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# QUALITY AND RISK ASSESSMENT OF COFFEE SENNA (*SENNA OCCIDENTALIS*) AND ITS ASSOCIATED SOIL FROM GARUJE POLLUTED SITE IN DANMAGAJI ZARIA, KADUNA STATE, NIGERIA

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## ABSTRACT

This study evaluates the levels of selected heavy metal contents in soil and coffee senna samples and the risk associated with their consumption, if polluted. Samples of leaves, roots, seeds, and soils were collected at L1, S1, R1, SL1, L2, S2, R2, SL2 (both polluted and control sites). Plant root, leaves and seed collected were washed with distilled water to remove attached soil particles, the root was cut into a smaller portions and then placed in a large crucible where it was dried to 100 $^{o}$C for 48 hours to remove moisture. Soil samples were collected at a depth of 0 – 5 cm and then dried to remove moisture, followed by sieving to remove debris the size of the mesh used was 2 mm. the samples were analysed for arsenic (As), cadmium (Cd), mercury (Hg), nickel (Ni), and lead (Pb) concentrations using A.A.S and risk assessments was conducted using EDI (estimated daily intake), HQ (hazard quotients), and TEQ (toxic equivalent quotient) metrics. The heavy metal contents in the leaves, root, soil and seed of the analysed samples were in the ranges of arsenic (As): 0.02 ± 0.01mg/kg (R1, S1) to 0.26±0.07 mg/kg (L2), cadmium (Cd): 0.12 ± 0.03 mg/kg (R1) to 0.73 ± 0.21 mg/kg (SL2), mercury (Hg): 0.08 ± 0.02 mg/kg (L1) to 1.03 ± 0.30 mg/kg (R2), Nickel (Ni) 0.01 ± 0.00 mg/kg (SL1) to 0.41 ± 0.12 mg/kg (SL2) while a range of 0.05 ± 0.02 mg/kg (L1) to 11.59 ± 3.35 mg/kg (SL2) was recorded for lead (Pb). Overall, the heavy metal concentrations revealed that L2, S2, R2, SL2 had the highest concentrations of heavy metals as compared to L1, S1, R1, SL1, this might be attributed to dumping refuse, burning of tire and waste from heavy trucks which deposited some of this metals. The roots and leaves showed more significant accumulation of metals than seeds, suggesting active uptake and storage mechanisms. Among the samples, SL2 showed markedly higher concentrations of heavy metals, particularly Pb: 11.59 ± 3.35 mg/L as compared to the control site (SL1) having 0.41 ± 0.12 mg/kg, reflecting potential contamination sources from waste dumping, and vehicular emissions. The part of the plant especially, roots generally showed the highest accumulation of mercury (Hg: 1.03 ± 0.30 mg/L in R2), indicating potential translocation from roots to aerial parts. The results indicated significantly elevated risk due to Pb and Hg in the samples, with HQ values far exceeding the requirement (HQ > 1), particularly for children, indicating potential carcinogenic health risks to them. The results of the proximate analysis indicate that sample S1 had the highest proximate contents, revealing a trend of crude protein > CHO > lipid > moisture >ash >fibre, this might be attributed to the composition of nutrients. These findings underscore the urgent need for environmental monitoring and intervention strategies to mitigate human exposure to heavy metal contaminants, as the root and soil are found to contain high amount of this toxic metal.

**Keywords**: Risk Assessment, Coffee Senna, Toxic Metals, AAS, Garuje, Zaria

## INTRODUCTION

*Senna occidentalis*, commonly known as coffee senna, styptic weed, or septic weed, is a species of flowering plant in the family Fabaceae and is native to the southern United States of America, Mexico and South America. It is a shrub with pinnate leaves, with three to seven pairs of broadly elliptic to egg-shaped leaflets, and yellow flowers arranged in groups of two to four, with six fertile stamens in each flower. It is an aggressive, pan tropical weed (Rotton & Klitgård, 2021).

The present of heavy metals in most plant pose a significant impact to health if accumulated much in the human body because they are not needed in the body with the exception of Nickel. Heavy metals tend to be less reactive than lighter metals and have far fewer soluble sulphides and hydroxides (Duffus, 2002). These soils where this plants grow may contain elevated levels of heavy metals like lead, cadmium, arsenic, manganese, Nickel and mercury, which the plant can absorb and accumulate in its tissues. Consumption or use of such contaminated plants poses potential health risks to humans and animals (Olapade *et al*., 2014). Despite its widespread use, there is limited data on the quality and safety of coffee senna in relation to the contamination levels of its growing environment. Risk assessment identifies and analyses potential (future) events that may negatively impact individuals, assets, and/or the environment (i.e. hazard analysis). It also makes judgments "on the tolerability of the risk on the basis of a risk analysis" while considering influencing factors (i.e. risk evaluation) (Manuele, 2016).

The daily environmental exposure to metals were assessed for non - carcinogenic elements. There are several ways of exposure pathway: intake of the metals through herbal medication and consumption, body contact and by skin absorption through bathing

This research is aimed at carrying out the quality and risk assessment of coffee senna (*senna occidentalis*) and its associated soil from Garuje polluted site in Danmagaji Zaria, Kaduna.

## MATERIALS AND METHODS

### Description of the Study Area

This research was conducted at Ungwan Dankali and Garuje Danmagaji Zaria Latitude 11.084770 and Longitude 7.688390 of Kaduna state. One site was chosen base on the level of

pollution and the presence of the target plant *Senna occidentalis*.

**Quality Assurance**
The glassware's were washed with liquid soap, rinsed with distilled water and then soaked in 10 % $HNO_3$ solution for 24 hours The glassware were then rinsed washed with distilled water and then dried in memmert drying oven at 80 $^0$C for 2 hours. All were ensured that they were fully calibrated before used (Todorovi *et al.,* 2001).

**Sample Collections**
The sampling for environmental samples (soil, root, seeds and leaves) was carried out according to standard analytical method describe below:

***Soil***
The samples were collected at different locations: R2, L2, S2 and SL2 were collected at a dumping ground in Garuje while the other samples R1, L1, S1, and SL1 were collected at a clean environment in Ungwan Dankali all in Danmagaji, Zaria, Kaduna state. The samples (15 gram) were collected at a depth of 0-5cm from where the target plant grew with an auger and stored in a well labelled airtight container at room temperature (Allen *et al.,* 1989).

***Plant (Root, Leaves and Seeds)***
Two plant were carefully uprooted and the leaves, root and seed where all collected bagged in a labelled container and taken to the laboratory for processing and analysis (Zhao *et al*., 2009).

**Sample Pre-Treatments**
***Soil***
In the laboratory, the soil samples were allowed to dry at room temperature for a period of eight days to attain a stable weight and large object such as glass, stones, some part of the plant root and polythene were handpicked in the soil sample. The dried soil sample was ground in a ceramic mortar with a pestle made of porcelain. The samples were passed through a 2mm sieve to remove the remaining debris (stones and large pieces of plant litter) leaving behind only the fine soils so that the integrity of the sample will be maintained. The 2 mm dried sample were kept inside a polythene bag until the time of analysis under dried condition (McGrath *et al*., 1985).

***Plant (root, leaves and seed)***
The plant root, leaves and seed collected during the sample collection where washed with distilled water to remove any attached soil particles, the root was cut into a smaller portions and then place in a large crucible were it was dried to 100 $^o$C for 48 hours to remove moisture. The dried samples were all crushed into fine particles using a clean acid washed, mortar and pestle and then stored in a well labelled container prior to digestion and analysis (Parkinson *et al*., 1989).

**Sample Digestion**
***Soil***
Exactly 2 g of each of the soil sample were weighed and transferred into a 100 $cm^3$ glass beakers. This beakers were pre- washed by soaking for 24 hours in detergent solution rinsing with tap water and finally rinsing with deionized water before used. Exactly 15 $cm^3$ concentrated HCl and 5 $cm^3$ concentrated $HNO_3$ were added into the beakers containing the dry soil samples. The samples were swirled gently and left to stand overnight. The beakers were placed on a hot plate heated at 90 – 100$^o$C under reflux condition for two hours. Refluxing was stop but boiling continue until the solution almost dried, but avoiding caking. The samples were cooled and the residue were dissolved in 5 $cm^3$ concentrated $HNO_3$. The digested samples were transferred into 50 $cm^3$ volumetric flask and deionized water was added to about 50 $cm^3$ mark. The solution was filtered with Whatman No 2 filter paper and transferred to a clean 100 $cm^3$ volumetric flask and top to mark with distilled water using polypropylene bottle. This solution was transferred with the 100 $cm^3$ polypropylene plastic bottle prior to analysis (Jeng and Bergseth, 1992).

***Plant (root, leaves, Seed)***
Exactly 0.50 g of each plant samples was weighed into 100.00 $cm^3$ beaker and a mixture of 5.00 $cm^3$ concentrated $HNO_3$ and 2.00 $cm^3$ $HClO_4$ were added and gently swirl digested at a low heat using a hot plate until the content was 2.00 $cm^3$. The digest was then allowed to cool and then filtered into 50.00 $cm^3$ standard flask. The solution was then transferred into the bottle polypropylene plastic (Awofolu, 2005).

**Sample Analysis**
The digested sample were taken to the multi-user science laboratory, Zaria, Kaduna State for determination of the concentrations of metals using A.A.S equipment (Perkin-Elmor model 306 United State of America).

**Proximate Analysis**
The proximate composition such as moisture content, crude protein, crude fibre, crude fat and total ash of the seeds of *S. occidentalis* were determined using standard (AOAC, 2005) methods as follows:

***Moisture content***
Exactly 5 g of previously ground sample was weigh and Placed in a drying oven at 105°C for 12 hours, after which the sample was allowed to cool in a dryer for an hour. It was then removed and weighed again, ensuring that it was not expose to the atmosphere. The moisture contents of the samples were calculated using equation 1 below.
Calculations:

$$\text{Moisture Content (\%)} = 100\,\frac{(B-A)-(C-A)}{(B-A)} \qquad (1)$$

Where:
A = weight of clean, dry scale pan (g),
B = weight of scale pan + wet sample (g),
C = weight of scale pan + dry sample (g)

***Crude protein***
Exactly 1 g of the sample was weighed and placed in the Kjeldahl flask, this was followed by the addition of 10 g potassium sulphate, 0.7 g mercuric oxide and 20 $cm^3$ concentrated sulphuric acid were added into the sample. The mixture were placed in a digester, until its boiling point was reached. The solution was retain until it was clear; the heating continued for 30 more minutes and allowed to cool, gradually adding approximately 90 $cm^3$ distilled water. When cold 25 $cm^3$ sodium sulphate solution was added and stir. And one glass bead and 80 $cm^3$ of 40% sodium hydroxide solution was added, keeping the flask tilted. Two layers where formed, and the mixture was quickly connected to the flask distillation unit, heated and collected 50 $cm^3$ of distillate containing ammonia in 50 $cm^3$of indicator solution. At the end of distillation, the receptor flask was removed. The end of the condenser was rinse and the solution was titrated with the standard chlorhydric acid solution. The amount of crude protein was determined using the following relations in equation 3.

Calculations:

Nitrogen in sample (%) = $100\left[\frac{A\times B}{C}\ 0.014\right]$ (2)

Crude protein (%) = nitrogen in sample × 6.25 (3)

Where:
A = chlorhydric acid used in titration (ml),
B = normality of standard acid,
C = weight of sample (g)

***Crude fat***

The extraction flasks were removed from the kiln without direct contact by hand, allowed to cool in a desiccator, and then weighed to the nearest milligram. Exactly 3 g of dry sample was weighed to within milligrams in an extraction thimble, handling it with tongs and place in the extraction unit. The flask containing petroleum ether at 2/3 of total volume was connected to the extractor. Bring the mixture to a boil, then adjust the heat to maintain approximately 10 reflux cycles per hour. Once complete, remove the ether by distillation or using a rotary evaporator. Cool the flasks in a desiccator and weigh them accurately to the nearest milligram. The crude lipid of the samples were calculated using equation 4 below.

Calculations:

Crude lipid contents (%) =$100\ \frac{B-A}{C}$ (4)

Where:
A = weight of clean dry flask (g),
B = weight of flask with fat (g),
C = weight of sample (g)

***Total ash***

Exactly 2.5 g of dry sampled was placed in a crucible previously calcined and brought to constant weight. The crucible was placed in a furnace and heated at 550°C for 12 hours; after which it was left to cool and transferred to a dryer. The crucible was carefully weighed again with the ash and the ash contents were determined according to equation 5.

Calculations:

Ash content (%) = $100\ \frac{A-B}{C}$ (5)

Where:
A = weight of crucible with sample (g),
B = weight of crucible with ash (g),
C = weight of sample (g)

**Statistical Treatment of the Data**

All statistical analysis on the data treatment was done using Microsoft excel spread sheet for the computation of mean and standard deviation while the analysis of variance and correlation analysis were computed using the SPSS soft-ware.

**Risk Assessment of the Sample**

Risk assessment was calculated based on hazard quotient (HQ), estimated daily intake (EDI), and reference dose (RFD).

***Hazard quotient***

Assessment of non - carcinogenic risk can be achieved by estimating the hazard quotient. It is calculated as the quotient between the environmental exposure and the reference dose (RD). HQ values were obtained for each element (Nii Korley *et a*l., 2020).

$$HQ = \frac{EDI}{RFD} \quad (6)$$

$$EDI = C_m \times \frac{FIR}{BW} \quad (7)$$

Where:
$C_m$ = Average concentration of metal in analytical sample,
FIR = food ingestion rate,
RFD=reference dose, (mg/kg/day)
EDI = Estimated daily intake, (mg/kg/day)
BW = Body weight (kg)

**RESULTS AND DISCUSSION**

**Proximate Analysis of Leaves and Seed of Coffee Senna. *(Senna occidentalis)***

The moisture contents, ash contents, lipid, protein, fibre and carbohydrates contents in the leaves and seed of the analysed samples as reflected in Table 1, these were found to be in the ranges of 6.77 ± 1.69 to 7.04 ± 1.77, 1.85 ± 0.47 to 2.60 ± 0.67, 6.98 ± 1.70 to 11.09 ± 2.80, 90.95±22.73 to 92.50 ± 23.13, 0.79 ± 0.20 to 1.95 ± 0.50, 88.59 ± 22.11 to 91.30 ± 2.83 respectively. The proximate analysis recorded in the analysed samples were found to be higher than values reported by (Olapade *et al.,* 2014) : 9.35% (moisture), 21.88% (crude protein), 19.72% (crude fibre), 16.88% (crude fat), 9.70% (Ash) and 22.47% (nitrogen free extract) in a similar studies. Overall on the basis the proximate analysis sample S1 had the highest contents. Revealing a trend of crude protein > CHO > lipid > moisture >ash >fibre, this might be attributed to the composition of nutrients. The low crude fibre contents of the analysed sample signifies its suitability for use as a food or food supplement, providing other nutrients like proteins or minerals (WHO, 2008). The moisture content was found to be slightly higher in L1 (7.04 ± 1.77%) as compared to S1 (6.77 ± 1.69%). This was attributed to the microbial activity and nutrient availability. Variations in moisture content can influence the decomposition of organic matter and the mobility of nutrients within the soil profile. Ash content, representing the total mineral content, is higher in S1 (2.60 ± 0.67%) than in L1 (1.85 ± 0.47%). This suggests a greater accumulation of inorganic minerals in S1, which could be attributed to differences in parent material or external inputs. Higher ash content indicates the presence of minerals such as calcium, potassium, and magnesium, essential for plant growth. The lipid content is notably higher in S1 (11.09 ± 2.80%) compared to L1 (6.98 ± 1.70%). Elevated lipid levels may result from increased microbial biomass or organic matter decomposition. Lipids in soil play a role in energy storage for microorganisms and can influence soil structure and water retention. Protein content is slightly higher in L1 (92.50 ± 23.13%) than in S1 (90.95 ± 22.73%). Proteins are vital components of soil organic matter and serve as a nitrogen source for plants and microbes. The similar protein levels suggest comparable organic matter inputs and microbial activity in both samples. S1 exhibits a higher fibre content (1.95 ± 0.50%) compared to L1 (0.79 ± 0.20%). fibre, primarily composed of cellulose and lignin, contributes to soil structure and carbon sequestration. Higher fibre content can enhance soil aggregation and water retention. Carbohydrate content is slightly higher in L1 (91.30 ± 22.83%) than in S1 (88.59 ± 22.11%). Carbohydrates serve as energy sources for soil microorganisms, influencing microbial activity and nutrient cycling. The marginal difference suggests similar levels of labile organic matter in both samples.

**Table 1**: **Proximate Analysis of Leaves and Seed of Coffee Senna (*Senna Occidentalis*)**

| Sample | Moisture | Ash | Lipid | Protein | Fibre | CHO |
|---|---|---|---|---|---|---|
| L1 | 7.04±1.77 | 1.85±0.47 | 6.95±1.70 | 92.50±23.13 | 0.79±0.20 | 91.30±22.83 |
| S1 | 6.77±1.69 | 2.60±0.67 | 11.09±2.80 | 90.95±22.73 | 1.95±0.50 | 88.59±22.11 |

**Heavy Metal Contents of L1, L2, S1, S2, R1, R2, SL1 AND SL2 of Coffee Senna (*Senna Occidentalis*)**

The heavy metal contents in the leaves, root, soil and seed of the analysed samples as reflected in Table 2 were found to be in the ranges of Arsenic (As): 0.02±0.01 (R1, S1) to 0.26±0.07 (L2). Cadmium (Cd): range from 0.12±0.03 in R1 to 0.73±0.21 in SL2. Mercury (Hg): range from 0.08±0.02 (L1) to 1.03±0.30 in (R2). Ni range from 0.01±0.00 in (SL1) to 0.41±0.12 in (SL2). Lead (Pb): Concentrations range from 0.05±0.02 in (L1) to 11.59±3.35 in (SL2). Arsenic is strongly correlated with Cd (0.957658), Hg (0.972676), and Ni (0.985927), indicating a strong positive relationship. Cadmium was found to correlate with As (0.957658), Hg (0.921115), and Ni (0.983682).

Mercury strongly correlated with As (0.972676), Cd (0.921115), and Ni (0.963285). Nickel strongly correlated with As (0.985927), Cd (0.983682), and Hg (0.963285), indicating a strong positive relationship. Lead moderately correlated with As (0.496723), Cd (0.593921), and Ni (0.521433), indicating a moderate positive relationship. The heavy metal analysis recorded in the analysed samples were found to be higher than those reported by Husain and Khan (2010) in *Jatropha curcas L,* in a similar studies. The lead contents in the polluted site in SL2 exceed the permissible limit this may cause a variety of negative effects in living organisms, such as cancer, respiratory, impairing effect on the immune system etc. This metal is especially dangerous to children since it harms their intelligence and nervous systems (Borges *et al*., 2003). Overall the heavy metal concentration analysis revealed that L2, S2, R2, SL2 have the highest concentrations of heavy metals compared to L1, S1, R1, SL1 this might be attributed to dumping refuse, burning of tire and waste from heavy trucks which deposit some of this metals.

In the plant parts, roots and leaves showed more significant accumulation of metals than seeds, suggesting active uptake and storage mechanisms. This observation was found to be consistent with the studies on the phytoremediation potential of *Senna occidentalis*, which demonstrated the plant's ability to accumulate heavy metals in its tissues (WHO, 2021). The findings from this study, indicate a clear variation in heavy metal concentrations between samples collected from polluted and control sites in Zaria. All the five analysed metals arsenic (As), cadmium (Cd), mercury (Hg), nickel (Ni), and lead (Pb) were present in varying concentrations in soil and Coffee senna plant tissues.

The polluted site (SL2) showed markedly higher concentrations of heavy metals, particularly lead (Pb = 11.59 ± 3.35 mg/L), compared to the control site (SL1), reflecting potential contamination sources from waste dumping, and vehicular emissions. Among plant parts, roots generally had the highest accumulation of heavy metals, especially mercury (Hg = 1.03 ± 0.30 mg/L in R2), supporting existing literature that roots act as the first barrier and major site of metal uptake. Root (R2) and Leaves (L2) also showed significant metal content, particularly lead, mercury and arsenic, indicating potential translocation from roots to aerial parts. This results suggest that there is a significant difference between the groups, as indicated by the p-value (0.016529) <0.05. Which is related to the variations in metal concentrations. This means that the null hypothesis of no difference between groups can be rejected.

**Table 2: Heavy Metal Concentrations In Coffee Senna Leaves, Seeds, Root, and Soil Sample Concentrations of Metals (mg/kg)**

| Samples | As | Cd | Hg | Ni | Pb |
|---|---|---|---|---|---|
| L1 | 0.16±0.05 | 0.41±0.12 | 0.08±0.02 | BDL | 0.05±0.02 |
| L2 | 0.26±0.07 | 0.29±0.08 | 0.88±0.25 | 0.25±0.07 | 0.31±0.09 |
| R1 | 0.02±0.01 | 0.12±0.03 | 0.26±0.07 | 0.02±0.01 | 0.28±0.08 |
| R2 | 0.25±0.07 | 0.21±0.06 | 1.03±0.30 | 0.18±0.05 | 0.59±0.17 |
| S1 | 0.02±0.01 | 0.44±0.13 | 0.56±0.16 | BDL | BDL |
| S2 | 0.13±0.04 | 0.31±0.09 | BDL | 0.18±0.05 | 0.48±0.14 |
| SL1 | BDL | 0.48±0.14 | BDL | 0.01±0.00 | 0.29±0.08 |
| SL2 | 0.17±0.05 | 0.73±0.21 | 0.10±0.03 | 0.41±0.12 | 11.59±3.35 |

**Risk Assessment of Metal in Soil and Coffee Senna Plant Control Site**

The risk assessment of each metal in the analysed sample L1 Table 3 were carried out using the hazard quotient and was found to be the range for both child and adult. Pb: Adult 0.7188(HQ) and child 1.9330(HQ), As: Adult 3.0660(HQ) and Child 8.2488(HQ), Hg: Adult 1.5330(HQ) and Child 4.1244(HQ), Cd: Adult 2.3550(HQ) and Child 5.9450(HQ), Ni: Adult 0.0000(HQ) and Child 0.0000(HQ). The risk assessment reveal that the sample contains significant levels of Pb, As, Hg, and Cd, which may pose a health risk to children. The HQ values indicate that children may be more vulnerable to these risks due to their higher EDI values. By analysing Table 3 the HQ values for lead (Pb) were substantially above 1, indicating a high risk of non-carcinogenic effects. Lead exposure is known to affect multiple body systems, with children being particularly vulnerable to its neurotoxic effects. Chronic exposure can lead to developmental issues, reduced IQ, and behavioural problems (WHO, 2020). Arsenic HQ values are alarmingly high, especially for children. Arsenic exposure is associated with skin lesions, developmental effects, cardiovascular disease, neurotoxicity, and an increased risk of cancer. The extremely high HQ values suggest a severe health risk from arsenic in coffee senna. Mercury exposure, particularly methylmercury, affects the nervous system and is especially harmful to developing foetuses and young children. The HQ values indicate a significant risk, necessitating immediate attention to prevent mercury-related health issues (EPA, 2021). Cadmium is a toxic metal that can cause kidney damage, bone demineralization, and is classified as a human carcinogen. The HQ values for cadmium are exceedingly

high, indicating a severe risk to both adults and children consuming coffee senna. Nickel levels are negligible in this sample, posing no significant health risk based on the current data.

**Table 3: Estimated Daily Intake and Hazard Quotient for Children and Adults for Sample L1**

| Sample | Metal | EDI | | HQ | |
|---|---|---|---|---|---|
| | | Adult | Child | Adult | Child |
| L1 | Pb | 0.0003 | 0.0007 | 0.7188 | 1.9333 |
| | As | 0.0009 | 0.0023 | 3.0667 | 8.2488 |
| | Hg | 0.0005 | 0.0012 | 1.5333 | 4.1244 |
| | Cd | 0.0024 | 0.0059 | 2.3575 | 5.9450 |
| | Ni | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

The risk assessment of each metal in the analysed sample S1 Table 4 were carried out using the hazard quotient and was found to be for both child and adult. Pb: Adult 0.0000(HQ) and child 0.0000(HQ), As: Adult 0.3833 (HQ) and Child 1.5333(HQ), Hg: Adult 10.7333(HQ) and Child 28.8711(HQ), Cd: Adult 2.530(HQ) and Child 6.8053(HQ), Ni: Adult 0.0000(HQ) and Child 0.0000(HQ). The risk assessment revealed that the sample contained a significant level of As, Hg, Cd signifying a potential health risk as the consumption of this plant from the assessed area poses serious non-carcinogenic health risks, and measures should be taken to prevent exposure especially to children. However Ni and Pb indicated no detectable health risk in the analysed sample, this might be attributed to the low level of the metal in the sample. Mercury HQ values are alarmingly high, particularly for both adult and children, especially methylmercury, is a potent neurotoxin that can impair neurological development in children. Exposure to high levels of methylmercury can lead to cognitive deficits, including impairments in language, attention, and memory (Naujokas *et al.,* 2013). Cadmium HQ values are exceedingly high, indicating a severe risk to both adults and children. Cadmium exposure is linked to kidney damage and developmental issues. Studies have associated early-life cadmium exposure with cognitive impairments and behavioural problems in children (Wilson, 2012*)*.

**Table 4: Estimated Daily Intake and Hazard Quotient for Children and Adults for Sample S1**

| Sample | Metal | EDI | | HQ | |
|---|---|---|---|---|---|
| | | Adult | Child | Adult | Child |
| S1 | Pb | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | As | 0.0001 | 0.0046 | 0.3833 | 1.5333 |
| | Hg | 0.0015 | 0.0040 | 4.9833 | 13.4044 |
| | Cd | 0.0007 | 0.0019 | 2.5300 | 6.8053 |
| | Ni | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

The risk assessment of each metal in the analysed sample R1 Table 5 were carried out using the hazard quotient and was found to be for both child and adult. Pb: Adult 4.0250(HQ) and child 10.8269(HQ), As: Adult 0.3833(HQ) and Child 1.0311(HQ), Hg: Adult 4.9833(HQ) and Child 13.4044(HQ), Cd: Adult 0.6900(HQ) and Child 1.856(HQ), Ni: Adult 0.0058(HQ) and Child 0.0155(HQ). The risk assessment reveal that the sample contains a significant level of Pb, As, Hg, Cd, Lead exposure is associated with various health issues, including cognitive deficits, behavioural problems, and developmental delays in children. Even low levels of lead exposure can negatively affect a child's health, leading to lower IQ, decreased ability to pay attention, and underperformance in school (CDC, 2024). Arsenic exposure is associated with various health issues, including cognitive deficits in children. Studies have shown that arsenic exposure correlates with poorer performance on intelligence measures, particularly verbal IQ, and these effects can persist into adolescence. Cadmium exposure is linked to kidney damage and developmental issues. Studies have associated early-life cadmium exposure with cognitive impairments and behavioural problems in children (EPA, 2024) and low detectable risk in Nickel. This may be attributed to low metal content the sample.

**Table 5: Estimated Daily Intake and Hazard Quotient for Children and Adults for Sample R1**

| Sample | Metal | EDI | | HQ | |
|---|---|---|---|---|---|
| | | Adult | Child | Adult | Child |
| R1 | Pb | 0.0016 | 0.0043 | 4.0250 | 10.8267 |
| | As | 0.0002 | 0.0003 | 0.3833 | 1.0311 |
| | Hg | 0.0015 | 0.0040 | 4.9833 | 13.4044 |
| | Cd | 0.0007 | 0.0019 | 0.6900 | 1.85600 |
| | Ni | 0.0001 | 0.0003 | 0.0058 | 0.0155 |

The risk assessment of each metal in the analysed sample SL1 Table 6 were carried out using the hazard quotient and was found to be for both child and adult. Pb: Adult 4.1687(HQ) and child 11.2133(HQ), As: Adult 0.0000 (HQ) and Child 0.00(HQ), Hg: Adult 0.00(HQ) and Child 0.0000(HQ), Cd: Adult 2.7600(HQ) and Child 7.4240(HQ), Ni: Adult 0.0029(HQ) and Child 0.0077(HQ). The result of the risk assessment reveal that the sample contains a significant level of Pb and Cd. Lead exposure is associated with various health issues, including cognitive deficits, behavioural problems, and developmental delays in children. Even low levels of lead exposure can negatively affect a child's health, leading to lower IQ, decreased ability to pay attention, and underperformance in school (CDC, 2024). Cadmium exposure is linked to kidney damage and developmental issues. Studies have associated early-life cadmium exposure

with cognitive impairments and behavioural problems in children and low detectable risk in Arsenic, mercury but in Nickel (Ni) HQ values exceed 1 in children, indicating a potential health risk. Nickel exposure can cause allergic reactions and has been associated with respiratory issues and other health problems. This may be attributed to the low metal content in the sample.

**Table 6: Estimated Daily Intake and Hazard Quotient for Children and Adults for Sample SL1**

| Sample | Metal | EDI | | HQ | |
|---|---|---|---|---|---|
| | | Adult | Child | Adult | Child |
| SL1 | Pb | 0.0012 | 0.0045 | 4.1687 | 11.2133 |
| | As | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Hg | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Cd | 0.0028 | 0.0007 | 2.7600 | 7.4240 |
| | Ni | 0.00006 | 0.0002 | 0.0029 | 0.0077 |

**Risk Assessment of Metal in Soil and Coffee Senna Plant in Polluted Site**

The risk assessment of each metal in the analysed sample L2 Table 7 were carried out using the hazard quotient and was found to be for both child and adult. Pb: Adult 4.4563(HQ) and child 11.9867(HQ), As: Adult 4.9833 (HQ) and Child 13.4044(HQ), Hg: Adult 16.8667(HQ) and Child 45.3689(HQ), Cd: Adult 1.6675(HQ) and Child 4.4853(HQ), Ni: Adult 0.0719(HQ) and Child 0.1933(HQ). The result of the risk assessment reveal that the sample contains a significant level of Pb, As, Hg, Cd therefore Lead, arsenic, mercury, and cadmium pose serious health risks, particularly to children. Lead and arsenic are linked to cognitive deficits, developmental delays, and neurotoxicity, even at low levels. Mercury exposure can impair motor skills and learning, especially in children and foetuses. Cadmium has been associated with cognitive and behavioural issues (Schoeters *et al*., 2006). Nickel showed minimal risk, likely due to its lower concentration in the sample.

**Table 7: Estimated Daily Intake and Hazard Quotient for Children and Adults for Sample L2**

| Sample | Metal | EDI | | HQ | |
|---|---|---|---|---|---|
| | | Adult | Child | Adult | Child |
| L2 | Pb | 0.0018 | 0.0048 | 4.4563 | 11.9867 |
| | As | 0.0015 | 0.0040 | 4.9833 | 13.4044 |
| | Hg | 0.0050 | 0.0136 | 16.8667 | 45.3689 |
| | Cd | 0.0017 | 0.0045 | 1.6675 | 4.4853 |
| | Ni | 0.0014 | 0.0039 | 0.0719 | 0.1933 |

The risk assessment of each metal in the analysed sample R2 Table 8 were carried out using the hazard quotient and was found to be for both child and adult. Pb: Adult 8.4812(HQ) and child 22.8133(HQ), As: Adult 4.7917 (HQ) and Child 12.8889(HQ), Hg: Adult 19.7417(HQ) and Child 5.3102(HQ), Cd: Adult 1.2075(HQ) and Child 3.348(HQ), Ni: Adult 0.0518(HQ) and Child 0.1392(HQ). The risk assessment revealed significant levels of Pb, As, Hg, and Cd in the samples, likely due to environmental contamination from refuse dumping, tire burning, and heavy truck emissions. Continued use of the plant as food or medicine could pose serious health risks, especially to children, including reduced IQ, attention deficits, and developmental delays. Arsenic and mercury are particularly neurotoxic, while cadmium exposure has been linked to cognitive and behavioural issues in children (Schoeters *et al*., 2006). Nickel showed low detectable risk due to its minimal concentration.

**Table 8: Estimated Daily Intake and Hazard Quotient for Children and Adults for Sample R2**

| Sample | Metal | EDI | | HQ | |
|---|---|---|---|---|---|
| | | Adult | Child | Adult | Child |
| R2 | Pb | 0.0034 | 0.0091 | 8.4812 | 22.8133 |
| | As | 0.0014 | 0.0039 | 4.7917 | 12.8889 |
| | Hg | 0.0059 | 0.0016 | 19.7417 | 5.3102 |
| | Cd | 0.0012 | 0.0032 | 1.2075 | 3.3480 |
| | Ni | 0.0010 | 0.0028 | 0.0518 | 0.1392 |

The risk assessment of each metal in the analysed sample SL2 Table 9 were carried out using the hazard quotient and was found to be for both child and adult. Pb: Adult 166.6000(HQ) and child 448.1460(HQ), As: Adult 3.2583(HQ) and Child 8.7644(HQ), Hg: Adult 1.9167(HQ) and Child 7.6667(HQ), Cd: Adult 4.1975(HQ) and Child 11.2906(HQ), Ni: Adult 0.1179(HQ) and Child 0.3171(HQ). The risk assessment indicates elevated levels of Pb, As, Hg, and Cd, with potential adverse health implications. Lead and arsenic pose significant neurodevelopmental risks, particularly in children, even at low exposure levels. Mercury exhibited notable neurotoxicity, while cadmium has been associated with cognitive and behavioural impairments in early life (Schoeters *et al*., 2006). Nickel presented minimal risk, likely due to its low concentration in the samples.

**Table 9: Estimated Daily Intake and Hazard Quotient for Children and Adults for Sample SL2**

| Sample | Metal | EDI | | HQ | |
|---|---|---|---|---|---|
| | | Adult | Child | Adult | Child |
| SL2 | Pb | 0.0664 | 0.1793 | 166.6000 | 448.1460 |
| | As | 0.0009 | 0.0026 | 3.2583 | 8.7644 |
| | Hg | 0.0006 | 0.0023 | 1.9167 | 7.6667 |
| | Cd | 0.0042 | 0.0113 | 4.1975 | 11.2906 |
| | Ni | 0.0024 | 0.0063 | 0.1179 | 0.3171 |

The risk assessment of each metals in the analysed sample S2 Table 10 were carried out using the hazard quotient and was found to be for both child and adult. Pb: Adult 6.9000(HQ) and child 18.5600(HQ), As: Adult 2.4917 (HQ) and Child 6.7022(HQ), Hg: Adult 0.0000(HQ) and Child 0.0000(HQ), Cd: Adult 1.7825(HQ) and Child 4.7946(HQ), Ni: Adult 0.05175(HQ) and Child 0.1392(HQ). The risk assessment revealed high levels of Pb, As, and Cd, indicating significant toxicological concerns, particularly for children due to their heightened vulnerability to neurodevelopmental effects. Nickel and Mercury posed minimal risk due to its low concentration. (Schoeters *et al.,* 2006). This may be attributed to low metal content in the sample.

**Table 10: Estimated Daily Intake and Hazard Quotient for Children and Adults for Sample S2**

| Sample | Metal | EDI | | HQ | |
|---|---|---|---|---|---|
| | | Adult | Child | Adult | Child |
| S2 | Pb | 0.0028 | 0.0074 | 6.9000 | 18.5600 |
| | As | 0.0007 | 0.0020 | 2.4917 | 6.7022 |
| | Hg | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Cd | 0.0018 | 0.0048 | 1.7825 | 4.7947 |
| | Ni | 0.0010 | 0.0028 | 0.0518 | 0.1392 |

## CONCLUSION

There was significant contamination of *Senna occidentalis* and surrounding soils samples with heavy metals, notably Pb (ranging from 11.59 mg/kg in SL2 and 0.59mg/kg in R2) and Hg (ranging from 1.03mg/kg in R2 and 0.88mg/kg in L2) in polluted sites coffee senna compared to the control locations. The elevated concentrations, particularly in plant roots and leaves, indicate active uptake and accumulation mechanisms. Risk assessments, including Estimated Daily Intake (EDI) and Hazard Quotient (HQ), suggest that the consumption of these plants poses potential non-carcinogenic and carcinogenic health risks, especially for children, due to HQ values (ranging from 8.48 for adult and 22.81 for child in R2, 6.9 for Adult and 18.56 for child in S2, 166.60 for adult and 448.10 for child in SL2) exceeding safe thresholds. Pb was found to be the predominant contributor to the overall toxic burden. These findings underscore the urgent need for environmental monitoring and intervention strategies to mitigate human exposure to heavy metal contaminants, as the root and soil are found to contain high amount of this toxic metal. Consuming this root as medicine will pose a tremendous health damage.

## RECOMMENDATION

Further Research should be conducted comprehensively to explore the mechanisms of heavy metal uptake in *senna occidentalis* and assess the long-term health impacts on local populations. Government should initiate soil remediation programs in heavily polluted areas to reduce heavy metal concentrations and restore soil health and local communities should be educated about the potential health risks associated with consuming plants from contaminated areas and promote safe agricultural practices.

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