Study on Heavy Metal Contamination from the Soot of Flared Gas on Selected Vegetation of Jeddo Community, Delta State, Nigeria

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ABSTRACT: *Soot is a black solid dispersed in air, which comes from the combustion of hydrocarbon molecules. From this study, some samples of Telfairia Occidentalis, local leaves (ugu) were collected from both Jeddo community (close to Warri Refinery and Petrochemical Company WRPC and other artisanal refineries) and Osubi Community (where there are no gas-flaring activities); all located in Okpe local government of Delta State, Nigeria. The vegetables were taken to the laboratory for analysis: to ascertain the level of heavy metal contamination from the soot that came from the gas-flaring and artisanal refineries in the area. From the result obtained, it was discovered that Zn, Cr, Cd and Pb in the vegetation had higher values above the WHO (1996) permissible limit, while Cu and Ni present in the vegetable, had values below the WHO permissible limit. This implies that soot from artisanal refineries had negative impact on the leafy vegetables (T. Occidentalis) in Jeddo community. These results then make the vegetation samples from Jeddo community unsafe for human consumption. The policies regulating the refineries should be enforced to achieve a safer atmosphere in the environment.*

KEYWORDS: contamination, gas flaring, heavy metals, Nigeria, soot, vegetation,

INTRODUCTION

Air pollution, which goes back in history to the 1952 Great London Smog has been a rising reason for sickness as well as death [Whyte, 2020]; and Niger Delta is an area in Nigeria that is faced with this environmental challenge of air pollution, amidst other challenges in the area [Ana, 2011].

Massive crude oil discovery as well as natural gas discovery moved the economy of Nigeria from farming to the natural resources [Obi-Udu et al, 2021]. Crude oil accounts for over 90% of Nigeria's GDP (Gross Domestic Product) [Amaechi and Emejulu, 2021]; and 17.2 billion m^3 of natural gas is being flared every year in Nigeria, since the discovery of large of amounts of crude oil in the country. This has resulted in health challenges for the citizens [Udok and Akpan, 2017]. Gas flaring also contributes to climate change as Nigeria is one of the countries in Africa with the highest amount of greenhouse emission [Orimoogunje et al., 2010]. More than two hundred and fifty toxins have been identified with the flaring of gas which leads to the pollution of air, water and soil. These flared gas is a leading cause of particulate matter, polycyclic aromatic hydrocarbon, black carbon and precursor gases [Giwa et al., 2019], which are released into the environment.

Particulate matter (PM) emitted from gas flares are largely black carbon, which is referred to as soot [Nwosisi, 2021]. Soot is a powdered particles that is black in colour, which is a product of incomplete burning of hydrocarbons [Niranjan and Thakur, 2017].

Soot being a constituent of PM, has negative health implications when inhaled into the lungs. Also the presence of soot in the environment: affects negatively the ecosystem, leads to poor agrarian output and intensifies global warming [Okorhi-Damisa, 2020]. Exposure to soot can lead to Pneumonias, which in turn exposes the patient to other diseases of the respiratory tract such as asthma [Elem, 2021]. An additional demerit of soot is its ability to join heavy metals and pesticides in the soil, due to the soot's high capability for adsorption. This in turn will lead to contamination of the food chain, which ultimately affects the humans that will consume such food produce [Anda and Illes, 2012] . This study aims at finding out the impact of soot from gas flared on vegetation in Jeddo Community of Delta State, Nigeria.

MATERIAL AND METHODS

Collection and Preservation of the Vegetation Samples

Random sampling technique was employed to collect vegetable leave samples (Telfaria occidentalis *(*T. OCCIDENTALIS.)), locally known as Ugu. Vegetation 1 (V_1) and Vegetation 2 (V_2) were the leafy vegetable samples in the area that has gas-flaring activities, where Jeddo community is situated. Vegetation Control 1 (VC_1) and Vegetation Control 2 (VC_2) were the control leafy vegetable samples collected from Osubi community situated in areas away from the gas-flaring activity; all in Delta State, Nigeria. The sample leaves were cut from the whole plant with the aid of a stainless-steel knife. These leaves were then placed in their respective Ziplock bags, labelled, and kept in ice chest prior transfer to the lab for analysis.

Materials/Reagents

Flame Atomic Absorption Spectrophotometer (Varian SpectrAA 600 model, Varian Inc. Palo Alto, California, USA;), Electronic analytical weighing balance (S-Mettler; FA210A model, USA), Distilled water, Nitric acid, Perchloric acid, Whatman No. 42 filter paper, Electrothermal hot plate (PEC Medical, DB-1 model; USA), anhydrous sodium sulphate, sonicator, Agilent GC-FID 6890 gas chromatograph with a flame ionization detector (FID), rotary evaporator, ceramic mortar and pestle, digestion flask, fume cupboard, Pyrex, Type 1 Class A borosilicate volumetric flask, plastic bottle, n-hexane, dichloromethane, acetone

Methods

Heavy Metal Analysis

This analysis was conducted using USEPA 7000B: a Flame Atomic Absorption Spectrophotometry analysis for heavy metals detection.

Procedure:

Freshly picked vegetable sample was chopped and air dried at room temperature for 3 – 5 days. The vegetable sample was then crushed and ground using a ceramic mortar and pestle. Heavy metal analysis in powdered vegetable sample was digested by weighing 1.0 gram of sample using Electronic analytical weighing balance (S-Mettler; FA210A model, USA) into a 100 mL digestion flask. 10 mL of distilled water was added to the digestion flask, followed by the addition of 5 mL of 4:1 v/v analar grade Nitric (HNO_3) - Perchloric acid ($HClO_4$). The digestion flask was placed on an Electrothermal hot plate (PEC Medical, DB-1 model; USA) inside a fume cupboard. The sample was allowed to digest for 20 - 30 minutes until a white fume was observed. The flask was allowed to cool and filtered through Whatman No. 42 filter paper with pore size of 125 mm into a 100 mL Pyrex, Type 1 Class A borosilicate volumetric flask and then made to mark with distilled water. This was then transfer to 100 mL plastic bottle for heavy metal analysis using Flame Atomic Absorption Spectrophotometer (Varian SpectrAA 600 model, Varian Inc. Palo Alto, California, USA;) with hollow cathode lamp (GBC Scientific, Australia). Certified heavy metal standards were prepared by diluting 1000 mg/L stock solution of the individual elements. A minimum of five standard working solutions were prepared from the stocks, the solution ranged between 0.1 mg/L to 10 mg/L. External calibration in the linear range of the metal was used to calibrate the equipment by running distilled water and a suite of calibration standards for each element. The calibration curve was then generated for each metal. Concentrations of the metals in the sample are calculated from the equation of the calibration curve.

Calculation:

Metal concentration of solid sample (mg/kg) $= \frac{(A-B)\times C}{D}$

Where A = Concentration of metal in sample (mg/L) as determined by AAS
B = Concentration of the metal found in blank (mg/L)
C = Volume of extract (mL)
D = Weight of dry sample (g)

RESULTS

Table 1: heavy metals of vegetation

	V_1	V_2	VC_1	VC_2	Mean V_{1-2}	Mean VC_{1-2}	WHO Permissible Value in plants (mg/kg)
Heavy Metals (mg/kg)							
Copper (Cu)	7.58	8.03	1.26	1.17	7.805	1.215	10.00
Zinc (Zn)	14.45	13.20	3.40	3.29	13.825	3.345	0.06
Chromium (Cr)	2.30	2.57	0.41	0.34	2.435	0.375	1.30
Cadmium (Cd)	1.06	1.04	<0.001	<0.001	1.05	<0.001	0.02
Lead (Pb)	6.29	4.30	0.35	0.24	5.295	0.295	2.00
Nickel (Ni)	**8.23**	**8.66**	**<0.001**	**0.06**	**8.445**	**0.030**	**10.00**

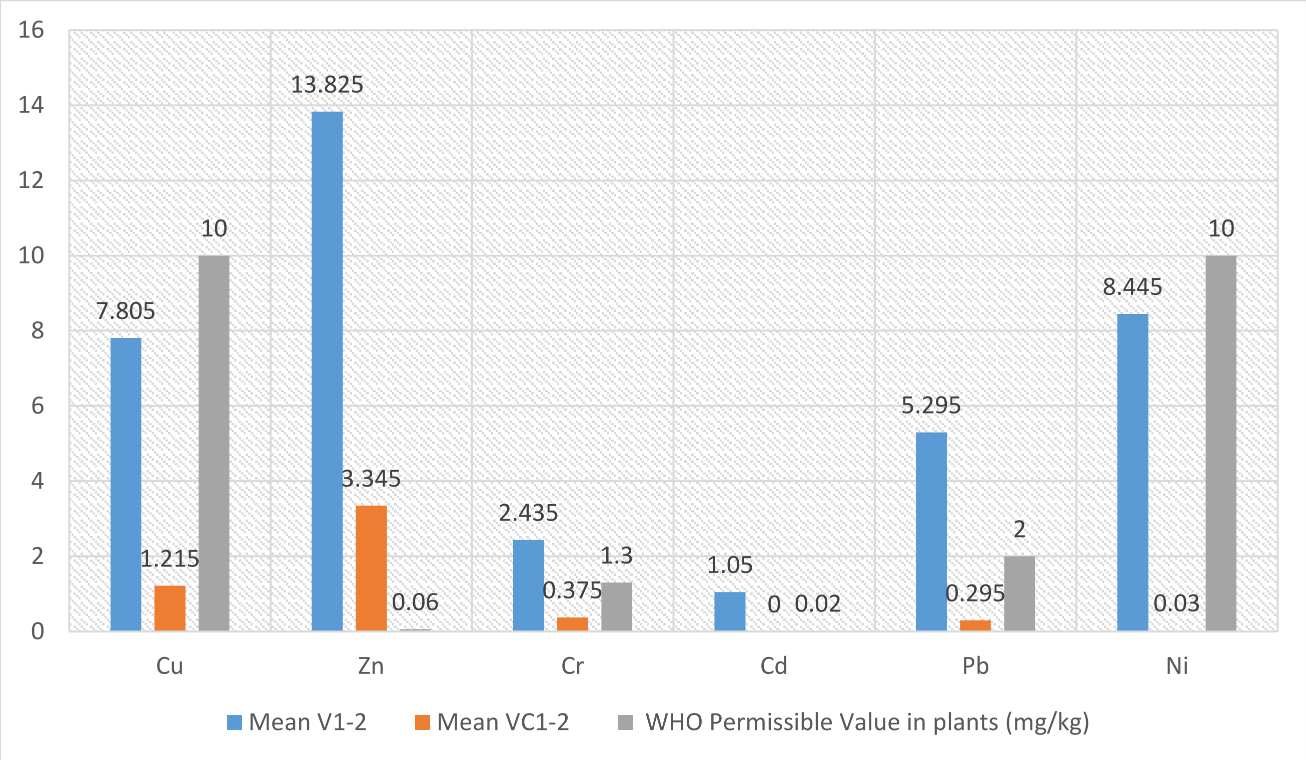

Figure 1: heavy metals on vegetation

DISCUSSION

Copper (Cu)
The mean values of Cu from the soot on the vegetation in Jeddo community, even though is far higher than the value on the control vegetation (in Osubi community), nevertheless, the Cu content is below the WHO acceptable limit for heavy metals in plants. This then means that such vegetation will not impair the health when consumed.

Zinc (Zn)
The mean value of Zn in V_1 and V_2, being 13.825 mg/kg in the Jeddo community is very high compared to the mean values of the VC_1 and VC_2, being 3.345 mg/kg along with WHO limit of 0.06 mg/kg. This then means that the presence of Zn in the vegetation is very toxic and lethal, and can cause serious damage. According to a review study conducted by Fosmire (1990), on zinc toxicity, the study stated that the extremely high intake of zinc into the human system can lead to vomiting, lethargy, nausea, fatigue and epigastric pain.

Chromium (Cr)
From the result in table 1, figure 1, the mean value of Cr in the vegetation of Jeddo community is higher than the mean value of the control, in Osubi community, and the WHO permissible limit for Cr in plants. This clearly exposes the consumers of such vegetation to negative health impact from Cr metal; and Cr, when in sufficiently high amount can be toxic and carcinogenic to humans [Achmad et al., 2017].

Cadmium (Cd)

From the result, Cadmium from V_1 and V_2 has higher value to VC_1 and VC_2, as well as the WHO limit. Therefore, this heavy metal in such high quantity in the vegetation of Jeddo poses a great danger to the residents of Jeddo that consume it; and from a study written by Rafati-Rahimzadeh et al (2017) it states that when humans are exposed to Cadmium metal for a long time, through agents such as: soil, air, water and food, such exposure can lead to be carcinogenic, and can also lead to toxicity of the different organs in the human system.

Lead (Pb)

Pb is another toxic heavy metal. From the study, the level of Pb in the vegetation harvested from Jeddo community is far higher than the WHO (1996) Pb limit in plants. This makes the vegetation from Jeddo community lethal for consumption. According to a review study undertaken by Boskabady et at (2018) on The effect of environmental lead exposure on human health and the contribution of inflammatory mechanisms, they stated that various studies exposure to Pb metal may lead to various diseseases ranging from digestive, neurologic, respiratory urinary to cardiovascular diseases.

Nickel (Ni)

From the result in table1, figure 1 for nickel metal, it was discovered that the content of Ni metal in the $V_{1\text{-}2}$, as well as $VC_{1\text{-}2}$ are below the WHO permissible limit. This means that the presence of Ni in the vegetation of Jeddo (the study area) will not generally affect residents that consume such vegetation. Nevertheless, according to Genchi et al. (2020), Kidney diseases, lung fibrosis and cancer of the nose, among others, are some side effects that can arise in the human system due to exposure to Ni.

CONCLUSION

From the result of the heavy metals in the vegetation, V_1 and V_2, as compared with the WHO permissible limit, it was discovered that Zn, Cr, Cd and Pb in the vegetation have higher values above the WHO limit, and can cause serious damage to the human system, while Cu and Ni have values, in the vegetation, below the WHO permissible limit. This clearly makes this vegetation from Jeddo community a threat to human health when consumed.

Conflict of interest

The authors declare that they have no known conflict of interest that could have appeared to influence the work reported in this paper.

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