EUROPEAN ACADEMIC RESEARCH
Vol. X, Issue 11/ February 2023

Impact Factor: 3.4546 (UIF)
DRJI Value: 5.9 (B+)

ISSN 2286-4822
www.euacademic.org

Heavy metal concentration in *Trigonella foenum-graecum* (fenugreek), Collected from River Nile State, Sudan

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Abstract

The study aimed to determine the concentration of heavy metal in fenugreek plants collected from different regions in River Nile State using X-ray fluorescence (XRF) technique. The XRF device was calibrated with a standard reference material and the samples were irradiated with X-rays to emit secondary X-rays that were analyzed by the XRF detector. The concentrations of heavy metals (Pb, Zn, Cr, Mn, Ni, Fe) in samples of Trigonella foenum-graecum (fenugreek) are reported in terms of milligrams per gram (mg/g). The result shows the average concentrations across all samples. It appears that the highest concentration of iron (Fe) was found in Damer, with 0.09 mg/g, while the lowest concentration of zinc (Zn) was found across all the samples, with an average concentration of 0.0014 mg/g.

The sample of fenugreek plant has higher concentrations of chromium (Cr) and iron (Fe) than the allowable limits, while the concentrations of lead (Pb), zinc (Zn), manganese (Mn), and nickel (Ni) are within the allowable limits. Excessive concentration of certain elements in plants can be harmful to both the plant itself and to animals and humans that consume the plant. For example, the high levels of chromium (Cr) can be toxic to the liver and kidneys. It is important to note that the allowable limit may vary depending on the plant species, growing conditions, and the intended use of the plant.

Keywords: X-ray fluorescence, fenugreek, Trigonella foenum-graecum, heavy metals

1-INTRODUCTION:

Heavy metal toxicity can occur when plants absorb excessive amounts of heavy metals from the soil or water [1]. These metals can accumulate in the leaves, stems, and roots of the plant, and can potentially be harmful to humans and animals that consume them. Some common heavy metals found in plants include lead, cadmium, mercury, and arsenic. Plants have a natural ability to detoxify heavy metals by binding them to cell walls or sequestering them in vacuoles, but some plants are more tolerant to heavy metals than others. However, even tolerant plants may accumulate heavy metals to such an extent that they become toxic to humans and animals [2].

The risk of contamination of a plant with heavy metals is significant, as exposure to these elements can have negative effects on plant growth and health. Heavy metals such as lead, cadmium, and mercury can accumulate in plant tissues,

making the plant and any products derived from it unsafe for human or animal consumption. Additionally, exposure to heavy metals can make a plant more susceptible to disease and pests [3-4].

Exposure to heavy metals cause various health problems, including damage to the nervous system, liver and kidney damage, and cancer. It is important to be aware of the potential for heavy metal contamination in plants and to take steps to minimize exposure, such as using soil and water testing, using fertilizers and pesticides that are low in heavy metals, and washing and cooking vegetables thoroughly [5].

Fenugreek is not known to have a high risk of contamination with heavy elements, but as with any plant, there is a potential for heavy metal contamination if the soil or water used to grow it contains high levels of these elements. Heavy metal contamination can occur naturally in soil or as a result of industrial pollution, agricultural practices, or the use of contaminated fertilizers or pesticides. Some of the potential sources of heavy metal contamination in fenugreek, Industries that release heavy metals into the air or water can contaminate nearby soil and water sources, which can then be taken up by plants and the use of contaminated fertilizers or pesticides can introduce heavy metals into the soil, which can then be taken up by plants [5-8].

Excessive concentration of certain elements in plants, including fenugreek, can be harmful to both the plant itself and to animals and humans that consume the plant. For example, high levels of lead (Pb) can cause damage to the nervous system and other organs, while high levels of zinc (Zn) can inhibit the absorption of other essential nutrients. High levels of chromium (Cr) can be toxic to the liver and kidneys, while excessive amounts of nickel (Ni) can cause respiratory problems. High levels of manganese (Mn) and iron (Fe) can also cause toxicity symptoms. Consuming large amounts of fenugreek plant with excessive concentration of these elements over a long period of time may cause chronic health issues [9-14]. XRF is a non-destructive method, and it allows for a quick and easy analysis of many samples in a short period of time[10-11].

In this study X-ray fluorescence (XRF) technique used to determine the elemental composition of a sample and measure the concentration of heavy metals in fenugreek. The sample is irradiated with X-rays and the emitted fluorescence is used to identify the elements present and their concentrations. XRF is a non-destructive technique and can be used to analyze powders, liquids, and solid samples. It is widely used in the analysis of food, plant, and soil samples to determine the presence and concentration of heavy metals.

2-MATERIAL AND METHODS

Fenugreek plant samples Collected from several regions in River Nile State 18°27′N 33°23′E [9], from different locations (Barbour, Damer, and Abu Hamad) and at different times to ensure a diverse range of samples. The samples are labeled and stored, ensuring they are kept in a cool and dry place to prevent decay or contamination.

To Measure the concentration of heavy metals in fenugreek BY using an X-ray fluorescence (XRF) device The XRF calibrated using a standard reference material that contains known concentrations of the heavy metals of interest. The prepared fenugreek samples are placed in the XRF device and irradiated with X-rays. The X-rays

cause the atoms in the sample to emit secondary X-rays, which are then analyzed by the XRF detector to determine the concentrations of the heavy metals.

The X-MET5000 Series handheld XRF analyzer is a suitable instrument for analyzing heavy metals in fenugreek plant samples collected from several regions in River Nile State. The XRF spectrometry method used by this instrument has low detection limits down to the parts-per-million (ppm) range, which allows for accurate results that rival those of lab analysis. The X-MET5000 is a lightweight and portable instrument that is designed for high-throughput elemental testing and spectro-chemical analysis of a wide range of metals and other materials. This makes it ideal for use in field studies or for on-site analysis [9-10].

3-RESULTS AND DISCUSSION

The heavy metals concentration in fenugreek (Trigonella foenum-graecum) was measured in localities of Barbour, Damer, and Abu Hamad, and the average concentrations of heavy metals in all fenugreek samples were calculated. Table-1 shows the concentrations of heavy metals in the samples and the average concentration of each element in all samples.

The concentrations of heavy metals (Pb, Zn, Cr, Mn, Ni, Fe) in samples of Trigonella foenum-graecum (fenugreek) is shown in Table-1. The concentrations are reported in terms of milligrams per gram (mg/g). The last row shows the average concentrations across all samples. It appears that the highest concentration of iron (Fe) was found in Damer, with 0.09 mg/g, while the lowest concentration of zinc (Zn) was found across all the samples, with an average concentration of 0.0014 mg/g. The results show the concentration of heavy metals in Trigonella foenum-graecum (fenugreek) samples collected from Abu Hamad, Damer, and Barbour regions. The table shows the averages of the concentration of each element in all samples. The highest concentration of iron is 0.06% mg/g, while the lowest is zinc with an average of 0.0014% mg/g. No concentration of lead and manganese was recorded in the samples.

Table-1: concentrations of heavy metals (Pb, Zn, Cr, Mn, Ni, Fe) in samples of Trigonella foenum-graecum (fenugreek), River Nile State, Sudan

Localities	Pb		Zn		Cr		Mn		Ni		Fe	
	STD	%	STD	%	STD	%	STD	%	STD	%	STD	%
Abu Hamad	0.000	0.00	0.001	0.00	0.004	0.028	0.000	0.00	0.001	0.01	0.007	0.04
Damer	0.000	0.00	0.002	0.00	0.005	0.03	0.000	0.00	0.001	0.01	0.009	0.09
Barbour	0.000	0.00	0.0015	0.005	0.006	0.025	0.0005	0.00	0.0005	0.01	0.014	0.07
A.v	0.000	0.0	0.0015	0.0014	0.007	0.027	0.0002	0.00	0.0003	0.01	0.0015	0.06

Figure-1 shows a comparison of heavy element concentrations in fenugreek, where it was found that the highest concentration of iron was 0.06% mg/g and the lowest concentration of zinc was an average of 0.0014% mg/g. No concentrations of lead or manganese were recorded in the fenugreek samples. Figure (2) shows a comparison of the average concentrations of elements in fenugreek for localities of Abu Hamad, Damer, and Barbour, and it is noted that the concentrations of iron and chrome are higher in Damer locality.

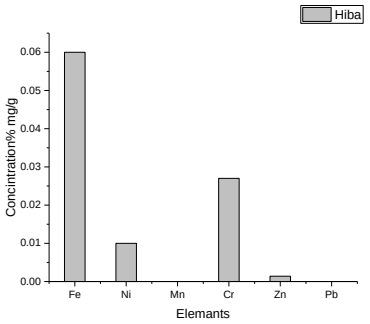

Figure-1: Comparison of heavy metals (Pb, Zn, Cr, Mn, Ni, Fe) in samples of Trigonella foenum-graecum (fenugreek), River Nile State, Sudan

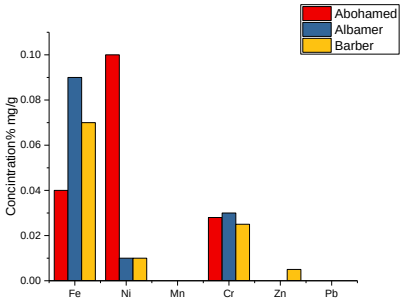

Figure-2: Comparison of heavy metals (Pb, Zn, Cr, Mn, Ni, Fe) in samples of Trigonella foenum-graecum (fenugreek) localities of Abu Hamad, Damer, and Barbour

Table -3 appears to be showing the concentration of various elements in a sample and comparing them to allowable limits. It looks like the sample has higher concentrations of Cr and Ni than the allowable limit, while the concentrations of Pb, Zn, Mn and Fe are within the allowable limits. The elements listed in the table are lead (Pb), zinc (Zn), chromium (Cr), manganese (Mn), nickel (Ni), and iron (Fe). The concentration of each element in mg/Kg is provided, as well as the allowable limit for each element in mg/Kg. The element lead (Pb) has a concentration of 0.00 mg/kg and an allowable limit of 0.0002 mg/kg, which means that it is well within the acceptable range. The element zinc (Zn) has a concentration of 1.4 mg/kg and an allowable limit of 0.1 mg/kg, which also means it is within the acceptable range. The element chromium (Cr) has a concentration of 27.00 mg/kg and an allowable limit of 0.02 mg/kg, which means it exceeds the allowable limit and may be cause for concern. The element manganese (Mn) has a concentration of 0 mg/kg and an allowable limit of 100 mg/kg, which means it is well within the acceptable range. The element nickel (Ni) has a concentration of 10 mg/kg and an allowable limit of less than 20 mg/kg, which means it is within the acceptable range. The element iron (Fe) has a concentration of 60 mg/kg and an allowable limit of less than 14 mg/kg, which means it exceeds the allowable limit and may be cause for concern.

Excessive concentration of certain elements in plants, including fenugreek, can be harmful to both the plant itself and to animals and humans that consume the plant. For example, high levels of lead (Pb) can cause damage to the nervous system and other organs, while high levels of zinc (Zn) can inhibit the absorption of other essential nutrients. High levels of chromium (Cr) can be toxic to the liver and kidneys, while excessive amounts of nickel (Ni) can cause respiratory problems. High levels of manganese (Mn) and iron (Fe) can also cause toxicity symptoms. Consuming large amounts of fenugreek plant with excessive concentration of these elements over a long period of time may cause chronic health issues. It is important to note that the allowable limit mentioned in the previous answer is a general limit and may vary depending on the plant species, growing conditions, and the intended use of the plant.

Table -3 Heavy Metal Concentration in *Trigonella foenum-graecum* Samples from River Nile State, Sudan: Comparison to Allowable Limit.

Element	Concentration (mg/Kg)	Allowable Limit (mg/Kg)
Pb	0.00	<0.0002
Zn	1.4	<0.1
Cr	27.00	<0.02
Mn	0	<100
Ni	10	<20
Fe	60	<14

4-CONCLUSION

The study aimed to determine the concentration of heavy metals in fenugreek plants collected from different regions in River Nile State using X-ray fluorescence (XRF) technique. The XRF device was calibrated with a standard reference material and the samples were irradiated with X-rays to emit secondary X-rays that were analyzed by the XRF detector. The sample of fenugreek plant has higher concentrations of chromium (Cr) and iron (Fe) than the allowable limits, while the concentrations of lead (Pb), zinc (Zn), manganese (Mn), and nickel (Ni) are within the allowable limits. Excessive concentration of certain elements in plants can be harmful to both the plant itself and to animals and humans that consume the plant. For example, the high levels of chromium (Cr) can be toxic to the liver and kidneys. It is important to note that the allowable limit may vary depending on the plant species, growing conditions, and the intended use of the plant.

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