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Heavy metals quantification of *teifera occidentalis* (*Fluted pumpkin,* Order: Violales, family: Cucurbitaceae) grown in niger delta oil producing areas

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Abstract

The focus of this study is the determination of the heavy metals content of *Teifera occidentalis* grown in the Niger Delta oil producing areas. To achieve this, four oil producing communities were randomly selected from Niger Delta. Five research stations were also selected from the sub-settlements that made-up each oil producing community. Samples of edible portions of *T. occidentalis* were collected from five spots in each sampling station, bulked, a composite drawn, wrapped in absorbent paper and taken to the laboratory for analysis. The analytical standards adopted were USEPA and APHA and the analytical instrument deployed for the determination of the heavy metals concentration is Agilent atomic absorption spectrophotometer model 240A. The results obtained were as follows; Cu concentration is between 0.63mg/kg to 29.01mg/kg with the mean of 8.14±13.92; the concentration of Zn is between 1.20mg/kg to 36.61mg/kg with mean concentration of 10.86±17.18; Mn concentration is between 15.72mg/kg to 150.00mg/kg with a mean concentration of 63.89±60.55; the concentration of Co is between 1.68mg/kg and 6.40mg/kg with a mean concentration of 3.57±0.02mg/kg and Cr concentration between 0.00mg/kg to 22.03mg/kg and has a mean concentration of 5.65±10.82mg/kg. The results of the mean concentrations of the parameters were further subjected to test of significance with analysis of variance (ANOVA) with df numerator 4 and denominator of 15 at 0.05 level of significance. The F ratio calculated is 1.05 while F-ratio crit is 3.06. The study thus recommends that *T. occidentalis* should be produced and consumed in the Niger Delta oil producing regions.

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Introduction

Vegetables are very important part of human diet because they contain carbohydrates, protein, vitamins, minerals and fibre required for good health (Suruchi & Khana, 2019; Sinha, Pandey; Gampla & Bhat, 2005; Singh, Kumar, 2006; Srinivas, Rao & Kumar, 2009). Vegetables have been recognised as key components of a healthy diet due to their high levels of health promoting nutrients and bioactive compounds including vitamins minerals fibre and phytochemicals (Liu, 2013; Adenipucum & Oyekunje, 2010; Aletor & Adeogun, 2005; Alsuminic & Badar, 2015). The Consumption of vegetables reduces the risk of obesity, weight and various types of chronic diseases such as hypertension, coronary heart disease, stroke (Boeing Bechthold, Bub, Ellinger, Italler, Krike, Leschik-Bonnet, Muller, Oberriter, Schulze, Stehle & Watzi, 2012; Atawodi, 2005; Bawat, Lar, Daboer, Audu, Lassa, 2012; Bellavia, Larsson, Bottai, Wolk, Orsric, 2013; Boskou, 2006). Rapid industrialisation, urbanisation and oil exploitation have contributed greatly to elevated levels of heavy metals in vegetables grown in urban and rural environments of developing and developed countries (Sarma, 2011; Sharma, Agarwal & Marshal, 2008; Sharma, Agrawal & Marshal, 207; Baskin & Engley, 2000; Turkdogen, Kilicel, Kara, Tuncer & Uygan, 2002). Heavy metals in foods, fruits and vegetables predisposes diseases such as cancer, osteoporosis, organ failure, nerve damage, respiratory disease, loss of memory etc. (Nwajei, 2018; Asagba, 2019; Baroon, Carls, Short & Rice, 2003; Dunel 2004; Pelletier, Burgess, Ho, Khun,mcKinney, Ryba 2014; Kaludomo, 2015).

The oil producing belt of Nigeria is the Niger Delta. It accounts for over 90 percent of the oil and gas mined in Nigeria (National Bureau of Statistics 2020; Salami 2019; Utomi, 2018; Ruwani, 2017). Sources of oil contamination in the environment include oil spillage, tank wash, equipment failure, flash flood, ballast water, gas flaring (Azuzu, 2016; Samson 2012; Obed, 2015). The chemical components of petroleum include carbon, hydrogen, oxygen, heavy metals and so on (Anyakora, Obechie, Palmer, Coker, Ukpo & Ogah, 2005; Prudent, Hedekei & Tatsukawa, 2002; Naghipour, Chenari, Tahari, Naghiron, Mehrabian, Attarchi, Jamfari & Roubaka, 2018). Nigeria Niger Delta has witnessed several oil spill since 1970 (Okecha, 2003; Okecha, 2004; Nigerian National Petroleum Corporation 2019; Friends of the Earth 2018; Zubilu & Ope 2016; Okubajo, Osagie & Nwadiulor, 2018, Obadoni & Uchenna, 2017).

Teifera occidentalis (fluted gourd) is a perennial, climbing, deciduous plant grown in West African as leaf vegetables but most commonly cultivated and consumed in the Niger Delta (Ukele, 2014; Obiozor and Odu, 2015; Osumor & Kubenje 2012, Osadilor & Osadolo, 2015). The perennial life cycle of *T. occidentalis* exposes it to bioaccumulation and biomagnification of petroleum contaminants through spills flooding, equipment malfunction, tank wash, flood, erosion (Ubeke, 2015; Ojugo and Odion, 2014; Ozah & Udalor 2012).

So much have been researched on the impact of oil production activities globally and in the Niger Delta but little or no study has been carried out on the bioaccumulation and biomagnification of oil contaminants on cultivated crops and this underscores this study. The metals to be investigated in this study are Cu, Zn, Mn, Co and Cr. These metals are of interest in this study because research reports on the heavy metals concentration in *T. occidentalis* have been so scanty and most times unavailable.

The study was guided by the following research questions:

1. What are the concentrations of heavy metals: Cu, Zn, Mn, Co and Cr in *T. occidentalis* grown in Niger Delta oil producing communities?
2. Are the concentrations of heavy metals in the *T. occidentalis* grown in the Niger Delta oil bearing communities within the limits prescribed by the world Health Organization for leafy vegetables?
3. Can the *T. occidentalis* grown in the Niger Delta oil producing communities be consumed?

The hypothesis tested for this study is as follows:

Ho: There is no significant difference between the heavy metals concentration in *T. occidentalis* in the Niger Delta and WHO maximum allowable concentration of heavy metals for leafy vegetables.

Materials and methods

Study Area

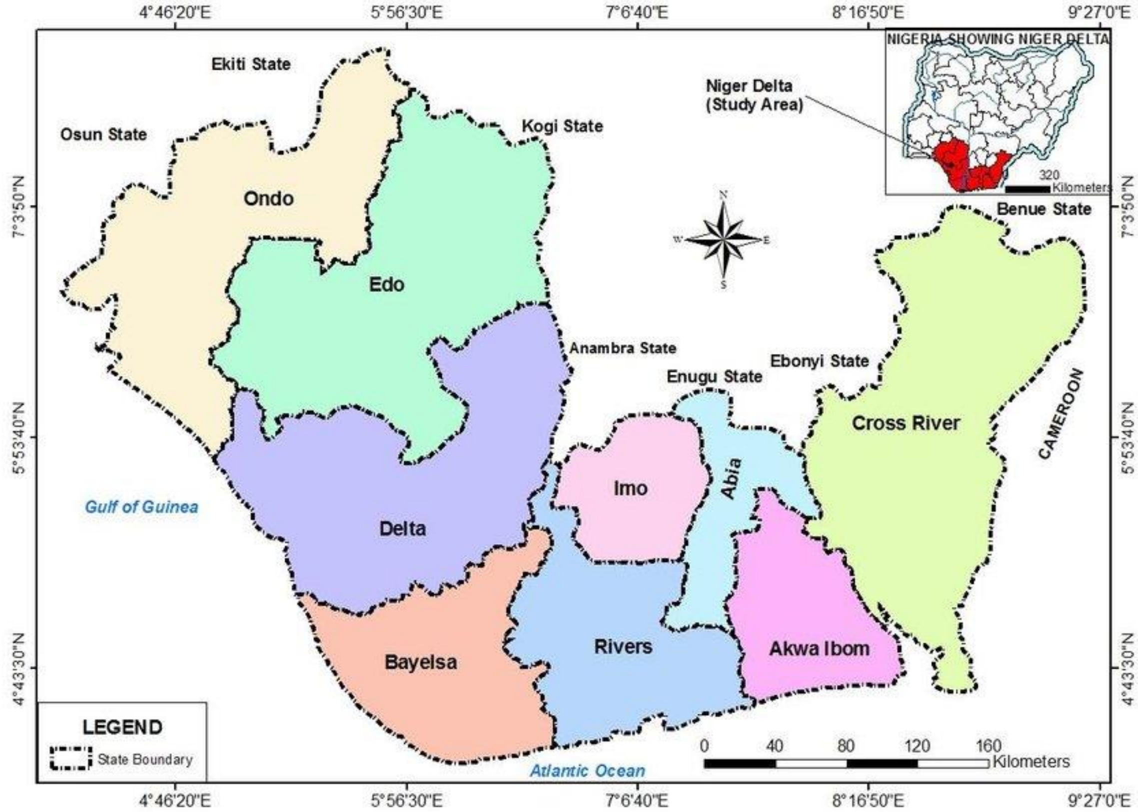

Fig. 1. Map of the Niger Delta.

Source: Niger Delta Environment Survey, 2017.

The Niger Delta is sitting on the Gulf of Guinea on the Atlantic Ocean. It lies within the coordinates of 5.5325°N and 5.8987°E and covers an area of 70000 square kilometres; it is the oil producing belt of Nigeria (Anyaegbunam 2014; Onosede, 2014; Osuntokon, 2015; Haruna, 2013, Banjo and Bantileo, 2018).

The people of the Niger Delta are agrarians, fisherman and fish farmers. Some are involved in petty trading while some are artisans. The main industries in the Niger Delta are oil exploration and exploitation with their attendant environmental degradation.

Sampling

This study covers the Niger Delta oil producing areas. For frontline oil producing communities were randomly selected for the study and these are: Ebedei waterside, Ebocha, Utagba-Ogbe and Uzere oil producing communities. Five settlements (quarters) were also randomly selected to make up the research sample stations and the sampled stations are: Utagba-Ogbe station with sampling sites as: Umusam, Isumpe, Umusadeli, and Umusadege. Ebedei station has Obiogene, Ukuole and Umuosele Adonishaka, and Obionye Onicha and Uzere sampling stations comprised: Urhoko, Uhei Iboro, Ezede and Uweye while Ebocha sampling station composed:mgbede, Okuzi, Ogoli, Egema and Ugoeze sampling stations. The sampling stations were mapped into five (5) adopting Herringbone design. For each of the sampling stations, five (5) sampling spots edible portion of *T. occidentalis* were collected, bulked and composite drawn, wrapped in absorbent paper properly coded for analyses.

Data Processing and Analysis

Plant samples were (oven-dried) at 40° (°C) to a constant weight. After cooling, 5g was weighed out and 25mL aqua regia (4HCl: $1HNo_3$) was added and digested in the hot plate till sample volume was about 1mL.

The solution then cooled and filtered into a 50mL standard flask and made up to mark with distilled water.

Determination of the heavy metals was carried out using an Agilent atomic absorption spectrophotometer model 240A equipped with an acetylene burner after digestion of plant samples. Hallow Cathode lamps of Cu, Zn, Mn, Co and Cr were used and background correction was done using deuterium lamp. Working standards for instrument calibration were prepared from stock solution of 1000 ppm for each metal by serial dilution using double distilled water. Blank samples were also run to check for background contamination.

Results

Table 1. Heavy metals concentrations in *T. occidentalis* in Ebedei and WHO MPC in mg/kg.

Parameters	Sampling Stations					Mean	Std. Deviation	WHO MPC
	A	B	C	D	E			
Cu	0.63	0.62	0.64	0.63	0.57	0.64	0.03	0.20
Zn	1.12	1.25	1.07	1.23	1.33	1.22	0.09	2.00
Mn	15.97	15.55	15.73	15.85	15.47	15.71	0.21	0.50
Co	1.77	1.68	1.56	1.72	1.66	1.67	0.08	0.05
Cr	0.55	0.63	0.47	0.56	0.57	0.55	0.05	0.01

Table 2. Heavy metals concentration of *T. occidentalis* in Utagba-Ogbe and WHO MPCmg/kg.

Parameters	Sampling Stations					Mean	Std. Deviation	WHO MPC
	A	B	C	D	E			
Cu	1.85	1.83	1.84	0.21	1.84	1.85	0.01	0.20
Zn	3.22	3.22	3.23	2.02	3.24	3.23	0.01	2.00
Mn	60.53	60.54	60.52	0.52	60.55	60.53	0.02	0.50
Co	3.44	3.45	3.43	0.04	3.46	3.45	0.02	0.05
Cr	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.01

Table 3. Heavy metals content of *T. occidentalis* grown in Uzere and WHO maximum permissible concentration in mg/kg.

Parameters	Sampling Stations					Mean	Std. Deviation	WHO MPC
	A	B	C	D	E			
Cu	28.04	27.92	29.06	28.08	28.96	29.01	0.07	0.20
Zn	37.48	35.72	36.55	36.60	36.68	36.61	0.10	2.00
Mn	154.00	154.04	150.60	154.50	150.07	150.24	0.28	0.50
Co	5.48	6.43	6.32	6.44	6.42	6.41	0.06	0.05
Cr	23.00	22.22	22.08	22.55	22.04	22.03	0.03	0.01

The mean concentrations of the parameters determined in Ebedei were presented graphically in bar chart as shown in Fig. 2.

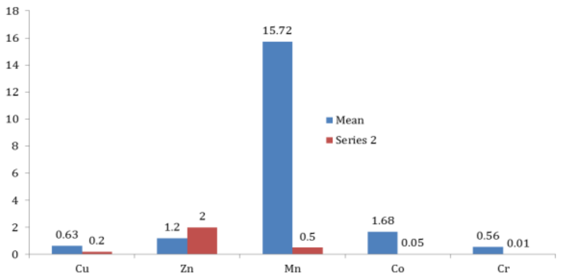

Fig. 2. Comparison of mean concentrations of the heavy metals in *T. occidentalis* collected in Ebedei (with) World Health Organization maximum permissible concentrations for each metal considered in mg/kg.

The mean concentration of the heavy metals content of *T. occidentalis* grown in Utagba-Ogbe was represented graphically with bar chart as shown in Fig. 3.

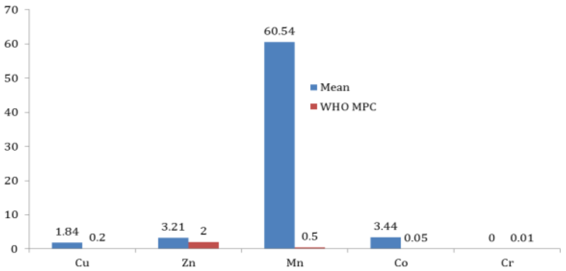

Fig. 3. Comparison of mean concentrations of the heavy metals in *T. occidentalis* in Utagba-Ogbe and WHO maximum permissible concentration for the metals in mg/kg.

The mean concentration of the heavy metals in *T. occidentalis* grown in Uzere oil producing community Niger Delta is as shown in table 3. The mean concentration of the heavy metals in *T. occidentalis* investigated in Ebocha oil producing area Niger Delta were presented in Table 4. The mean concentrations of the heavy metals investigated in *T. occidentalis* grown in Ebocha were presented in Fig. 5.

Table 4. Heavy metals investigated in Ebocha and WHO MPC mg/kg.

Parameters	Sampling Stations					Mean	Std. Deviation	WHO MPC
	A	B	C	D	E			
Cu	1.17	1.02	1.30	0.78	1.25	1.09	0.10	0.20
Zn	2.43	2.51	2.22	2.45	2.34	2.43	0.06	2.00
Mn	29.55	28.98	27.87	29.33	29.49	29.11	0.68	0.50
Co	2.97	2.92	2.57	2.61	2.44	2.76	0.18	0.05
Cr	.00	.00	.00	.00	.00	0.00	0.00	0.01

Table 5. Levels of selected heavy metals in *T. occidentalis leave from* Niger-Delta oil producing areas.

Parameters	Ebedei	Utagba_Ogbe	Ebocha	Uzere	mean	Std. Deviation
Cu	0.62	1.85	1.08	29.01	8.13	13.91
Zn	1.21	3.22	2.42	36.61	10.85	17.17
Mn	15.73	60.51	29.12	150.24	63.87	60.54
Co	1.67	3.43	2.75	6.40	3.56	2.03
Cr	0.55	0.00	0.00	22.03	5.64	10.91

The mean concentration of the heavy metals content of *T. occidentalis* grown in Uzere was presented graphically with bar chart as shown in Fig. 4.

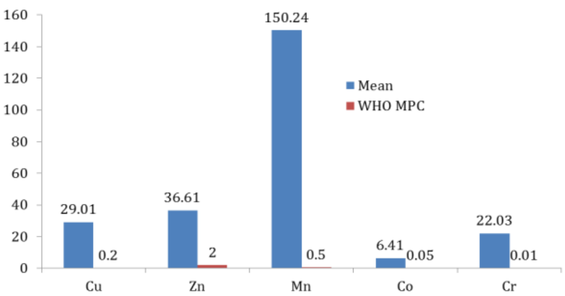

Fig. 4. Comparison of heavy metals concentration of *T. occidentalis* grown in Uzere and WHO maximum allowable concentration for heavy metals in leafy vegetables.

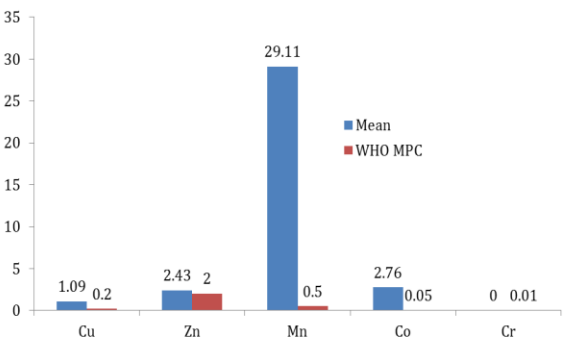

Fig. 5. Comparison of the heavy metals investigated in *T. occidentalis* grown in Ebocha and WHO MPC in mg/kg.

The aggregate mean concentrations of Cu, Zn, Mn, Co and Cr in *T. occidentalis* grown in the oil producing communities in the Niger Delta and World Health Organisation MPC for the heavy metals investigated. The aggregate mean concentration of the heavy metals investigated was presented in Fig. 6.

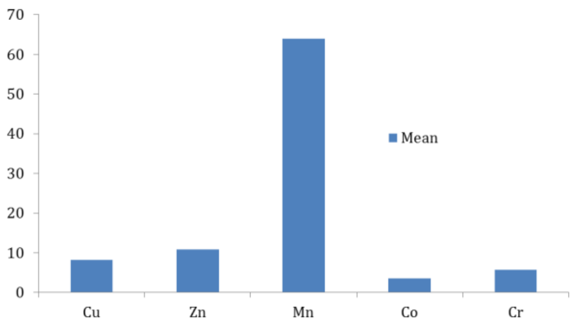

Fig. 6. Mean concentrations of heavy metals in *T. occidentalis* grown in the Niger-Delta oil producing communities investigated.

The aggregate mean resulted of the heavy metals were then subjected to test of significance with analysis of variance (ANOVA) with numerator 4 and denominator 15 at 0.05 level of significance. The F calculated value is 5.06 while the F ratio crit is 2.05, thus rejecting Ho and accepting Ha revealing that there is significant difference between the concentrations of the heavy metals investigated in *T.*

occidentalis and WHO maximum allowable concentration for heavy metals in leafy vegetables.

Discussion

Contamination of fruits and vegetables by industrial effluents is a global phenomenon with its attendant health implications. Determination of the concentration of toxicants in crops such as fruits and vegetables is becoming inevitable for healthy living. The results of the investigation of the heavy metals content in *T. occidentalis* grown in the Niger Delta oil region revealed. High concentration of Cu in *T. occidentalis* grown in Niger Delta could be associated with oil exploitation activities in the region. High concentration of Cu in leafy vegetables has been reported by researchers (Zurera-Ceabano, Moreno-Ragas & Salmeron-Egea, 2007; Zhuang, Yang, Wang & Shu, 2007). Human exposure to high dosage of Cu give rise to health disorders such as liver damage, abdominal disorder, cramps, nausea, diarrhea, headache eyes, irritation (Agency for Toxic Substances and Diseases (ATSDR), 2002; Naghipour, Cheneri, Naghipour *et al.*, 2018).

The concentration of Zn in *T. occidentalis* grown in Niger Delta oil producing communities is within a tolerable limit recommended by WHO except the concentration in Uzere oil producing communities. Low concentration of Zn in leafy vegetables has been reported ~~in~~ (Fleming, 2014; Breword, Young Crout, Tye, Noir & Thompson, 2004). High dose of Zn has attendant health implications of stomach disorder, kidney failure, zinc intoxication, metal fume fever, damage to pancreas (ATSDR, 2002; Anyakora, Ogbeche 2006, Palmer *et al.*, 2005).

This study revealed that Uzere has the highest concentration of Mn in *T. occidentalis* compared to other oil producing sites. However, the lowest concentration was again recorded in Ebedei where Mn concentration. The increased concentration of Mn in Uzere is attributable to the long period of oil exploitation activities while Ebedei low concentration is due to the fact that oil exploitation began less than a decade in the community. The mean concentration of Mn in all the communities investigated is higher than the World Health Organisation maximum allowable concentration for Mn in leafy vegetables. Similar results have been obtained (Sharma, Agarwal & Marshal, 2007; Khan, Caoa, Zheng, Huang & Zhu, 2008). Human exposure to high dose of Mn has been associated with human health disorders such as impotency in males and infertility in females, hallucination, Parkinson disease, memory loss and forgetfulness, lung embolism, bronchitis, facial muscular spasm aggressiveness and so on (Sadeghi, Muhammadi, Sharafi & Bohloul, 2015; Arora Kiron & Rani *et al.*, 2008).

Co concentration in *T. occidentalis* in the communities in the Niger Delta investigated showed that Uzere recorded the highest concentrations of Co followed by Utagba-Ogbe while the least is also Ebedei. The mean concentration of Co in the study areas is higher than the World Health Organisation maximum allowable concentration for Co the leafy vegetables. The elevated concentration of Co in the *T. occidentalis* grown in these communities is as the result of oil contamination of the soil and air. This result is similar to the earlier reports (Arora, Kiran, Rani, Rani, Kauri & Mittal, 2008; Ge, Murray, Hendershot & Sauve, 2002). Exposure to high Co dose has been implicated in some health complications such as asthma, shortness of breath disease, pulmonary disease, fibrosis, permanent disability respiratory hypersensitivity dermatitis, death and so on (Sadeghi, Muhammadi, Sharafi & Bohloul, 2015; Sharma, Agarwal & Marshal, 2007).

The level of Cr in the area of study indicated that ~~is~~ Uzere has the highest concentration relative to Ebedei, but Utagba-Ogbe and Ebocha had no Cr. The concentration of Cr ~~while~~ is higher than WHO maximum allowable limit for Cr in leafy vegetables. The higher mean of Cr concentration in the area of study were contributed by Uzere and Ebedei. Low concentration of Cr in leafy vegetables has been reported by other authors (Achugbu & Ologo, 2014; Ogelenya & Obinibo, 2017). However, high concentration of Cr in leafy vegetables have been reported (Saffari, Zarabi, Hoseire, Kasman & Jaafari, 2015; Mohaddum *et al.*, 2018). High human exposure to Cr has the concomitant effect of some health challenges such as liver damage, kidney failure, pulmonary congestion, respiratory irritation, upper abdominal pain, respiratory tract cancer and nose damage (ATSDR, 2002; Naghipour, Cheneri *et al*., 2018).

Conclusion

The result of the investigation on the heavy metals: Cu, Zn, Mn, Co and Cr content of *T. occidentalis* in the Niger Delta oil producing communities revealed that the concentrations have significant difference with WHO maximum stipulated limit for the metals in leafy vegetables which means that world best practices were not adopted by the oil extracting companies operating in the study area; they are enjoined to operate with, the set standards for environmental protection and restoration. The mantra the world over is sustainable development.

Consequent upon the results of this study, it is thus recommended:

1. *T. occidentalis* should not cultivated and consumed by farmers and students in various Niger Delta communities studied
2. Environmental monitoring agencies should tab on the oil companies operating in these communities to ensure that world best practices are adhered to at all times.

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