around the soil. The organic soil matter of garden soil differs statistically. The high value recorded from unsterilized garden soil may be because of soil type and sterilization methods employed before inoculating it, the garden soil contained debris from plant and animal materials as well as the soil microbes, all together might have formed water- soluble organic matter. As a matter of fact, mine tailing are known with low nutrients composition including organic matter, because they lack plant and animal debris. If any micro-organism exists in this, their number may be very low, and soil micro plays a vital role in busting the soil nutrients and its recycling. This report is in line (21), reported that soil organic matter is made up of biodegradable organic components which are comprised of lipid, carbohydrates, amino acid with proteins and humic substances. In the report of (22 & 23), that forest tree and soil organic matter are usually exposed under intense fire that is generated to the earth crust. Also, the low organic matter content in my tailing soil might be as a result of nutrient defiance. This finding is in line with (22) Romero *et al*., 2021 who reported low organic matter in my tail soil. The percentage Nitrogen soil does not differ statistically in both the garden and mine tailing soil, that was either sterilized or unsterilized. The difference in phosphorous level of garden and mine tailing soil might be as a result of high-level clay soil in the unsterilized soil was higher which might have given them high affinity of binding phosphorous. This is in concomitant with the report of (21), phosphorous usually exist in small concentration and are found attached to clay soil. The heating process might have affected those in the sterilized soils. The Mg, Ca, Na and K differ are cations which are based in nature that possess the ability to change the soil pH. In this regard, this variation may be due to the high presence of anions, which give them advantages to attract this cation. The quantity of these that can be attracted to the soil also depend on composition of the soil, soil pH and hydrogen oxide presence. This result is in line with that of (24), who reported that heating soil can bring about alteration in its physical and chemical composition. However, the difference in Na content in both soil might be as result of presence of other mineral elements might have been a factor responsible for, usually it exist alongside with other mineral element, but after subjecting the soil to heat treatment the Na^{+} this elements might have been able to displace other elements during the heating process, by so doing it give its strong binding ability to CEC formation. This go contrary to the report of (24), reported less binding capacity for Na with other cation, though; heat treatment was not given in their case. A similar scenario was seen in EC concentration which differs statistically with the sterilized soil appearing higher in concentration, for both garden and mine tailing soil. However, from the result obtained all the soil is believed to be in saline state, but with heating they become strongly saline. Though it is believed not to have direct impact on plant growth, however, it shows the amount of nutrients available for plant up take and level of it salinity. The two soil been from arid and semi-arid regions might have undergo salinization given high level of EC. This is in line with the report of (24), reported that high temperature brings about in Na ions in the soil, and presence of this Na ion can bring about high EC. The sandy properties of the two soils differ statistically, with the unsterilized GUS and MTUS having the highest value, the lower value obtained from GST and MTST might have attributed to heating process they were subjected to. This is in line with the report of (25), which reported that high temperatures usually affect the soil physical properties. The silt contents of garden do not differ statistically; however, the statistical difference observed in the tailing soil might be as a result of carbon depletion because of high temperature from the heating. (25), reported the effect of soil heating on aggregate properties and organic carbon depletion. The clay particles of garden soil do not differ statistically, but statistical difference was observed in the mine tailing with the MTUS having the highest value. The colours type of the soil might be a reason behind this variation seen, because darker soils are believed to withstand heat than the lighter soil, however, mine tailing are lighter in colours, with that properties it may not be able to withstand much heat. (26), reported that soil with black soil absorbs more heat and soil that are lighter in colours.

The result presented in table 2 shows the presences of As, Cr, Fe and Pb in mine tailing and garden soil both in sterilized and unsterilized form, prior to planting. The As, Cr, Fe and Pb content, in both sterilized and unsterilized garden soil do not differ from each other's. This might be because of weather and erosion. This agrees with the findings of (27) Wu *et al.* 2021, who reported high concentration of metals through weather and erosion. Also, the heat which these soils were subjected to might have served as one of the determinant factors of this change, probably the allotrope atoms in the metal might have been displaced causing difference reconfiguration, this does not only alter the structure of the metal but also bring about reduction in its strength and hardness. (28), reported that heating the soil to extremely high temperature help reduced soil contaminated with, organic, inorganic and radioactive compound.

CONCLUSION

Significant ($p<0.05$) differences were found in organic carbon (Org. C%), organic matter (%Org. M), phosphorus (P), magnesium (Mg), calcium (Ca), potassium (K), sodium (Na), electrical conductivity (EC), and soil texture components (sand, silt, and clay). Additionally, significant differences were noted in the concentrations of arsenic (As), chromium (Cr), iron (Fe), and lead (Pb) in garden soil and mine tailing.

Competing interests

We declare that this study is free of any conflicting financial or other interests.

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Authors' contributions

SIA oversees field work, data collection, laboratory and Statistical analysis as well as manuscript preparation. ISU designed the experiment and monitored the experimental outcome. WSJ reviews the whole work and monitors the outcome from the field. Mathia A. Chia took part in field work, Manuscript preparation and reviewed the entire work.

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