

ASSESSMENT OF AROMATIC VOLATILE ORGANIC COMPOUNDS EMITTED FROM DIESEL ENGINES USED IN LOCAL FOOD PROCESSING MARKET, AGO, ISALE KOTO AREA, ILORIN, NIGERIA.

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ABSTRACT

Diesel engines are important emission sources of aromatic Volatile Organic Compounds species including Benzene, Toluene, Ethylbenzene and o, m, p Xylene (BTEX). In this study, the impact of aromatic VOCs emission from diesel engines operation was investigated in a local food market.

The aim of this study was to assess the contribution of diesel engines to VOCs emission in a local food processing market, Ago, Ilorin, Nigeria, on workers, patronizers and inhabitants. Fabricated passive samplers were deployed at ten locations for both indoor and outdoor within the market at above 1.5m human breathing height containing 30grams of activated charcoal each as adsorbent. The samplers were exposed for one month, the analytes were recovered by desorption process with carbondisulphide CS₂ and subjected to Gas Chromatography fitted with flame ionization detector.

The VOCs concentrations found are ranged from 0.0021-0.0026 mg/m³ for Benzene; 0.0017-0.0023mg/m³ for Toluene; 0.0009-0.0017 mg/m³ for Ethylbenzene; 0.00101- 0.00192 mg/m³ for Xylene for outdoor sampling while for indoor sampling the ranged are 0.0024-0.0031 mg/m³ for Benzene; 0.0018-0.0023 mg/m³ for Toluene; 0.0013-0.0023 mg/m³ for Ethylbenzene; 0.00093- 0.00222 mg/m³ for Xylene. The averaged BTEX concentration at the indoor was higher than outdoor environment. The averaged concentrations of BTEX at all locations were lower than the limit of air quality standards. The mean lifetime cancer risk for workers, patronizers and inhabitants exposed to benzene and ethylbenzene for 25 years were estimated at 1.33×10^{-7} and 1.16×10^{-7} for indoor and outdoor respectively. Non cancer risks Hazard Index were estimated to be 1.11×10^{-5} and 8.74×10^{-6} for both indoor and outdoor respectively. Both cancer risk and non-cancer risk assessment are within acceptable limit.

This study established that significant aromatic VOCs are emitted from diesel engine exhausts and recommends hydrogen powered engines in place of diesel engines as to eliminate VOC emissions in local food processing industries.

Keywords: diesel engine; cancer risk ; non-cancer risk; internal engine combustion; exhaust emission

1.0 INTRODUCTION

The processing and operation of food processing engines in a local food market with diesel engines at Ago, Ilorin, Nigeria is consociated with the emission of various pollutants such as nitrogen oxides (NO_x), carbon monoxide (CO), burned and unburned hydrocarbon (HC), and particulate matter (PM), heavy metals and sounds into the atmosphere. The burned and unburned hydrocarbon from diesel engine emission contains significant amount of volatile organic compound (VOCs) that causes of severe environmental problems and affecting human health [1]. These VOCs emissions are originated from internal engine combustion of diesel engines use during food grinding and processing. Studies on long term motoring of toxic pollutants VOCs from local industrial facilities confirm a significant exposure for workers, patronizers and inhabitants of these areas [2]. Once VOCs are released into the environment they rise and disperse into the stratosphere and degrade the environment. Studies have shown that continuous exposure to VOCs can shorten human life by fourteen years for living around where its emission occur [3].

VOCs are one of the major hydrocarbon air pollutants which threaten human life and ecosystem when released to the atmosphere. When inhaled and in contact with human skin, they can cause a lot of damages to human health and her immediate environment if not properly managed and controlled. The continuous release of VOCs emissions can cause acute toxic symptoms including nausea, headaches, conjunctive irritation, nose and throat discomforts,

headache and sleeplessness, allergic skin reaction, nausea, fatigue and dizziness and stimulation of eyes and nose [4]. Long-term exposure to VOCs is also reported to have direct toxic effect with increase in the risk of mutagenicity, carcinogenicity neurotoxicity [5]. Human exposure to certain level of VOCs induce negative impact on the outcome pregnancies [2] causes DNA breakdown in bone marrow cells and luteal functions in women [3]. Furthermore long term exposure of VOCs is known to have cause Sick Building Syndrome (SBS) for the inhabitants where VOCs are continuously released.

In 1999, a study was conducted in Thailand environmental institute on industries in Map Ta Phut industrial estate. The results reviewed that VOCs are mostly released from fuel combustion, incinerator, industries, petrol stations and storage tanks. It was observed that students in the communities nearby the industrial estate complained about nuisance odor, dizziness, sinusitis, sore throat and fatigue which are as a result of VOC's released to the atmosphere [6]. VOCs are known for degrading air quality. VOCs as hydrocarbons in the atmosphere, contribute to stratospheric ozone depletion, enhance local and global greenhouse effect [2]. The important characteristic of VOCs is their toxicity for human, animals and the environment [5].

Benzene, toluene, ethyl benzene and xylene (BTEX) are the most toxic VOCs pollutants in the air [6]. They frequently occur together during various forms of combustion. Benzene has been classified as a class 1 carcinogen by the World Health Organization (WHO) and the International Agency for Research (IARC) [7]. Long exposure to benzene may cause bone marrow damage, aplastic anemia, and leukemia [2]. Ethylbenzene is known as a suspected carcinogenic material [8]. Toluene and xylene are harmful and classified as group d, which means non-carcinogenic [8]. Toluene may cause eye, nose, and throat irritation as well as headaches and dizziness by impacting the central nervous system. Long exposure to xylene irritates eyes and may cause eye blindness. [9] reported that long exposure to toluene, xylene, and ethylbenzene may cause chronic nerve damage.

In view of environmental and health significance of toxic VOCs emissions from the exhaust of diesel engines used during local food processing, thus this research aims at assessing aromatic volatile organic compounds emitted from diesel engines for both indoor and outdoor air quality in local food processing market, Ago, Isale Koto area, Ilorin, Nigeria.

2.0 MATERIALS AND METHODS

Description of Study Area: Ago market is one of the major markets in Ilorin city, northcentral Nigeria, with a beehive of activities. It is situated at Isale Koto area, Ilorin south local government. It is located on latitude $8^{\circ}29'33.36''\text{N}$ and longitude $4^{\circ}33'05.11''\text{E}$. The market hosts at least more than 300 people at a time.

On the basis of climate, Ilorin metropolis experience two climate seasons i.e. rainy and dry season. The rainy season is between towards the end of April and lasts till October. The dry season begins in November and ends in April. The temperature of Ilorin ranges from 33°C to 37°C with days being very hot during the dry season. The annual rainfall varies from 1000mm to 1500mm, with the peak between September and early October. The rainfall in Ilorin exhibits the double maxima pattern and greater variability both temporary and spatially. The relative humidity in Ilorin city ranges from 75% to 88% from May to October, while in the dry season it ranges from 35% to 80%. Also, the mean monthly temperature is generally high throughout the year with the temperature being highest on average in March at around 29°C while August is the coldest month with temperature averaging 24.5°C [10].

Description of Sampling Site: Ten locations were identified and selected for both inside and outside of local food processing outlet market in Ago, Ilorin. These locations characterized with emission from the exhaust pipes of the diesel engines used in grinding and processing local foods.

Sampling Locations: Samples were taken from both inside and outside of the shops of local food processing market. The sampling system was placed at human breathing height of 1.5m for a sampling period of one month. Five each for indoor and outdoor sampling, respectively.

2.1 Methods

The procedure adopted for this research work includes; passive sampling, extraction process, and chromatography analysis

Passive Sampling system: This is made up of plastic container (adsorption column) with diameter 7cm and height 15cm perforated at top and bottom to allow natural convection flow of the contaminated air in and out of the adsorption column. The adsorbent media (granular activated charcoal of mesh 10) of 30 grams were placed in the adsorption column supported by plastic gauze in the column. The contaminated air from diesel engines exhaust

within the selected locations at the local food processing market was ensured its dispersed and diffused into the adsorption column via adsorbent media. The adsorption columns (plastic container) were wrapped with binding wire for suspension in the air. The sampling period adopted was one month. The passive sampling system was assembled at specific spot in the market where sampling was carried out.

After one month, samples collection were carried out, the adsorbed activated charcoal were collected in a sampling bottles and taken to the laboratory for extraction



Plate 1: Air sampling system at Sampling location.

Extraction procedure: The extraction of the adsorbed activated carbon was carried out using rotary evaporator modeled R300, BUCHI Labortechnik AG, Switzerland. 30g of each sample were weighed into the sample flask, 50.0 ml of carbon disulfide (CS_2) that is the solvent for the extraction, was added to the sample flask which was fixed onto the rotary evaporator and submerged in the heating bath maintained at 50°C . The sample was allowed to solubilize in the solvent while inside the heating bath for 10 minutes. Thereafter, the pressure pump was activated and the extracted solutions (distillate) were collected in the cleaned receiver flask and then transferred to bottle containers which were stored in the refrigerator prior to the time of further analysis. This was repeated for every sample.

Chromatography Analysis: The quantitative determination of extracted solutions were analyzed with Gas Chromatography method (GC Model: HP 6890) fitted with a Flame Ionizations Detector (GC-FID). The capillary column was HP 5MS with length, inner diameter and particle size set at $(30\text{m} \times 0.25\text{mm} \times 0.25\mu\text{m})$. It was attached to the injection port. The flow rate of carrier gas (hydrogen) was 1.0 ml/min. The hydrogen pressure and compressed air were set at 22psi and 28psi respectively. The injection temperature was split injection set at 150°C , the detector temperature at 320°C , and the oven temperature was programmed at 50°C with the 1st ramped $5^\circ\text{C}/\text{min}$ to 150°C and 2nd ramped at $0^\circ\text{C}/\text{min}$ to 250°C . A 1ml aliquot of the final solution was injected in the GC (split ratio; 20:1). Calibration standards were provided by the laboratory which was used for calculation of concentrations from chromatography peaks. Calibration standards were run thereafter samples were run and quantified by ChemStation software. The sampling collections and quantitative analysis described above are consistent with ANSI/ASTM procedure.

3.0 RESULTS AND DISCUSSION

The results obtained from chromatography analysis were presented in Table 1 and Table 2 for both outdoor and indoor of ten different locations at the local food processing market, Ago, market while Table 3 presents compliance of identified VOCs species emissions at the market with air quality standards.

According to the results, benzene concentrations are the most abundant aromatic VOCs species identified in all the locations with $0.012 \text{ mg}/\text{m}^3$ and $0.0135 \text{ mg}/\text{m}^3$ for both indoor and outdoor sampling respectively. Benzene Concentrations ranged from $0.0021\text{--}0.0026 \text{ mg}/\text{m}^3$ at outdoor while ranged from $0.0024\text{--}0.0031 \text{ mg}/\text{m}^3$ at indoor. Indoor concentrations were found to be more than outdoor concentrations due to their closeness to exhaust diesel engines and confinement of indoor environment. Comparing the sampled average concentrations of benzene as against local and international standards as shown in Table 3. The mean concentration of benzene was lower when compared to United States Environmental Protection Agency (USEPA) (Chronic inhalation guidelines), ATSDR (Acute inhalation guidelines) and National Environmental Standards and Regulations Enforcement

Agency(NESREA) (air emission guidelines for petroleum based and chemical industries) and Agency for Toxic Substances and Disease Registry (ATSDR) (Chronic inhalation guidelines) standards. This implies that benzene emissions from the market are within allowable limits, however continuous exposure to benzene at location A indoor for one year or more(chronic inhalation) could be hazardous to populace within the market most especially the workers and inhabitants close to location A because its emission was more than USEPA(IRIS) chronic inhalation guidelines.

Toluene species concentrations are next to benzene species in descending order of distribution in the market air basin with 0.01 mg/m³ and 0.0109 mg/m³ for both outdoor and indoor sampling respectively. Toluene concentrations ranged from 0.0017-0.0021 mg/m³ at outdoor while ranged from 0.0018-0.0023 mg/m³ at indoor. Comparing the sampled average concentrations of toluene as against local and international standards as shown in Table 3. The mean concentration of toluene was lower when compared to USEPA (Chronic inhalation guidelines), ATSDR (Acute inhalation guidelines), ATSDR (Chronic inhalation guidelines), and NESREA (air emission guidelines for petroleum based and chemical industries) standards. This indicates that toluene emissions from the market are within allowable limits and that operational routine of the market can be said to have no adverse effect.

The concentrations of ethyl benzene at the air basin of the local food processing market are 0.0069 mg/m³ and 0.0092 mg/m³ for both outdoor and indoor sampling respectively in all sampling locations. Ethyl benzene concentrations ranged from 0.0009-0.0017 mg/m³ at outdoor while ranged from 0.0018-0.0023 mg/m³ at indoor. The trends of ethyl benzene emissions could be traced to other VOCs species earlier considered. Comparing the sampled average concentrations of ethyl benzene as against local and international standards as shown in Table 3. The mean concentration of ethyl benzene is lower when compared to USEPA (Chronic inhalation guidelines), ATSDR (Acute inhalation guidelines), ATSDR (Chronic inhalation guidelines) and NESREA (air emission guidelines for petroleum based and chemical industries) standards. This indicate that ethyl benzene emissions from the local food processing market are within allowable limits .

The chromatographic analysis identified three isomers of xylene. They are para-xylene (p-xylene), meta-xylene (m-xylene), ortho-xylene (o-xylene). Trace level of xylene concentrations were observed. P-xylene is the most prominent among xylene isomers identified. The concentrations of P-xylene are 0.0044 mg/m³ and 0.00481 mg/m³ for both outdoor and indoor sampling respectively. P-xylene concentrations ranged from 0.0006-0.0011 mg/m³ at outdoor while ranged from 0.0009-0.0014 mg/m³ at indoor. M-xylene concentration is next to P-xylene in order of dispersion distributions. The least among the xylene isomer is o-xylene. All xylene isomers detected are extremely at low value probably due to photochemical reactions.

Comparing the sampled average concentrations of xylene isomers as against local and international standards as shown in Table 3. The mean concentrations of xylene isomers are lower when compared to USEPA (Chronic inhalation guidelines), ATSDR (Acute inhalation guidelines), ATSDR (Chronic inhalation guidelines), and NESREA (air emission guidelines for petroleum based and chemical industries) standards. These indicate that xylene emissions from the market are within allowable limits.

Table 1: Sum and average measured concentrations (mg/m³) of VOCs Species at the outdoor of the shops of local food processing market at location A, B, C, D and E

S/N	Location	Benzene	Toluene	Ethylbenzene	P-Xylene	M-Xylene	O-Xylene	Xylene
1	A	0.0021	0.0017	0.0009	0.0006	0.0004	0.00001	0.00101
2	B	0.0026	0.002	0.0016	0.0011	0.0008	0.00002	0.00192
3	C	0.0024	0.0023	0.0013	0.0009	0.0008	0.00002	0.00172
4	D	0.0023	0.0019	0.0017	0.001	0.0007	0.00001	0.00177
5	E	0.0026	0.0021	0.0014	0.0008	0.0006	0.00002	0.00142
SUM		0.012	0.01	0.0069	0.0044	0.0033	0.00008	0.00784
AVERAGE		0.0024	0.002	0.00138	0.00088	0.00066	0.000016	0.001556
Standard Deviation		0.0002121	0.000224	0.000311448	0.0001924	0.0001673	5.48E-06	

Table 2: Sum and average measured concentrations (mg/m³) of VOCs Species at the indoor of the shops of local food processing market at location A, B, C, D and E

S/N	Location	Benzene	Toluene	Ethylbenzene	P-Xylene	M-Xylene	O-Xylene	Xylene
1	A	0.0031	0.0023	0.0023	0.0014	0.0008	0.00002	0.00222
2	B	0.0024	0.0018	0.0013	0.0009	0.0006	0.00001	0.00151
3	C	0.0028	0.0023	0.0021	0.0013	0.0008	0.00002	0.00212
4	D	0.0027	0.0022	0.0019	0.0011	0.0009	0.00001	0.00201
5	E	0.0025	0.0023	0.0016	0.00011	0.0008	0.00002	0.00093
SUM		0.0135	0.0109	0.0092	0.00481	0.0039	0.00008	8.79E-03
AVERAGE		0.0027	0.00218	0.00184	0.000962	0.00078	0.000016	1.76E-03
Standard Deviation		0.000274	0.000217	0.000397	0.000514	0.00011	5.48E-06	

Table 3: Comparison of average measured VOCs species concentrations with Ambient Air Quality Standards for all locations in both indoor and outdoor environment at the local food processing market, Ago, Ilorin

VOCs Species	ATSDR acute inhalation guidelines mg/m ³	ATSDR chronic inhalation guidelines mg/m ³	USEPA(IRIS) chronic inhalation guidelines mg/m ³	NESREA air emission guidelines for petroleum based and chemical industry mg/m ³	Local Processing (average concentration) mg/m ³	Food Market measured concentration in mg/m ³
					Outdoor	Indoor
Benzene	0.2871	0.00957	0.03	0.05	0.0024	0.0027
Toluene	3.76	0.3	0.4	0.05	0.002	0.00218
Ethyl benzene	21.68	0.26	1	0.02	0.00138	0.00184
p-xylene	8.67	0.22	0.1	0.02	0.00088	0.000962
m-xylene	8.67	0.1	0.1	0.02	0.00066	0.00078
o-xylene	8.67	0.22	0.1	0.02	0.000016	0.000016

Sources: [11];[12]; [13]

For Duration, Acute = 1 to 14 days and Chronic = 1 year or longer.

VOCs Species Correlation for both indoor and outdoor emission: In this research, Pearson's correlation (2-tailed) analysis was employed for VOCs species emissions to determine their strength of association or co-occurrence. The determined correlation is presented in Table 7 and discussed in more detail below. The positive correlation 0.5 – 0.59 indicates a moderate correlation, 0.6–0.69 shows an above moderate correlation, 0.7–0.79 a strong correlation, and 0.8 and above a very strong correlation. Below are the Pearson correlation results:

Table 4: Correlations of Benzene and Toluene

		Benzene	Toluene
Benzene	Pearson Correlation	1	.704*
	Sig. (2-tailed)		.023
	N	10	10
Toluene	Pearson Correlation	.704*	1
	Sig. (2-tailed)	.023	
	N	10	10

*. Correlation is significant at the 0.05 level (2-tailed).

Table 5: Correlations of Benzene and Ethylbenzene

		Benzene	Ethylbenzene
Benzene	Pearson Correlation	1	.885**
	Sig. (2-tailed)		.001
	N	10	10
Ethylbenzene	Pearson Correlation	.885**	1
	Sig. (2-tailed)	.001	
	N	10	10

**. Correlation is significant at the 0.01 level (2-tailed).

Table 6: Correlations of Benzene and Xylene

		Benzene	xylene
Benzene	Pearson Correlation	1	.709*
	Sig. (2-tailed)		.022
	N	10	10
xylene	Pearson Correlation	.709*	1
	Sig. (2-tailed)	.022	
	N	10	10

*. Correlation is significant at the 0.05 level (2-tailed).

From Table4 to Table 6 are results of correlations of VOCs species. The Pearson's correlations are 0.704, .709 and 0.885 among benzene, toluene, xylene and ethylbenzene respectively. These indicate a very strong positive relationship among benzene, toluene, xylene and ethylbenzene. These means that changes in benzene emissions is strongly related to toluene, xylene and ethylbenzene emissions and vice versa suggesting that their primary sources of origin are similar. The sig. (2-tailed) value were 0.253, .022 and .001 (value less than 0.05) respectively; which show that relationship among benzene, toluene, xylene and ethylbenzene respectively are statistically significant. This implies that increase or decrease in benzene emission is significantly related to increase or decrease in toluene, ethylbenzene and xylene emission. This further indicates that BTEX co-exist and they are from the same similar sources.

Cancer and Non-cancer inhalation health risk assessment of aromatic VOCs emitted from diesel engines used in local food processing market: Cancer and non-cancer health risks assessment were determined using the USEPA approach (1989). Benzene and ethylbenzene are carcinogenic substances while toluene and xylene are non-carcinogenic substances. Local information on health risk assessment (HRA) based on impact of diesel engine emissions from the exhausts in local food processing market, Ilorin, Nigeria, were obtained by the questionnaire distribution during the sampling period.

The cancer risk assessment can be calculated according to the following equation:

$$\text{Cancer risk} = \text{CDI} \times \text{CSFi} \quad (1)$$

$$\text{CDI} = (\text{CA} \times \text{IR} \times \text{ET} \times \text{EF} \times \text{ED}) / (\text{BW} \times \text{AT}) \quad (2)$$

where CDI represents chronic daily intake (mg/kg/day), CA: daily pollutant concentration in the air (mg/m³), IR inhalation rate (0.875 m³/hr for adult; [36], BW :body weight (57.8 kg, the average BW of workers from the questionnaire), ET the exposure time (8hrs/day for workers from the questionnaire), EF exposure frequency (355 days/year for workers from the questionnaire), ED exposure duration (25 years for workers from the questionnaire), and AT (day) is the average time for cancer estimation (60 years x 365 day/year from the questionnaire). CSFi cancer slope factor (mg/kg/day)⁻¹ for Benzene is 2.73x10⁻²; Ethylbenzene is 3.85x 10⁻³ [11]. A cancer risk of > 10⁻⁶ is considered carcinogenic effects of concern and a value ≤10⁻⁶ was considered an acceptable or safe level.

The non-cancer risk assessment can be expressed as Hazard Quotient (HQ) and be calculated according to the following equation:

$$\text{HQ} = \text{EC} / \text{RfC} \quad (3)$$

$$\text{EC} = (\text{CA} \times \text{ET} \times \text{EF} \times \text{ED}) / \text{AT} \quad (4)$$

Where EC and RfC represents Exposure Concentration (mg/m^3), Reference Exposure Concentration or Inhalation Reference Concentration (mg/m^3), respectively. Inhalation reference concentrations for BTEX are as follows: Benzene: 3×10^{-2} ; Toluene: 5; Ethylbenzene: 1; Xylene: 1×10^{-1} [11]. AT (hour) is average time for non-cancer estimation: life in years $\times$ 365 days/year $\times$ 24 hours/day.

A value of $\text{HQ} > 1$ are considered adverse non-carcinogenic effects of concern while a value $\text{HQ} \leq 1$ was considered acceptable or safe level. The non-cancer health impact was expressed as the hazard index (HI) or Total Risk determined by the summation of all HQs at a certain location.

Table 4: The average VOCs species exposure emitted from diesel engines emissions and associated health risk among workers, patronizers and inhabitants of Ago market, Ilorin.

Site	VOCs species	CDI ($\text{mg}/\text{kg}/\text{day}$)	EC (mg/m^3)	Cancer Risk	Non-cancer risk (HQ)
Indoor	Benzene	4.42×10^{-6}	1.22×10^{-5}	1.21×10^{-7}	4.07×10^{-8}
	Toluene		9.82×10^{-6}		1.96×10^{-6}
	Ethylbenzene	3.01×10^{-6}	8.29×10^{-6}	1.15×10^{-8}	8.29×10^{-6}
	Xylene		7.92×10^{-6}		7.92×10^{-7}
Total Risk				1.33×10^{-7}	1.11×10^{-5}
Outdoor	Benzene	3.93×10^{-6}	1.08×10^{-5}	1.07×10^{-7}	3.6×10^{-8}
	Toluene		9.01×10^{-6}		1.80×10^{-6}
	Ethylbenzene	2.26×10^{-6}	6.21×10^{-6}	8.70×10^{-9}	6.21×10^{-6}
	Xylene		7.02×10^{-6}		7.02×10^{-7}
Total Risk				1.16×10^{-7}	8.74×10^{-6}

From Table 4, The average lifetime cancer risks for exposure of local food market workers and inhabitants to benzene and ethylbenzene emitted by diesel engines were estimated at 1.07×10^{-7} and 8.70×10^{-9} for Outdoor and 1.21×10^{-7} and 1.15×10^{-8} for Indoor respectively. The cancer risk estimation at the indoor was higher than outdoor. The cancer risk for benzene and ethylbenzene emissions at both indoor and outdoor was less than acceptable limit of 1×10^{-6} . This could indicate that health impacts of diesel engines emissions are not worrisome. This could be as a result of large volume of natural air dilution. Also result from the questionnaire shared among workers supported and revealed that none of the workers has had cancer since commencement of operations of diesel engines for food processing for almost forty years of its operations.

The non-cancer risk of VOCs species were estimated using Hazard Index or Total Risk. The HQ and $\Sigma\text{HQ} = \text{HI}$ estimated were lower than reference hazard level which is within limit for human (HI or $\text{HQ} < 1$) for both indoor and outdoor. These indicate no adverse non-carcinogenic effects such as bone marrow, hematological and neurological toxicities [36].

Suggested strategies to abate and control VOCs emission in the sampled environment. VOCs are emitted during grinding process of local food processing market from the exhaust pipes of the food processing diesel engines. Controlling VOCs emission has been a major challenge and of serious concern most especially for diesel engines. Researchers and Scientists have developed various devices like catalytic incinerator, thermal incinerator, enclosed oxidizing flares and others. All of these devices and strict regulations from pollutions regulatory bodies as well have not really tame VOCs emissions, however the environments continue to get exposed to VOCs emissions from internal diesel engines combustion. Therefore, this study suggest that there is a need for globally shift from fossil fuel engines to hydrogen powered engines in order to eliminate or mitigate exposure to VOCs emissions and any other pollutants thereby creating a carbon free environment.

4.0 CONCLUSION

This study assessed aromatic VOCs species (BTEX) exposure, emitted from diesel engines used in grinding and processing local food in Ago market, Ilorin, Nigeria. The total averaged BTEX concentrations sampled are $1.56 \times 10^{-3} \text{ mg}/\text{m}^3$ and $1.76 \times 10^{-3} \text{ mg}/\text{m}^3$ for both outdoor and indoor sampling environment. The descending order of distributions of BTEX detected are Benzene (32.72%) > Toluene (27.26%) > Xylene (21.21%) > Ethylbenzene (18.81%) for outdoor sampling while Benzene (31.85%) > Toluene (25.71%) > Ethylbenzene (21.70%) > Xylene (20.74%) for indoor sampling. The percentage Benzene and Toluene at the outdoor are more

than indoor due to external exhaust pipes of diesel engines contributing sources. Pearson's correlation (2-tailed) analysis revealed that identified VOCs species at the local food market coexist, have very strong relationship among themselves and are of similar multiple sources.

All identified VOCs species measured were in compliance with inhalation and occupation standard limits. Since Benzene and Ethylbenzene are significant contributors, more studies should be carried out on polycyclic aromatic hydrocarbon (PAH) and carcinogenic Heavy metals for more investigation on cancer risk assessment. This study suggested hydrogen powered engines to replace diesel engines in order to eliminate VOCs emissions in the local food industry.

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Competing interest:

There were no competing interest among the authors.

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ETHICAL CONSIDERATIONS

Ethical issues have been completely observed by the authors

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