Journal of Family and Society Research 4(1), June 2025; pp 82-96
ISSN – 1668 (online) 1676 (print) **DOI:** https://doi.org/10.66043/jfsr.v4i1.118

Microbial and Heavy Metal Contents of Selected Herbal Medicines Sold in Enugu State, Nigeria

***Nnubia, F.C[1] & Eniola, A.[1]**
[1]Department of Pharmacy, Hill City University of Science and Technology, Monrovia, Liberia.
Correspondence: mendyfavour062@gmail.com

Submitted – May 16, 2025
Final revision – June 19, 2025
Accepted – June 19, 2025

Abstract

This study investigates the microbial and heavy metal contents of selected herbal medicines sold in Enugu State, Nigeria. Specifically, the study evaluated the presence of bacterial, parasitic, and fungal loads and heavy metals (mercury, lead, zinc, and iron) in herbal medicine samples. Ten branded samples were purchased from Ogige and Ogbete main markets and labelled A to J. These medicines were indicated for the treatment of malaria, typhoid fever, ulcers, sexually transmitted infections, worm infestations, and general blood cleansers. Laboratory analysis, using standard methods, was employed to determine the microbial and heavy metal contents of the samples. Culturing and microscopy methods were used for microbial analysis while heavy metal analysis was done using atomic absorption spectrophotometry. The analyses were carried out in duplicates using percentages, means, and standard deviations. The results showed that 60% of the samples exceeded safety limits for microbial contamination, while all samples had excessive iron levels. Sample (A) contained mercury (0.161mg/100ml) above the safe standards established by the FAO/WHO. Seven samples (A, B, C, D, E, G, and I) were found to contain coliform bacteria and sample A contained *Escherichia coli, Proteus mirabilis, and Bacillus polymyxa* above safety limits. No sample was found with fungal and parasitic load above safety limits. The study concludes that herbal medicines may not be assured of safety in terms of bacterial, and heavy metal (iron and mercury) contents. The findings underline the health risks associated with unregulated locally prepared herbal medicines.

Keywords: Herbal Medicine, Microbial Contamination, Heavy Metals, Safety, Nigeria.

Introduction

Herbal medicine, also called botanical medicine or phytomedicine, refers to the use of plant seeds, fruits containing seeds, roots, leaves, bark, or flowers for medicinal purposes. Herbalism, or the use of phytomedicine, has a long tradition outside conventional medicine, dating back to the time of early humans (Hosseinzadeh et al., 2015). According to Hosseinzadeh et al. (2015), literature from Chinese and Egyptian papyrus documents as early as 3,000 BC, highlights the medical applications of many plants. Herbal remedies were utilized in the ancient

Journal of Family and Society Research 4(1), June 2025; pp 82-96
ISSN – 1668 (online) 1676 (print) **DOI:** https://doi.org/10.66043/jfsr.v4i1.118

medical systems of Ayurveda and Traditional Chinese Medicine, while other indigenous cultures, such as Native American and African societies, incorporated plants into their healing rituals. Researchers found that people used similar or identical plants for comparable purposes worldwide (WHO, 2023). In the early 19th century, with the advent of chemical analysis, scientists began extracting and modifying active ingredients from plants. Subsequently, chemists created their own versions of plant compounds, leading to a decline in the use of herbal medicines in favor of conventional drugs. Today, nearly one-fourth of pharmaceutical drugs are derived from botanicals.

However, over the past three decades, the use of traditional medicine and supplements has increased tremendously with at least 80% of people worldwide relying on them for some part of primary healthcare (WHO, 2023). The WHO reported that these numbers are expected to continue to rise rapidly, and they are no longer used only for certain aspects of primary healthcare; people now turn to them for treating various health challenges in different national healthcare contexts. According to the WHO, in many affluent countries, 70% to 80% of the population has utilized alternative or complementary medicine, including Ayurvedic, homeopathic, naturopathic, traditional oriental, and Native American Indian medicine. The WHO also acknowledges that herbal remedies are the most popular form of traditional medicine and are quite lucrative in the global medical industry (WHO, 2023).

We can attribute the increase in the use of herbal medications to several factors. Over the past 20 years in the United States, public dissatisfaction with the cost of prescription medications, combined with a growing interest in returning to natural or organic remedies, has led to a rise in herbal medicine use (Nelson & Perrone, 2000). It has been suggested that part of the reason for this increase in interest is that certain innovations and quality control measures, adequate labeling, and appropriate patent information have been implemented in the manufacturing processes of these phytomedicines; however, there is still significant room for improvement since some of their therapeutic claims have not yet undergone clinical tests and therefore have not been proven to be true (Bellanger & Seeger, 2021; Davis & Choisy, 2024). One of the primary reasons for the continued popularity of herbal medication products is their perceived natural origin and historical use. Many societies have a long-established tradition of using herbal treatments to manage a wide range of illnesses and enhance overall well-being. The easy accessibility of these phytochemicals also plays a major role in their increasing use, as they can be easily grown in gardens and are especially useful in treating minor ailments.

Herbal drugs have indeed proven to be very potent but little consideration has been made to how these medicines are produced. Some of these medications might not meet the standard requirements for human consumption. During observation of some methods of preparation, the

Journal of Family and Society Research 4(1), June 2025; pp 82-96
ISSN – 1668 (online) 1676 (print) **DOI:** https://doi.org/10.66043/jfsr.v4i1.118

researchers noticed some unhygienic practices. For example, some herbs are forbidden to be washed with water and are to be prepared in the same state they were harvested. These are superstitious beliefs that can pose a serious threat to human health. Several studies have extensively documented the presence of microbial contaminants in unbranded herbal medicines, including a wide variety of bacteria, fungi, and molds (Ahiabor et al., 2024; Olaniran et al., 2022). These contaminants often originate from multiple sources, such as raw materials contaminated during harvesting, inadequate processing methods, and improper storage conditions, such as exposure to moisture or unsanitary environments. In some cases, the use of non-sterile equipment during the production process can exacerbate the contamination. Common pathogens found in herbal products include *Salmonella spp.*, *Escherichia coli*, *Staphylococcus aureus*, and various species of *Aspergillus* (Dabo et al., 2023). These harmful microorganisms can be introduced to herbal medicines at any point along the supply chain, from cultivation to retail. When consumed, contaminated herbal medicines can lead to a variety of adverse health effects, including gastrointestinal infections, food poisoning, allergic reactions, and even more severe systemic illnesses such as sepsis or fungal infections (Foster, 2017). The risk of these health issues is especially high among individuals with weakened immune systems, such as the elderly, children, and those with chronic diseases (Ramon-Torrell, 2024). Given the increasing popularity of herbal medicines as an alternative or complementary form of treatment, the presence of microbial contamination poses a significant and growing threat to public health. The lack of stringent regulatory practices in many regions further compounds this issue, emphasizing the need for more robust safety standards and testing protocols in the production and distribution of herbal products.

Herbal medicines are also highly susceptible to contamination by heavy metals, including lead, mercury, cadmium, and arsenic (Alharbi et al., 2024). These toxic metals can enter herbal products through several environmental and production-related pathways. For instance, they may accumulate in the soil from contaminated water or air pollution, which is then absorbed by plants as they grow. Heavy metals can also be introduced during the processing stage, where they may be present in water, equipment, or packaging materials that are not adequately regulated or monitored. In some cases, these metals may even be used intentionally in some traditional practices or as adulterants to enhance the appearance or perceived potency of herbal products (Briffa et al., 2020). Chronic exposure to heavy metals, particularly through the consumption of contaminated herbal medicines, poses significant health risks. Long-term exposure to lead and mercury, for example, can lead to neurological disorders, including cognitive impairment and developmental delays in children (Fatima et al., 2025). Cadmium is known to be nephrotoxic, meaning it can cause severe kidney damage, while arsenic is

Journal of Family and Society Research 4(1), June 2025; pp 82-96
ISSN – 1668 (online) 1676 (print) **DOI:** https://doi.org/10.66043/jfsr.v4i1.118

a known carcinogen, increasing the risk of cancers in organs such as the skin, lungs, and bladder (Genchi et al., 2020). Additionally, heavy metals can contribute to cardiovascular diseases by causing damage to blood vessels, leading to high blood pressure, heart disease, and stroke (Ozarde et al., 2025). Vulnerable populations, including pregnant women, children, and the elderly, are especially at risk of the harmful effects of heavy metal exposure. For pregnant women, exposure to certain metals like lead and mercury can affect fetal development, leading to birth defects, low birth weight, and developmental delays, in addition, children are particularly sensitive to the neurotoxic effects of heavy metals, which can impair their cognitive development and learning abilities (Al-Saleh et al., 2024). The elderly, on the other hand, may have compromised kidney and liver function, making them more susceptible to the toxic effects of these metals. Given the widespread use of unchecked herbal products, especially in developing countries where regulation may be lax, heavy metal contamination is a growing public health concern (Aaseth et al., 2021).

The need for research on the safety of these medications is, therefore, critical due to the growing demand and usage of these medications worldwide. For example, a recent survey found that more than 70% of the German population used "natural medicines" and that, for most of them, herbal medicinal items were their first option for treating minor ailments or problems (Welz et al., 2019). The global use of herbal medicines is large, so it is vital to evaluate the dangers associated with their usage based on population exposure alone (WHO, 2004). Things that can affect the safety of herbal medicines are numerous ranging from agricultural factors such as the kind of climate, soil quality in which the plants grew, and manufacturing factors such as how it was processed. Several studies have been carried out on some traditional medicines in other countries but few studies have been carried out on the herbal medicines in Nigeria (Hlihor et al., 2022). Therefore, it is imperative that we carry out this research.

Objectives of the Study

- To analyze the microbial contamination (bacteria, fungi, parasites) in commonly used herbal medicines.
- To assess the presence of heavy metals in herbal samples.
- To evaluate the safety of the herbal medicines.

Materials and Methods

Sample Procurement and Preparation

The samples were procured from Ogbete market situated in the capital city of Enugu State and Ogige market located in Nsukka, Enugu State, Nigeria. Ten different Herbal samples were purchased from different sellers in the markets. These medicines were indicated for the treatment of malaria, typhoid fever, ulcers, sexually transmitted infections, worm infestation, and general blood cleansers. They were labelled accordingly and transported immediately to the laboratory for analysis. The study was carried out in two laboratories at the

Journal of Family and Society Research 4(1), June 2025; pp 82-96
ISSN – 1668 (online) 1676 (print) **DOI: https://doi.org/10.66043/jfsr.v4i1.118**

University of Nigeria, Nsukka, Enugu state, Nigeria. The heavy metal analysis was conducted at the Analytical Laboratory of the Department of Nutrition and Dietetics, and the microbial analysis was carried out at the Microbiology Laboratory of the Department of Pharmacy.

The microbial analysis was carried out using a combination of serial dilution and streak-plating techniques used in the identification of organisms, especially bacteria as described by Sanders (2012). One millilitre of the herbal drugs was diluted in 9 ml of sterile water under strict aseptic conditions. Using a sterile wire loop, a loopful of the dilutions was inoculated by streaking on glucose-enriched sterile agar under aseptic conditions. The cultures were incubated in an inverted position. After the due period of incubation, the culture plates were observed for growth and the results were recorded.

Determination of the Original Cell Population in the Herbal Samples via the Surface Viable Count Method

The original cell populations were determined using the Miles and Misra method of surface viable count (Miles et al., 1938). One ml of the herbal liquid samples was diluted in 9 ml of sterile water under aseptic condition thus, 10^-1 Dilution was obtained. A 10^-2, 10^-3, 10^-4, 10^-5 dilutions were obtained from the suspensions using 10-fold serial dilution techniques. A 0.02ml from each of the dilutions was plated out separately to determine the dilution that could give countable colonies. The culture plates were allowed to stand for 15 minutes for proper absorption before incubation. The culture plates were incubated in inverted position at 37°**c** for 24 hours. After the due period of incubation, the plates were observed for growth. The colonies were counted using a digital colony counter and the mean colony count per drop was determined.

Thus, the total viable count (TVC) was calculated as followed:

Original cell population (OCP) (cfu/g)

$$= \frac{\text{mean colony count/drop} \times \frac{1}{dilution}}{\text{volume/drop}}$$

Where: Mean colony count/drop (mcc/d) is obtained

Dilution factor = $10^{-2,}$ = $\frac{1}{dilution\ factor}$, = 10^{2}

Volume per drop = 0.02 ml

Identification of Bacteria Isolate

Each colony was then isolated and transferred onto oven-dried sterile agar plates using a sterile inoculating wire loop. The plates were then incubated. Following the incubation periods, the culture plates were examined for purity of the isolates. The bacteria isolates were identified using various tests based on colonial morphology like a change of colour, shape, and texture. The methods used for macroscopic characterization were got using the criterion by Varghes and Joy (2014). The specific pathogens tested for were *Bacillus subtilis*, *Escherichia coli*, *Proteus mirabilis*, *Micrococcus varians*, *Staphylococcus aureus* and *Bacillus polymyxa*.

Heavy Metal Analysis

Destruction of Organic Matter: The method used for the destruction of organic matter was the dry-ashing method. A suitable quantity of the well

Journal of Family and Society Research 4(1), June 2025; pp 82-96
ISSN – 1668 (online) 1676 (print) **DOI:** https://doi.org/10.66043/jfsr.v4i1.118

mixed sample in a tared silica dish was weighed accurately. It was heated first by means of a soft flame to volatilise as much organic matter as possible, then the basin was transferred to a temperature-controlled muffle furnace. The muffle was kept at about 300ºC. Once the material was dry and charred, the temperature was allowed to rise to 450ºC and ashed at this temperature till no carbon remained. It was suspected that all carbon had not been removed, so the ash was cooled, about 1 to 2 ml of conc. Nitric acid was added, the mixture was allowed to evaporate to dryness and again heated in a muffle furnace. After ashing was complete, the dish was removed from the muffle furnace and cooled. The dish was covered with a watch glass, and 40 to 50 ml of hydrochloric acid (1 +1) was gently added. The watch glass was then rinsed down with water and heated on a steam bath for 30 minutes, uncovered, and then rinsed again. It was put in the steam bath and heated for another 30 minutes. Ten millilitre (10 ml) of hydrochloric acid (1+1) and water were added to dissolve the salts. It was then filtered into a 100 ml volumetric flask using Whatman No. 44 filter paper. The residue and basin were washed twice using dilute HCl. The flask was then filled with water. This procedure was repeated for all the other samples.

Separation and Concentration of the Element of Interest: The use of reagents and distilled water of suitably low metal content was ensured, taking into consideration that the concentrated mineral acids were used in amounts several times more than the sample. Reagent blank determination was also carried out. Blanks were prepared with the same quantities of the reagents as were used in the test. In expressions (1+2) and (1+3), used with the name of a reagent, the first numeral indicates (volume/weight) of (liquid/solid) reagent and the second numeral indicate volume of water. For example, HCl (1+2) means a reagent prepared by mixing one volume of HCl with two volumes of water. All chemicals used in these procedures were of the highest purity i.e. AR grade. The chemicals were not transferred to other bottles. Some of the chemicals that had any kind of impurity were then purified.

Determination

Determination of Lead in the Herbal Mixtures Using Atomic Absorption Spectrophotometer.

Lead was determined using the Mance (1987) method. Here, 10 ml of the ash solutions were treated with 10ml of 10% tartaric acid in a 50ml volumetric flask. One milliliter of 10% potassium cyanide solution was added, followed by 10ml of 50% ammonia. Furthermore, 0.5ml of 10% sodium sulphate was added and the mixtures were diluted to mark. These were shaken and allowed to stand for 10 minutes after which the absorbance was read at 430 nm in a spectrophotometer, the results were read and recorded.

Determination of Mercury in Herbal Mixtures Using Mercury Analyzer: The method of Wendoff (2004) was used in the determination of mercury in the samples. 10 ml of the ash solutions were pipetted into a 50 ml test tube. 5ml reagent solution was added and the test tube was shaken vigorously. The lower layer was collected while the upper layer was discarded. 5 ml 1% sodium nitrate was added followed by 1 ml

Journal of Family and Society Research 4(1), June 2025; pp 82-96
ISSN – 1668 (online) 1676 (print) **DOI:** https://doi.org/10.66043/jfsr.v4i1.118

HCl. The solutions were shaken and allowed to separate. The lower layer was discarded, and the upper layer was retained this time. The recovered layer was then treated with a 5ml working solution. The mixtures were shaken, and the absorbance was read at 490 nm, the results were read and recorded.

Determination of Zinc in Herbal Mixtures (Colorimetric Dithizone Method): The samples were dry ashed. Lead, copper, cadmium, bismuth, antimony, tin, mercury, and silver were eliminated as sulphides with added copper as a scavenger agent. Cobalt and nickel were eliminated by extracting metal complexes of a-nitroso-β- naphthol and dimethyl glyoxime, respectively. Zinc was extracted as zinc dithizonate with CCl4, for colour measurement, and the results were read and recorded.

Determination of Iron in Herbal Mixtures: Organic matter in the samples was destroyed by ashing and the resulting ashes were dissolved in hydrochloric acid and diluted to a known volume with water. The whole of the iron present in the aliquot of ash solutions was reduced with hydroxylamine hydrochloride and the Fe (Il) was determined spectrophotometrically as its coloured complex with α, - α-dipyridyl, the solution being buffered with acetate buffer solution. Absorption of the resulting complexes was read at 510 nm, and the results were read and recorded.

Data/Statistical Analysis: The analysis was conducted in duplicate. Descriptive statistics (means and standard deviations) were used following this formula: $\frac{1st\ Reading+2nd\ Reading}{2}$

The values obtained were compared to the WHO standard.

Results

Characteristics of the Study Samples

Table 1 shows the different samples according to their labelling from A to J. It also includes their various indications, manufacturing dates, and expiration dates. Sample F did not have manufacturing or expiry dates.

Table 1: Characteristics of Study Samples

	Code	Indications	MF Date	Expiry Date
1	Sample A	Sexual enhancement	8/11/2023	08/11/2028
2	Sample B	Pile	13/10/2023	12/10/2027
3	Sample C	Worm expeller	25/07/2022	24/06/2027
4	Sample D	Malaria/Typhoid	08/09/2022	07/09/2027
5	Sample E	Blood Purifier	01/06/2022	01/05/2028
6	Sample F	Blood cleanser	_	_
7	Sample H	STD (staphylococcus)	18/01/2024	18/01/2027
8	Sample I	Ulcer healer	08/09/2022	07/09/2027
9	Sample J	General cure (Malaria, Typhoid, Sexual enhancement, UTI and Immunity)	04/01/2023	03/01/2026

Journal of Family and Society Research 4(1), June 2025; pp 82-96
ISSN – 1668 (online) 1676 (print) **DOI:** https://doi.org/10.66043/jfsr.v4i1.118

10	Sample K	General cure (STDs, menstrual pain, *E. coli*, Hepatitis, Maaria and Typhoid.	Nov, 2023	Nov 2026

MF: Manufacturing Date

Bio load and Potential Risks of Microbial Content of the Samples

Table 2 shows the bio load and potential risks of microbial content of the samples. The results show that no form of microbial contamination was detected in samples F, G, I, and J. No parasitic and fungal growths were found in all the herbal medicines. Samples A, C, D, and H contained coliform bacteria. The acceptable limit for coliform bacteria in herbal medicines is Zero (State of Connecticut, 2009) . Samples B and E did not contain coliform bacteria. Sample A contained bacteria in excess (1.2×10^6). According to the WHO, the safety limit for the *Bacillus subtilis* is $\leq 10^5$.

Table 2: Bio load and Potential Risks of Microbial Content of the Samples

Sample code	Total Viable Count (cfu/ml) via Surface Viable Count Method	Total Coliform Count (cfu/ml) via Surface Viable Count Method	Isolates identified	Remark (According to the WHO standard for acceptable limits of microorganisms in foods and water)
A	1150000 ≅$1.2x10^6$	450000 ≅ $4.5x10^5$	*Escherichia coli, Proteus mirabilis, Bacillus polymyxa*	Coliform bacteria present, other bacteria Exceeded
B	700000 ≅$7.0x10^5$	-	*Bacillus subtilis*	Not exceeded
C	900000 ≅$9.0x10^5$	300000 ≅$3.0x10^5$	*Micrococcus varians, Bacillus subtilis, Escherichia coli*	Coliform bacteria present, other bacteria not exceeded
D	600000 ≅ $6.0x10^5$	150000 ≅$1.5x10^5$	*Bacillus subtilis, Proteus mirabilis, Staphylococcus aureus*	Coliform bacteria present, other bacteria not exceeded
E	650000 ≅$6.5x10^5$	-	*Bacillus subtilis,*	Not exceeded
F	-	-		No microorganisms found
G	-	-		No microorganisms found
H	550000 ≅ $5.5x10^5$	250000 ≅$2.5x10^5$	*Escherichia coli, Bacillus subtilis*	Coliform bacteria present, other bacteria not exceeded.
I	-	-		No microorganisms found
J	-	-		No microorganisms found

Journal of Family and Society Research 4(1), June 2025; pp 82-96
ISSN – 1668 (online) 1676 (print) **DOI:** https://doi.org/10.66043/jfsr.v4i1.118

Heavy Metal Content and Potential Risk of Toxicity of the Samples

Table 3 shows the heavy metal content of the samples. The results showed that all the samples had iron above the stipulated standard set by the WHO (Iron < 0.03mg/100ml). There were no samples exceeding the limits for zinc and lead (Zinc = 5.0mg/100ml and Lead = 1.0mg/100ml). Sample A alone was found to contain excess mercury. According to the WHO, the safety limit for mercury is 0.1 mg/100 ml.

Table 3: Heavy Metal Content of the Samples

Sample	Hg (mg/100ml)	Remark	Pb (mg/100ml)	Remark	Fe (mg/100ml)	Remark	Zn (mg/100ml)	Remark
A	0.161	Exceeded	0.022	Not Exceeded	0.97	Exceeded	0.11	**Not Exceeded**
B	0.140	Not Exceeded	0.014	Not Exceeded	0.56	Exceeded	0.05	**Not Exceeded**
C	0.110	Not Exceeded	0.012	Not Exceeded	0.94	Exceeded	0.03	**Not Exceeded**
D	0.114	Not Exceeded	0.022	Not Exceeded	0.51	Exceeded	0.11	**Not Exceeded**
E	0.113	Not Exceeded	0.305	Not Exceeded	1.90	Exceeded	0.84	**Not Exceeded**
F	0.125	Not Exceeded	0.023	Not Exceeded	0.44	Exceeded	0.07	**Not Exceeded**
G	0.127	Not Exceeded	0.007	Not Exceeded	0.47	Exceeded	0.02	**Not Exceeded**
H	0.142	Not Exceeded	0.019	Not Exceeded	0.92	Exceeded	0.04	**Not Exceeded**
I	0.141	Not Exceeded	0.015	Not Exceeded	0.18	Exceeded	0.05	**Not Exceeded**
J	0.129	Not Exceeded	0.014	Not Exceeded	0.49	Exceeded	0.04	**Not Exceeded**

Remarks were based on the comparison with the WHO acceptable limits for heavy metals in food and drinking water. (Mercury=0.1mg/100ml, Iron= 0.1mg/100ml, Lead= 1.0mg/100ml, Zinc= 5.0mg/100ml)

Discussion of Findings

The presence of microbiological contaminants as well as the microbial load in each sample showed that herbal medicines may not be assured of safety in terms of bacterial, and heavy metal (iron and mercury) contents. The results showed that samples F, G, I, and J were found not to contain any form of microbial contamination. There were no parasitic and fungal growths found in all the herbal medicines. A study done at the University of Ghana Medical School reviewed 50 studies out of which 49 (98%) reported on bacterial contaminants, 35 (70%) reported on fungal contaminants, and only 1 (2%) study reported on parasitic contaminants in herbal medicines (Ahiabor et al., 2024). This implies that fungal and parasitic contamination are not as common as bacterial

Journal of Family and Society Research 4(1), June 2025; pp 82-96
ISSN – 1668 (online) 1676 (print) **DOI:** https://doi.org/10.66043/jfsr.v4i1.118

contamination in herbal medicines as has also been seen in this study.

In sample A, coliform bacteria (*Escherichia coli)* and anaerobic bacteria *(Proteus mirabilis and Bacillus polymyxa)* were found. Turco (2018) noted that while most coliform bacteria are harmless, some, like certain strains of *E. coli,* can cause gastrointestinal issues like diarrhoea, stomach cramps, vomiting, and in rare cases, more serious complications. The presence of coliform bacteria is indicative of the presence of faecal matter and other pathogenic bacteria in the sample (Turco, 2018). The presence of coliform bacteria even in minute quantities render the herbal mixture unsafe. The maximum acceptable limit for coliform bacteria in samples is zero (State of Connecticut, 2009 ; Kira et al., 2021).

Aside from coliform bacteria, the total viable count of other microbial organisms in the sample according to the World Health Organization (WHO, 2019) should not exceed 10^5. Sample A (1150000 $\cong$ $1.2x10^6$) exceeded the safety limit. *Proteus mirabilis*, an anaerobic bacteria found in sample A causes various illnesses including urinary tract infections (UTIs), kidney stones, and in severe cases, sepsis (Jamil et al., 2023). *Bacillus polymyxa* can lead to gastrointestinal illnesses like emesis and diarrhea (Turnbull, 1996). Hence it can be deduced that some herbal medications used for sexual enhancement may not be free of microbial contamination. Samples B and E did not contain coliform bacteria but they contained *Bacillus subtilis* although within acceptable limits (700000 $\cong$ 7.0x10^5 and 650000 $\cong$ 6.5x10^5 respectively). None was found to exceed 10^5 below which they are not harmful to man.

Samples C, D, and H on the other hand contained various coliform bacteria. These organisms can cause serious health issues. For instance, *Staphylococcus aureus* found in sample D can lead to various infections from minor skin ailments like boils, rashes, and pimples to more serious issues like sepsis, pneumonia, and septic shock (Larry & Vazquez-Pertejo, 2019). *Micrococcus varians* found in sample C have occasionally been reported as the cause of pneumonia, meningitis associated with ventricular shunts, septic arthritis, bacteraemia, and endocarditis (Beresford & Williams, 2007). A cross-sectional study done in Morogoro Municipality in Tanzania on 50 herbal medicines revealed that about 88% of the tested samples significantly had higher total bacterial counts than WHO-recommended levels. Ten percent of the products were contaminated with the pathogenic *E. coli* and 8% with *S. aureus* (coliform bacteria) (Kira et al., 2021). Another study done in Macapa, Brazil showed that the microorganisms mostly isolated from the 132 herbal medicines analyzed were *S. aureus* (49.2%), followed by *Salmonella spp*. (34.8%), *E. coli* (25.8%), and *P. aeruginosa* (14.4%). Water samples analyzed showed that 77.8% were positive for total coliforms (1 ml) and in 66.7% of water samples *E. coli* was detected (1 ml), making them unfit for consumption (Lima et al., 2020). These studies confirmed that bacterial contamination of herbal medicine is common in various parts of

Journal of Family and Society Research 4(1), June 2025; pp 82-96
ISSN – 1668 (online) 1676 (print) **DOI:** https://doi.org/10.66043/jfsr.v4i1.118

the world and is a major concern to public health.

The results of heavy metal analysis showed that all the samples had iron above the stipulated standard (iron < 0.03 mg/100 ml or < 0.3mg/L) (Bureau of Indian Standards, 2012). Excessive iron in herbal medicines can lead to liver damage (cirrhosis), heart failure, diabetes, arthritis and even liver cancer (Hong et al., 2015). No samples exceeded the limits for zinc (5.0 mg/100 ml) and lead (1.0mg/100 ml). Sample A alone was found to contain excess mercury (≈0.2mg/100ml). According to the WHO, the safety limit for mercury is 0.1mg/100ml. Excess mercury in herbal medicines can lead to a range of health problems including damage to the nervous system, kidneys, and other organs, as well as developmental issues, particularly in children and fetuses (World Health Organization (WHO), 2024). Another study identified the concentrations of five heavy metals cadmium (Cd), lead (Pb), arsenic (As), mercury (Hg), and copper (Cu) in 1773 samples around the world. According to Chinese Pharmacopoeia, 30.51% (541) samples were detected with at least one over-limit metal. Pb, Cd, As, and Hg resulted in higher than acceptable risks in 25 kinds of herbs (Luo et al., 2021). This shows that the problem of heavy metal toxicity of herbal medications is a global concern.

Limitations of the Study

It is generally recommended that laboratory analysis be carried out in triplicates to offer a more accurate representation of the true value of a sample by allowing for the calculation of a standard deviation and identifying any outlier values. However, this study was conducted in duplicates due to limited resources, therefore, the results obtained should be interpreted with caution.

Conclusions

This study highlighted the safety concerns in the consumption of herbal medicines in Nigeria. Significant microbial contamination was found in the samples tested. The presence of pathogens like *E. coli* and *Bacillus spp.* necessitates safety attention both from the consumers and regulatory bodies. Although most of the medicine samples had lead, zinc, and mercury with safety limits, their high iron contents remain a public health concern. Herbal medicines are consumed to offer relief and cure for various health problems, however, if they are not microbially and chemically safe, they could aggravate existing health conditions and/or cause other problems. The implications of microbial along with mercury and excessive iron contamination, underscores the urgent need for improved regulatory frameworks and quality control standards in herbal medicine production. Ensuring the safety of herbal products requires a multifaceted approach that addresses contamination sources, strengthens regulations, and promotes public health awareness.

Recommendations:

1. To improve the safety of locally produced herbal medicines, there is a pressing need to establish quality control standards. These standards should regulate manufacturing processes, storage, and testing for

Journal of Family and Society Research 4(1), June 2025; pp 82-96
ISSN – 1668 (online) 1676 (print) **DOI: https://doi.org/10.66043/jfsr.v4i1.118**

microbial and heavy metal contamination. Regulatory bodies must ensure compliance to protect public health.

2. Additionally, public awareness campaigns should be launched to educate consumers about the risks of unregulated herbal remedies. These campaigns should focus on the importance of purchasing certified products and understanding potential health hazards, empowering consumers to make safer choices.

Future Research Directions:

Although some of the herbal medicines were not found to contain microbes and heavy metals. It is important to recall that other toxicants could probably be present in these medicines so some recommendations for further studies are:

1. Analysis of other toxicant contaminations in herbal medicines such as aristolochic acid .
2. Analysis of other heavy metals like arsenic and cadmium.

References

Aaseth, J., Alexander, J., Alehagen, U., Tinkov, A., Skalny, A., Larsson, A., Crisponi, G., & Nurchi, V. M. (2021). The aging kidney—as influenced by heavy metal exposure and selenium supplementation. *Biomolecules*, *11*, 1078. https://doi.org/10.3390/biom11081078

Ahiabor, W. K., Darkwah, S., & Donkor, E. S. (2024). Microbial contamination of herbal medicines in Africa, 2000-2024: A systematic review. *Environmental Health Insights 18.* 1-18. https://doi.org/10.1177/11786302241293345

Al-Saleh, I., Alnuwaysir, H., Al-Rouqi, R., Aldhalaan, H., & Tulbah, M. (2024). Fetal exposure to toxic metals (mercury, cadmium, lead, and arsenic) via intrauterine blood transfusions. *Pediatric Research*, *97*(2):647-654. https://doi.org/10.1038/s41390-024-03504-w

Alharbi, S. F., Althbah, A. I., Mohammed, A. H., Alrasheed, M. A., Ismail, M., Allemailem, K. S., Alnuqaydan, A. M., Baabdullah, A. M., & Alkhalifah, A. (2024). Microbial and heavy metal contamination in herbal medicine: a prospective study in the central region of Saudi Arabia, *BMC Complementary Medicine and Therapies*, 24(2) 1-6. https://doi.org/10.1186/s12906-023-04307-y

Bellanger, R. A., & Seeger, C. M. (2021). Complementary and alternative medicine. *Side Effects of Drugs Annual, 43,* 493–502. https://doi.org/10.1016/bs.seda.2021.07.003

Beresford, T., & Williams, A. (2007). *Micrococcus - an overview.* ScienceDirect Topics. https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/micrococcus

Briffa, J., Sinagra, E., & Blundell, R. (2020). Heavy metal pollution in the environment and their toxicological effects on humans. *Heliyon*, *6*(9), e04691. https://doi.org/10.1016/j.heliyon

.2020.e04691

Bureau of Indian Standards. (2012). Indian standard drinking water specification (Second Revision). *Bureau of Indian Standards*, *IS 10500* (May), 1–11. http://cgwb.gov.in/Documents/WQ-standards.pdf

Chaachouay, N., & Zidane, L. (2024). Plant-derived natural products: a source for drug discovery and development. *Drugs and Drug Candidates*, *3*(1),184–207. https://doi.org/10.3390/ddc3010011

Dabo, D. A., Kwasen, I. Z., Goewam, P., Mus, N. N., Solomon, P. D., & Vwamkat, A. S. (2023). Assessment of microbial contaminationof solid herbal medicine sold in Makurdi Metropolis. *World Journal of Advanced Research and Reviews*, *21*(2), 496–505. https://doi.org/10.30574/wjarr.2024.21.2.0433

Davis, C. C., & Choisy, P. (2024). Medicinal plants meet modern biodiversity science. *Current Biology*, *34*(4), R158–R173. https://doi.org/10.1016/j.cub.2023.12.038

Fatima, G., Raza, A. M., & Dhole, P. (2025). Heavy metal exposure and its health implications: A comprehensive review. *Indian Journal of Clinical Biochemistry*. https://doi.org/10.1007/s12291-025-01322-3

Foster, T. J. (2017). Staphylococcus - *Medical Microbiology* - NCBI Bookshelf. 1–12. papers3://publication/uuid/54D6E550-2009-4C3E-A44D-FABEDF6493E6

Genchi, G., Sinicropi, M. S., Lauria, G., Carocci, A., & Catalano, A. (2020). The effects of cadmium toxicity. *International Journal of Environmental Research and Public Health*, 17(11), 3782.. https://doi.org/10.3390/ijerph17113782

Hlihor, R. M., Roşca, M., Hagiu-Zaleschi, L., Simion, I. M., Daraban, G. M., & Stoleru, V. (2022). Medicinal plant growth in heavy metals contaminated soils: responses to metal stress and induced risks to human health. *Toxics*, 10(9), 499. https://doi.org/10.3390/toxics10090499

Hong, M., Li, S., Tan, H. Y., Wang, N., Tsao, S. W., & Feng, Y. (2015). Current status of herbal medicines in chronic liver disease therapy: The biological effects, molecular targets and future prospects. In *International Journal of Molecular Sciences*, 16(12), 28705–28745. https://doi.org/10.3390/ijms161226126

Hosseinzadeh, S., Jafarikukhdan, A., Medicine, A. H.-... of C., & 2015, U. (2015). The application of medicinal plants in traditional and modern medicine: A review of *Thymus vulgaris*. *International Journal of Clinical Medicine*, *6(9), 635-642* https://www.scirp.org/html/6-2101145_59593.htm?pagespeed=noscript

Jamil, R. t., Foris, L. A., & Snowden, J. (2023). *Proteus mirabilis* infections - *StatPearls - NCBI Bookshelf* (21–24). https://www.ncbi.nlm.nih.gov/books/NBK442017/

Kira, J. D., Mkupasi, E. M., Katakweba, A. A. S., & Ngowi, H. A. (2021).

Assessment of bacterial contamination in herbal medicine products vended in Morogoro Municipality, Tanzania. *East and Central African Journal of Pharmaceutical Sciences*, *24(2)*, 21–28.

Larry, B. M. & Vazquez-Pertejo, M.T. (2019). Staphylococcus aureus infections - Infections - Merck Manual, Consumer Version. *College of Medicine, Florida Atlantic University*. https://www.merckmanuals.com/en-ca/home/infections/bacterial-infections-gram-positive-bacteria/staphylococcus-aureus-infections

Lima, de S., Fujishima, Teles, C. M., Lima, M. A., Mastroianni, de P., Bruno, Carvalho, P., Sousa, D., Oliveira, F. F., & da Silva, J. O. (2020). Microbial contamination in herbal medicines: a serious health hazard to elderly consumers. *BMC Complementary Medicine and Therapies*, *20*, 1-9. https://doi.org/10.1186/s12906-019-2723-1

Luo, L., Wang, B., Jiang, J., Fitzgerald, M., Huang, Q., Yu, Z., Li, H., Zhang, J., Wei, J., Yang, C., Zhang, H., Dong, L., & Chen, S. (2021). Heavy metal contaminations in herbal medicines: determination, comprehensive risk assessments, and solutions. *Frontiers in Pharmacology, 11*, 595335. https://doi.org/10.3389/fphar.2020.595335

Ramon-Torrell, J.M. (2024). *Perspective chapter: emerging infectious diseases as a public health problem*. Intech Open. https://doi.org/10.5772/intechopen.113051

Miles, A. A., Misra, S. S., & Irwin, J. O. (1938). The estimation of the bactericidal power of the blood. *The Journal of hygiene*, *38*(6), 732–749. https://doi.org/10.1017/s00221724 0001158xNelson, L., & Perrone, J. (2000). Herbal and alternative medicine. In *Emergency Medicine Clinics of North America* (Vol. 18, Issue 4, pp. 709–722). https://doi.org/10.1016/S0733-8627(05)70154-1

Olaniran, O. B., Ajayi, S. E., Oluwatobi, O. B., & Adeleke, O. E. (2022). Assessment of microbial quality and detection of extended spectrum β - lactamase genes in Gram-negative bacterial isolates of herbal mixtures commonly hawked in Sagamu metropolis*, African Journal of Clinical and Experimental Microbiology, 23*(3), 257–268. https://doi.org/:10.4314/ajcem.v23i3.5

Ozarde, Y., Purandare, D., Deshmukh, S., & Gadhave, R. (2025). *Heavy metals and cardiovascular health_ Uncovering links and health challenges.* ScienceDirect. https://doi.org/10.1016/j.jtemb.2025.127648

Sanders, E. R. (2012). Aseptic laboratory techniques: Plating methods. *Journal of Visualized Experiments,* 63, e3064. https://doi.org/10.3791/3064

State of Connecticut, Department of Public Health. (2009). *Recommendations to the connecticut general assembly for ensuring the adequacy and purity of new private drinking water wells* . https://portal.ct.gov/dph/environmental-health/private-well-water-program/private-wells

Turco, R. F. (2018). Coliform Bacteria. In

Methods of Soil Analysis, Part 2: Microbiological and Biochemical Properties (pp. 145–158). https://doi.org/10.2136/sssabookser5.2.c9

Turnbull, P. C. B. (1996). Bacillus. *Medical Microbiology, (4th edition*), NCBI Bookshelf. https://www.ncbi.nlm.nih.gov/books/NBK7699/

Varghes, N., & Joy, P. P. (2014). *Microbiology Laboratory Manual* (1st ed.). Aromatic and Medicinal Plants Research Station.

Welz, A. N., Emberger-Klein, A., & Menrad, K. (2019). The importance of herbal medicine use in the German health-care system: Prevalence, usage pattern, and influencing factors. *BMC Health Services Research*, *19*(1), 952. https://doi.org/10.1186/s12913-019-4739-0

WHO. (2023). Traditional medicine has a long history of contributing to conventional medicine and continues to hold promise. *World Health Organization* (pp. 1–2). https://www.who.int/news-room/feature-stories/detail/traditional-medicine-has-a-long-history-of-contributing-to-conventional-medicine-and-continues-to-hold-promise

World Health Organization (WHO, 2019). WHO guideines for accessing quality of herbal medicines with reference to contaminants and residues. *Sustainability (Switzerland)*, *11*(1), 1–14. http://scioteca.caf.com/bitstream/handle/123456789/1091/RED2017-Eng-8ene.pdf?sequence=12&isAllowed=y%0Ahttp://dx.doi.org/10.1016/j.regsciurbeco.2008.06.005%0Ahttps://www.researchgate.net/publication/305320484_SISTEM_PEMBETUNGAN_TERPUSAT_STRATEGI_MELESTARI

World Health Organization (WHO). (2024). *Mercury*. https://www.who.int/news-room/fact-sheets/detail/mercury-and-health