Levels of Polycyclic Aromatic Hydrocarbons in Selected Crops from two Gas Flaring impacted Communities in Rivers State. Nigeria.

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ABSTRACT:

The process of burning associated gas from wells, hydrocarbon processing plants, or refineries, either as a means of disposal or to relieve pressure, is known as gas flaring. This study assessed the levels of Polycyclic Aromatic Hydrocarbons on selected crops from Agbada11 and Umuebulu communities in Rivers State.The following crops; bitter leaf, plantain, pawpaw, pepper, cassava and water leaf were randomly sampled from two study areas; Umuebulu and Agbada11. These samples were subjected to laboratory analysis for the determination of Polycyclic Aromatic Hydrocarbons (PAHs) using Gas chromatography- Flame Ionization Detection (GC-FID) method. The results obtained showed that the average cumulative concentrations of PAHs for Agbada11 location ranges from 0.000 to 0.027mg/kg. the values for Umuebulu vary from 0.000 to 0.073mg/kg while the pollutant was not detected for the control location. The study further indicated a statistically significant interaction effect of crops based on locations on the concentration of PAHs ($P<0.01$). The concentration of cumulative PAHs was high in all leaf samples from Umuebulu while in samples from Agbada11, bitter leaf and cassava leaf were below DPR limit; pawpaw leaf, water leaf, pepper leaf and plantain leaf were above DPR limit. The study had shown that the crops are polluted and that can pose serious health hazard to the humans and animals.

Key word: Gas Flaring, Crops, Levels, Agbada11, Umuebulu and PAHs.

1. INTRODUCTION

Natural gas is a hydrocarbon gas combination found naturally in the soil. In some situations, it consists of a mixture of higher alkanes such as ethane, propane, and butane. Carbon dioxide, nitrogen, and/or hydrogen sulfide are all present in some form. Its development is the result of thousands of years of exposing decomposing plant and animal debris to extreme temperatures and pressures. The plants store the energy they get from the sun in the form of chemical bonds in the gas. When compared to other energy sources such as oil or coal, natural gas is commonly referred to simply as "gas" [1]. Natural gas can be discovered in coal beds, either in combination with oil in oil fields or alone in natural gas fields (as coalbed methane). When petroleum is used to make gas, it is frequently vented or flared. There is a controlled system that involves the burning of associated gas in the process of normal operations that are involved in the extraction of oil and gas. That procedure is known as gas flaring, and it can occur in oil wells, refineries, and even chemical facilities, according to Oil and Gas Producers [2]. Flared gas is completely natural gas, which is made up of hydrocarbons. Globally, around 100 billion cubic meters (m3) of natural gas are flared each year [3],[4]. Natural gas linked with crude oil is burned during the production of crude oil in a process known as gas flaring. Flaring is a big issue in petroleum-producing locations where the infrastructure to use the natural gas produced is lacking. It's a means to get rid of the gas that's created in those places. As straightforward as it may appear, this has a number of negative consequences for both the people in debt and the ecosystem in general [5]. It depletes natural resources and generates hazardous waste, both of which have severe consequences for society. Various ecological and human disasters have happened over the previous three decades, and gas flaring by oil firms has been implicated as a key contributor to environmental deterioration and pollution of varying magnitudes. Gas flaring, like all carbonaceous fuel combustion, produces carbon (C0x), sulfur (S0x), and nitrogen (NOx) oxides, water vapour, and volatile and non-volatile trace metals such as lead (Pb), mercury (Hg), cadmium (Cd), and arsenic (As). Incomplete combustion of flared gas creates greenhouse gases (CH4), as well as other gaseous pollutants such CO and organic elemental particles (Coke). Acid rain is formed when these released gases and other chemical compounds precipitate in the atmosphere and fall to the ground [6], [7].

2. MATERIALS AND METHODS

This prospective comparative study was carried out on crops harvested from farms around Umuebulu and Agbada11 gas flare stations in march 2020. A total of 81 samples were collected for this study.

2.1 Study Area

2.1.1 Study location: The study areas consist of Umuebulu in Etche LGA and Agbada II in Obio/Akpor LGA both in Rivers State, Nigeria. Agbada11 falls within latitude N4055'54.142"and longitude 700'55.951" E, while Umuebulu is within latitude 04063.674N and longitude 007007.129'E.

2.1.2 Climate: The studied areas are located in the Niger-humid Delta's tropical zone, and their climate is heavily impacted by their closeness to the Atlantic Ocean and the Imo River. Rainfall occurs throughout the year, with the highest amounts occurring in June and September and the lowest amounts being from November to February. The yearly rainfall averages about 2200 mm. Moisture from the coastal area is brought in by the southwest trade winds. The lands were defined by two seasons: wet and dry. The rainy season lasted from April to October, and the dry season lasted from November to March. In the dry season, the greatest temperature (^oC) values ranged from 34.0 to 36.3 and occurred between 1300 and 1800 h, while the lowest temperature (^oC) values occurred between 0400 and 0800 h. During the rainy season, temperatures range between 24.5 and 29.0 ^oC in the early hours (0400 – 0600 h). Between 0900 and 1800h, temperatures were higher (ranging from 29 to 32 ^oC).

2.1.3 Vegetation: The vegetation is a mixture of primary and secondary regrowth forests. Sparse vegetation was found in the areas.

2.1.4 Land use: The dominant land use activity is agriculture. Crops such as cassava, plantain, pawpaw, bitter leaf, water leaf etc are grown. Domestic animals are also reared. Industrial activities found in the area include gas flaring and oil flow station.

2.2 PLANTS SAMPLING AND PREPARATION

2.2.1 Plants Sampling: It was expected that the gas flaring activities at the study locations will pose some detrimental effect to its immediate surroundings. To establish the level of this threat, six (6) plant types were selected for sampling in the study area. The plants were bitter leaf (*Vernonia amygdalina*) and plantain (*Musa paradisiaca*) leaf, pawpaw (*Carica papaya*) leaf & fruit, pepper leaf & fruit, cassava (*Manihot esculenta*) leaf & tuber and water leaf (*Talinum trangulare*). The crops were harvested from farms sited at two (2) gas flare stations and control. The various crops were randomly harvested from three farms within each location. Samples of each crop collected were put in an uncontaminated polyethylene bag. The bags were tagged for proper identification

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before taken to the laboratory for analysis. The control site was 3km from Umebulu flow station.

2.2.2 Preparation of Samples: Crop varieties that were obtained in similar quantities from different farms at each site were combined. Before drying, the leaves were removed from the stem, rinsed with de-ionized water, drained in a colander, and shredded. Both the pepper and the pawpaw were cleaned in de-ionized water, and the pawpaw was peeled before being diced and dried. The cassava was also cleaned in water to remove soil and dirt before being peeled and thinly sliced and dried. All samples were dried for 72 hours in an air oven at 60°C, then cooled to room temperature, milled in a hammer mill, and sieved through a 1mm diameter mesh. Until they were needed for examination, the milling samples were kept in airtight plastic containers.

2.2.3 Laboratory Analysis: The crop samples prepared were further analysed for Polycyclic Aromatic Hydrocarbons (PAHs). Polycyclic Aromatic Hydrocarbons (PAHs) were analysed using the Gas Chromatography-Flame Ionization Detection (GC-FID) method

2.2.4 Determination of PAHs: Gas Chromatography-Flame Ionization Detection was used to examine PAHs (GC-FID). The Gas Chromatographic system consisted of a single Flame Ionization Detector, a 30mm long, 1m thick, 0.25mm internal diameter capillary column input, and a liquid auto-sampler or injector. The samples were moved using air, hydrogen, and helium as carrier gases. When air and hydrogen gases were burned, a flame was formed, which ignited the sample extract and caused it to elute from the FID column, causing the detector to respond. The results of the analytes acquired from each crop sample were recorded on the monitor as an electronic signal (the chromatogram). The results were presented in milligrams per kilogram (mg/kg) concentrations. The analyzed PAH components were Benzene,1,2,3-trimethyl, Naphthalene, 2-Methylnaphthalene, Acenaphthylene, Acenaphthene, Fluorene, Anthracene, Phenanthrene, Fluoranthene, Pyrene, Benz(a)anthracene, Chrysene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(a)pyrene, Diben(a,h)anthracene, Indeno(1,2,3-cd) pyrene, and Benzo(g,h,i)perylene.

2.3 Statistical Analysis: Statistical Analysis of the data obtained were done using Two-way Analysis of Variance (ANOVA); IBM SPSS Statistics 26.

3. RESULTS

Table 1. Indicate the concentration cumulative of

		AGBADA			UMUEBULU			CONTROL		
Sample id	**UNIT**	**Sp 1**	**Sp 2**	**Sp 3**	**SP 1**	**SP 2**	**SP 3**	**SP 1**	**SP 2**	**SP 3**
BL. L	Mg/kg	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PL. L	Mg/kg	0.03	0.01	0.00	0.09	0.12	0.01	0.00	0.00	0.00
CA. L	Mg/kg	0.01	0.01	0.00	0.09	0.08	0.02	0.00	0.00	0.00
CA. T	Mg/kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PP. L	Mg/kg	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PP. F	Mg/kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PW. L	Mg/kg	0.05	0.03	0.00	0.08	0.09	0.01	0.00	0.00	0.00
PW. F	Mg/kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WF. L	Mg/kg	0.03	0.02	0.00	0.06	0.07	0.01	0.00	0.00	0.00

PAHs in the crops while table 2 is the mean and standard deviation of the concentrations of cumulative PAHs in the crop samples. Figure 1 Compares' the mean concentrations of cumulative PAHs in crops across the study locations

TABLE 1: CUMULATIVE CONCENTRATIONS OF PAHs DETECTED IN CROP SAMPLES

Note: BL.L - Bitter Leaf, PL.L – Plantain Leaf, CA.L – Cassava Leaf, CA.T Cassava Tuber, PP.L – Pepper Leaf, PP.F – Pepper Fruit, PW.L Pawpaw Leaf, Pw.F – Pawpaw Fruit, WL.L – Water Leaf, SP – Sample Point.

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Table 2: Mean and Standard Deviation of Concentrations Cumulative PAHs detected in Crop Samples

	AGBADA					UMUEBULU					CONTROL				
	SP1	**SP2**	**SP3**	**MEAN**	**STD**	**SP1**	**SP2**	**SP3**	**MEAN**	**STD**	**SP1**	**SP2**	**SP3**	**MEAN**	**STD**
BL.L	0.000	0.020	0.000	**0.007**	**0.012**	0.000	0.000	0.000	**0.000**	**0.000**	0.000	0.000	0.000	**0.000**	**0.000**
PL.L	0.030	0.010	0.000	**0.013**	**0.015**	0.090	0.120	0.010	**0.073**	**0.057**	0.000	0.000	0.000	**0.000**	**0.000**
CA.L	0.010	0.010	0.000	**0.007**	**0.006**	0.090	0.080	0.020	**0.063**	**0.038**	0.000	0.000	0.000	**0.000**	**0.000**
CA.T	0.000	0.000	0.000	**0.000**	**0.000**	0.000	0.000	0.000	**0.000**	**0.000**	0.000	0.000	0.000	**0.000**	**0.000**
PP.L	0.020	0.030	0.000	**0.017**	**0.015**	0.000	0.000	0.000	**0.000**	**0.000**	0.000	0.000	0.000	**0.000**	**0.000**
PP.F	0.000	0.000	0.000	**0.000**	**0.000**	0.000	0.000	0.000	**0.000**	**0.000**	0.000	0.000	0.000	**0.000**	**0.000**
PW.L	0.050	0.030	0.000	**0.027**	**0.025**	0.080	0.090	0.010	**0.060**	**0.044**	0.000	0.000	0.000	**0.000**	**0.000**
PW.F	0.000	0.000	0.000	**0.000**	**0.000**	0.000	0.000	0.000	**0.000**	**0.000**	0.000	0.000	0.000	**0.000**	**0.000**
WF.L	0.030	0.020	0.000	**0.017**	**0.015**	0.060	0.070	0.010	**0.047**	**0.032**	0.000	0.000	0.000	**0.000**	**0.000**

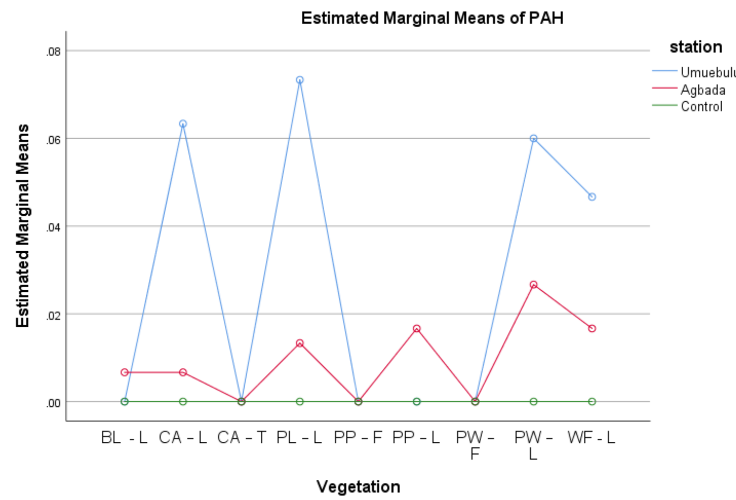

Figure 1: Comparison of the mean concentrations of cumulative PAHs in crops across the study locations.

4. DISCUSSION

From table 2, the average concentrations of cumulative PAHs for Agbada location ranges from 0.000 to 0.027mg/kg. the values for Umuebulu vary from 0.000 to 0.073mg/kg while the pollutant was not detected for the control location. Table 2 also shows that the concentration of PAHs in cassava leaf was from 0.007 in Agbada while in Umuebulu it was 0.063mgkg. similarly, there was a difference in the levels of PAHs in pawpaw leaf (0.027mg/kg) in Agbada and that of Umuebulu (0.060mk/kg).

There was a statistically significant interaction effect of vegetation based on location on the concentration of PAHs ($P<0.01$), 46% variation can be attributed to the interaction of vegetation on a location. There was also main effect of the station on the concentration of PAHs ($P<0.01$), 36% variation can be attributed to the station independent of the vegetation. The present study showed that gas flaring activities going on in Agbada11 and Umuebulu Communities has statistically increased the concentration of PAHs in the area; PAH was found to be very high in Umuebulu when compared with control, it was present in Agbada11 but was not very high when compared with control. Interestingly, there was also main effect of vegetation on the concentration of PAHs ($P<0.01$), 40% variation can be attributed to the vegetation independent of station, PAH was found to be high in plantain leaf followed by cassava leaf, next was pawpaw leaf before water leaf. PAH was not detected in any of the root plants and fruits; the result from the research could be as a result of duration of the individual plant in the affected areas. According to Nwaichi, Agbam, and Iwu, PAH concentrations in all samples except yam from akalaolu were significantly higher than those in the ogale community [8].

Following the DPR intervention limit of 0.01mg/kg dw and EU limit of 0.2 mk/kg for food as reported by Nwaichi, Wegwu and Nwosu [9], PAHs concentration level in leaf samples from Umuebulu was above limit when compare to DPR intervention limit but below limit when compared with EU limit. The levels of cumulative PAHs were high in all detected samples from Umuebulu when compared with DPR. Agbada, bitter leaf and cassava leaf were below limit; pawpaw leaf, water leaf, pepper leaf and plantain leaf were above limit when compared with DPR. Previous work by Tuteja, Rout and Bishon, show that the mean concentration of PAHs in leafy and underground vegetation was 0.032 and 0.060mg/kg [10].

Other report showed a varying result. However, in the present study PAHs concentration were reportedly statistically significant in leafy part than other part of the crops. PAH concentrations are generally greater on plant surface (peel, outer leaves) than on internal tissue [11], this may be the reason why PAHs were not detected in any fruit or tuber of the samples from both Umuebulu and Agbada11 communities, since the peels of the fruits and tubers were taken off. The atmosphere is the most important means of PAH dispersal, which is the more reason why resident and consumers of crops from Umuebulu and Agbada11 may be at risk from the pollution from gas flaring activity in these communities.

5. CONCLUSION

The study has been able to assess the effects of flared gas on crops harvested from Agbada 11 and Umuebulu communities. The selected crop types play important role to humans and other living things. The concentrations of PAHs were significant in some crop samples between Umuebulu and Agbada 11 locations. The findings also show that the concentrations of the pollutant were higher than the regulatory standard and control location in some areas

Polycyclic Aromatic Hydrocarbons were also found to be significant higher in leafy part of the crops from both Umuebulu and Agbada11.

The study had shown that the crops are polluted and that can pose serious health hazard to the humans and animals.

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