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Characterization of polycyclic aromatic hydrocarbon from open burning of disposable COVID-19 facemask: Spatial distribution and risk assessment

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ABSTRACT

The use of facemasks as a preventive measure against infection of the COVID-19 virus has some associated environmental impacts, especially in Subs-Saharan African countries where the used facemasks are being disposed of using open burning. Hence this study characterized Polycyclic Aromatic Hydrocarbons (PAHs) emissions from different COVID-19 facemask materials and determined the associated risk of open burning of facemask. Facemasks of different materials were sourced from open dump sites. Each material was combusted in an open reactor and the emissions were collected using A filter-sorbent sampling system. Analysis of PAHs in the sample was carried out using GCMS. The associated health risk was assessed using Incremental Life Cancer Risk (ILCR) and Hazard Quotient (HQ). The result showed the concentration of PAHs emission ranged \sum PAHs 73.33–368.16 $\mu\text{g}/\text{m}^3$ while carcinogenic PAHs ranged \sum CarPAHs 26.79–179.74 $\mu\text{g}/\text{m}^3$. The result also showed the surgical and N95 facemask emits the highest concentration of PAHs. The modeled annual ground-level PAHs Isopleth reveals the presence of a high concentration of PAHs around the vicinity of the burning site after a year. Proper disposal of these facemask using controlled medical incinerator is highly recommended.

1. Introduction

The outbreak of coronavirus (COVID-19) has affected the world economy and the way of life. Unfortunately, this disease is going to be around for a long time. There are 609,848,852 confirmed cases of COVID-19 infections globally and 6,507,002 deaths have been recorded globally (WHO, 2022). Although a lower death rate from this virus is recorded in Africa compared to other continents, about 9,318,590 were recorded in this continent (WHO, 2022). After the lockdown in the year 2020, various measures are being put in place to curtail the spread of the virus, which include, frequent washing of hands, social distancing, travel restriction, isolation, avoiding crowded spaces, and as well as the mass wearing of face masks (Lin et al., 2020; Chintalapudi et al., 2020).

A facemask decreases the excretion of respiratory droplets from infected individuals and helps reduce the spread of infections (ECDC, 2020). It also reduces the number of times a person touches the face/mouth/nose with unwashed hands, which can significantly reduce the chance of infection (Fadare and Okoffo, 2020). Research has also shown

the effectiveness of face masks in preventing the virus from entering the respiratory system (Elachola et al., 2020; Barasheed et al., 2016). The use of face masks as one of the precautionary measures has led to a global shortage of these disposable facemasks (Wu et al., 2020). Between 2019 and 2021 about 2.5 billion N95 face mask was produced (statistica.com) and The United Nations has forecasted the demand for surgical masks alone to be in the region of 2.4 billion (unicef.org). Due to the high demand for the COVID-19 disposable facemask, the government in the developing countries of Africa such as Nigeria is encouraging the production of large quantities of locally made facemask produced from local fabrics and materials.

However, the use of facemasks has created environmental challenges, especially in the developing world with poor waste management policies. These masks are dumped indiscriminately in the environment which also blocks the water channels, and some of these masks find their way to the open incineration site where they are being combusted openly. Also, most countries of Sub-Saharan Africa practice open burning in disposing of their wastes where used masks from hospitals

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and public places are combusted in open incineration sites (Awodele and Adewoye, 2016; Chisholm et al., 2021). However burning wastes such as facemasks is associated with the emission of Polycyclic Aromatic Hydrocarbon (PAHs) (Mugica-Alvarez et al., 2015; Abdel-Shafy and Mansour, 2016; Kalisa et al., 2018; Adesina et al., 2020).

PAHs are products of incomplete combustion formed as a result of the fusion of two or more Benzene rings and they are carcinogenic, teratogenic, and mutagenic (Pongpiachan et al., 2015; Wang et al., 2015; Patel et al., 2020). There are also non-carcinogenic risks associated with exposure to PAHs to human which can be long-term health effects such as liver damage, and cardiopulmonary death (Zhao et al., 2023). PAHs can persist in the environment and can also accumulate in vascular plants and have health effects along the food chain (Zha et al., 2018).

There had been studies on open incineration of waste (Adesina et al., 2020; Cheng et al., 2022) but no focus of disposable COVID-19 facemask. However, studies on combustion of facemask in which levels of Particulate Matter was the focus (Pastukhov et al., 2023; Szefer et al., 2021).

However none of these studies focused on the characterization of PAHs from combustion of different COVID-19 disposable facemasks either from incinerator or open burning. Hence this study characterized PAHs from the open burning of different types of disposable COVID-19 facemask and the risk associated with inhalation of PAHs from the open burning of facemask. The study also modeled the ground concentrations of PAHs around the point source emission of PAHs from the burning of PAHs.

2. Materials and methods

Different facemasks of different materials were sourced at the incineration site of Afe-Babalola University Multi-system Hospital. Safety precaution was taken to avoid infection of the virus during sampling. A total number of 10 different COVID-19 facemasks made from different materials were used for the study. This Includes Surgical, Cotton, Scarf, Plastic shield, and N95 Nose masks. Others are Linen, Spandex, and Organiza nose masks.

2.1. Emission sampling

50g of each facemask material was put in an open reactor of 35cm in diameter and 25cm height. The materials were combusted and emission from each materials was taken. Particulate plus vapor-phase PAHs were collected using A filter-sorbent sampling system of European standard stationary source emission and determination of concentration method (EN- 1948 –SS) with Polyurethane Foam (PUF) (4cm diameter, 5cm thick) as an adsorbent material. The samples were collected isokinetically withdrawn from the gas stream and collected into the train of a sample probe, a filter paper, and a packed column consisting of absorbent material (Hoyos et al., 2008; Adesina et al., 2017). The filter paper and PUF were wrapped in aluminum foil and taken to the laboratory for analysis.

2.2. Extraction and samples analysis

PAHs in PUF and filter paper were extracted into Dichloromethane (Sigma–Aldrich) using a Soxhlet extractor placed on the heating mantle, the temperature was set to 60 °C and extraction was done for 7 hr. The extracts were then subjected to a Clean-up procedure using conventional liquid–solid adsorption chromatograph in open glass columns at atmospheric pressure. The column was prepared by adding about 10 to 15-mm plug of glass wool to a chromatograph column and alumina and silica (200–400 mesh, Zico-Tech) were added to the column in the ratio (1:2). The column packing was slightly deactivated using methanol-DCM solution (1:3) for better recovery. The sample extract was decanted into the column and eluted with 40mL 1:1, DCM: n-Hexane

(Sigma–Aldrich) (Adesina et al., 2017). The extracted samples were then concentrated using a rotary evaporator (Infitec Co. Ltd) which was later analyzed for PAHs.

2.3. PAHs quantification

The analysis of PAHs was done using A gas chromatograph (Agilent Model 7890A) coupled to a mass selective detector (Varian 3800/4000 GC–MS) (Agilent Technologies, Pato Alto, CA) with column size (60 m x 0.32 mm) using selected ion monitoring mode with Nitrogen as the carrier gas. The GC–MS was calibrated by standard solutions containing all 16 target compounds at different concentrations. 2.0 µL of sample extract was injected into the gas chromatograph using the splitless mode at a temperature of 250 °C. The initial column temperature was 70 °C, at 10 °C min⁻¹ to 260 °C. It was increased to 300 °C min⁻¹ and for 8 min. The solvent delay was 7 min, dwell time of 0.1 s was used for each *m/z* value. The MS transfer line was maintained at 250 °C, and quantification was based on calibration with the standard analyte using the mass spectrometer in selective ion monitoring (SIM) mode. The obtained concentrations of the different PAH constituents were subjected to source identification and diagnosis using the appropriate mathematical ratios. Quantitative analysis was performed using calibration data from the PAH standard, which contained the sixteen PAHs specified by the EPA.

2.4. Quality assurance/ quality control (QA/QC)

Field and laboratory blanks were analyzed along with the samples, and the determination of instrument detection limits (IDLs) and method detection limits (MDLs) followed (Norlock et al., 2002) procedure. Concentrations of PAHs in the field blanks were below the detection limit for all targeted compounds and no blank correction was carried out. Prior to extraction, 20 ng of Phenanthrene d10 recovery standard (RS) was used to spike the sample and the recovery range of the PAH was between 80% and 90%.

2.5. Health implications

2.5.1. Toxic equivalent

The Toxicity equivalent which is the toxicity potential of individual PAHs is calculated by multiplying PAHs concentration with the toxicity equivalence factor (TEF)(eq. i) (Van den Berg et al., 2006). Where *C* is the individual concentrations of PAHs

$$\text{Toxic Equivalency (TEQ)} = C \times \text{TEF} \quad (1)$$

2.5.2. Incremental lifetime cancer risk and Hazard Quotient

Incremental Lifetime Cancer Risk (ILCR) from human contact by inhalation of emission from the exhaust of the generator is calculated using eq. ii. Also, the non-carcinogenic risk, Hazard Quotient (HQ) is calculated using eq. iii

$$\text{ILCR}_{\text{inh}} = \frac{C \times \text{IR} \times \text{ED} \times \text{EF} \times \text{IUR}}{\text{AT} \times \text{BW}} \quad (2)$$

$$\text{HQ} = \frac{C \times \text{IR} \times \text{ED} \times \text{EF}}{\text{AT} \times \text{BW} \times \text{RfD}} \quad (3)$$

C is the PAH concentration (µg m⁻³) *IhR* is the Inhalation rate (20 m³/day for adults and 9.6 m³/day was assumed for children. (US EPA, 2011; Adesina et al., 2021) *ED* is exposure duration in years (3 years was adopted, the outbreak of COVID-19 occurred in 2020), *EF* is exposure frequency in days yr⁻¹ (52 days, it is assumed the open burning of the mask occurs at least once in a week). *AT* is the average exposure time in days, 25,550 was adopted for calculation with the expected lifetime of 70 years. *IUR* is a cancer risk factor, *ILCR* was calculated using 6 × 10⁻⁴ for USEPA and 8.7 × 10⁻² for WHO inhalation risk factors. *BW* is body

weight (70kg) and 30kg for children. RfC is the reference dose of PAHs ($2 \times 10^{-3} \mu\text{g m}^{-3}$).

2.6. Spatial distribution

Environmental Protection Agency Regulatory Model (ISCST3 AER-MOD) software was used to predict the spatial distribution of PAHs from the burning of different face masks. The concentration of PAHs at different distances from open burning sources was predicted using the software. Data inputted were Source PAHs concentration, Wind direction, Emission temperature, and Emission height. A uniform Cartesian grid was used in this study, and a point source emission type was selected at the source pathway (Adepoju et al., 2018). The PAHs emissions dispersion outputs were carried out for 1 hr, 8hrs, 24-hr and 1 year averaging period for all facemasks materials.

3. Result and discussion

In this study 16 PAHs were analyzed: naphthalene (Naph), acenaphthalene (Acy), acenaphthene (Ace), fluorene (Flu), phenanthrene (Phe), anthracene (Ant), fluoranthene (Flt), pyrene (Pyr), benz[a]anthracene (BaA), chrysene (CHR), benzo[b]fluoranthene (BbF), benzo[k]fluoranthene (BkF), benzo[a]pyrene (BaP), indeno[1,2,3-cd]pyrene (IcP), dibenz[a,h]anthracene (DhA), benzo[ghi]perylene (BgP). Table 1 shows the concentration of PAHs at different sampling locations. The surgical nose mask has the highest sum of PAHs concentration of $368.16 \pm 39.14 \mu\text{g/m}^3$ with Pyr as the most dominant having concentration of $69.75 \mu\text{g/m}^3$. Other materials with high concentrations of PAHs are cotton and N95 face masks with \sum PAHs of $353.31 \pm 51.6 \mu\text{g/m}^3$ and $352.89 \pm 34.91 \mu\text{g/m}^3$, respectively. However, facemask materials with the lowest \sum PAHs are spandex and organza material with concentrations of $73.33 \pm 14.3 \mu\text{g/m}^3$ and $72.86 \pm 17.88 \mu\text{g/m}^3$, respectively. The only concentration of PAHs observed from the emission of two materials is close to the observation of studies by Cheng et al. (2022) and Adesina et al. (2020) which was done on the characterization of PAHs from open burning Municipal Solid Waste (MSW). The concentrations of PAHs emission from other facemask materials are way higher than the results from these studies. This implies combustion of facemasks especially N95, Surgical, and cotton facemasks will elevate the concentration of PAHs from the open burning of MSW. It is also observed that open burning of locally made facemasks emits fewer PAHs compared with conventional surgical and N95 facemasks, this could be a result of the simple structure of the composition of locally made facemasks.

The United States Environmental Protection Agency has identified 7 compounds of PAHs to be carcinogenic (Benzo[a]anthracene, Chrysene, Benzo[b]fluoranthene, Benzo[k]fluoranthene, Benzo[a]pyrene, indeno [1, 2, 3-cd] pyrene and Dibenzo (a,h) anthracene). Fig. 1 shows the sum of carcinogenic PAHs while Fig. 2 shows the distribution of carcinogenic PAHs. Among all carcinogenic PAHs Benzo[a]pyrene is usually used as an indication of PAHs toxicity, the result reveals cotton facemask emitted the highest concentration of Benzo[a]pyrene of $30.21 \pm 4.50 \mu\text{g/m}^3$. Surgical and N95 facemasks have the highest concentration of \sum carcinogenic PAHs of $179.34 \pm 22.00 \mu\text{g/m}^3$ and $165.05 \pm 10.90 \mu\text{g/m}^3$, respectively. This is worrisome as these facemasks are the ones recommended by WHO as most effective in the prevention of COVID-19. Benzo[a]anthracene and Chrysene are the most dominant carcinogenic PAHs in all the materials studied this may be connected with the combustion temperature which favors the emission of these compounds. Open burning usually takes place at a lower temperature than incineration (Zhang et al., 2011).

The distribution of PAHs based on the number of rings is shown in Fig. 3. 2-ring PAHs (Nap), 3-ring PAHs (Ace, Acy, Flu, Phen, and Anth), 4-ring PAHs (Flt, Pyr, BaA, and Chr), 5-ring PAHs (BbF, BkF, BaP, and DhA), and 6-ring PAHs (BghiP and Ind) (Hassanvand et al., 2015;

Table 1
PAHs emission from different facemask.

µg/m ³	surgical		cotton		Towel		scarf		Face Shield		N95		linen		Spandex		Organza		Std
	Std		Std		Std		Std		Std		Std		Std		Std		Std		
Nap	28.23	3.2	13.22	2.3	5.65	0.6	4.35	0.8	5.3	0.21	27.00	2.2	0.11	0.3	0.11	0.02	0.11	0.01	0.01
Acy	1.80	0.6	27.7	5.3	0.4	0.1	6.43	0.9	0.04	0.01	0.95	0.2	5.05	0.3	4.95	0.3	5.12	1.2	1.2
Acen	40.35	3.7	21.41	4.6	9.72	0.7	6.96	1.2	8.9	0.21	39.47	4.6	5.97	1.7	4.70	0.3	4.52	1.6	1.6
Flu	11.02	1.3	47.88	6.2	4.17	0.3	8.23	1.3	4.2	0.23	10.35	2.3	9.96	3.2	9.22	1.5	9.47	2.1	2.1
Phe	8.27	0.8	62.37	8.9	3.89	0.1	3.99	0.6	3.99	0.13	8.27	2.1	12.3	3.1	12.08	2.1	12.4	2.3	2.3
Ant	7.35	0.6	15.12	1.8	3.39	0.2	7.00	1.3	3.82	1.1	8.30	3.2	3.75	1.3	3.75	1.2	3.6	1.3	1.3
Flt	12.86	1.2	35.27	3.1	3.89	0.2	7.00	1.2	4.17	1.3	12.44	2.2	7.84	1.2	7.95	2.1	8.02	2.3	2.3
Pyr	69.75	5.7	8.20	2.1	14.63	0.6	6.89	0.9	13.75	1.23	70.67	4.8	2.61	0.3	2.72	1.1	2.79	1.3	1.3
BaA	67.92	8.2	33.36	3.1	14.28	2.1	0.88	0.2	14.24	2.4	68.59	0.3	7.67	1.32	7.60	1.32	7.56	2.1	2.1
CHR	67.00	8.9	8.83	1.3	13.43	2.3	3.39	1.2	13.22	2.6	67.53	5.5	3.53	1.5	3.46	1.4	3.39	1.2	1.2
BbF	35.23	3.2	17.63	3.4	7.21	0.6	7.17	1.2	7.42	0.23	20.74	3.2	4.06	1.2	4.45	1.2	3.89	1.21	1.21
BkF	0.92	0.5	5.65	0.5	0.04	0.03	7.07	2.2	0.04	0.1	1.02	0.4	0.53	0.2	0.67	0.3	0.57	0.01	0.01
BaP	2.76	0.4	30.21	4.5	0.11	0.09	4.20	1.3	0.11	0.1	2.01	0.1	7.39	1.21	7.28	1.21	7.17	0.01	0.01
IcP	3.67	0.5	20.14	3.7	0.14	0.08	3.82	0.8	0.14	0.12	3.11	0.3	3.89	1.4	3.82	1.2	3.82	1.2	1.2
DhA	1.84	0.3	5.05	0.6	0.07	0.01	3.85	1.3	0.07	0.21	2.05	1.1	0.39	0.01	0.53	0.1	0.39	0.01	0.01
BgP	9.19	0.3	1.27	0.2	0.14	0.06	5.16	1.3	3.46	1.2	10.39	2.4	0.04	0.3	0.04	0.01	0.04	0.02	0.02
\sum PAHs	368.2	39.4	353.31	51.6	81.2	8.5	87.1	17.7	82.87	11.4	352.9	34.9	75.09	18.6	73.33	14.3	72.86	17.9	17.9
\sum CarPAHs	179.34	22	120.87	17.1	35.28	5.21	30.38	8.2	35.24	5.76	165.05	10.9	27.46	6.84	27.81	5.65	26.79	5.74	5.74

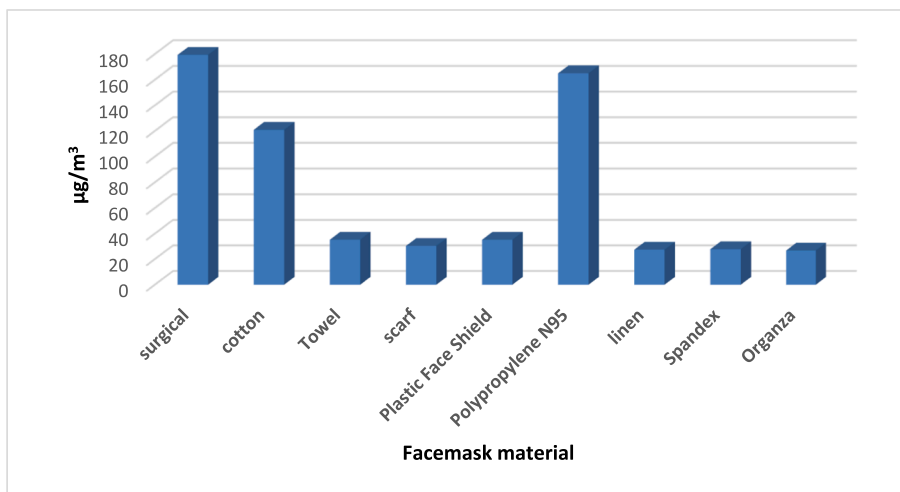


Fig. 1. Sum of carcinogenic PAHs concentration.

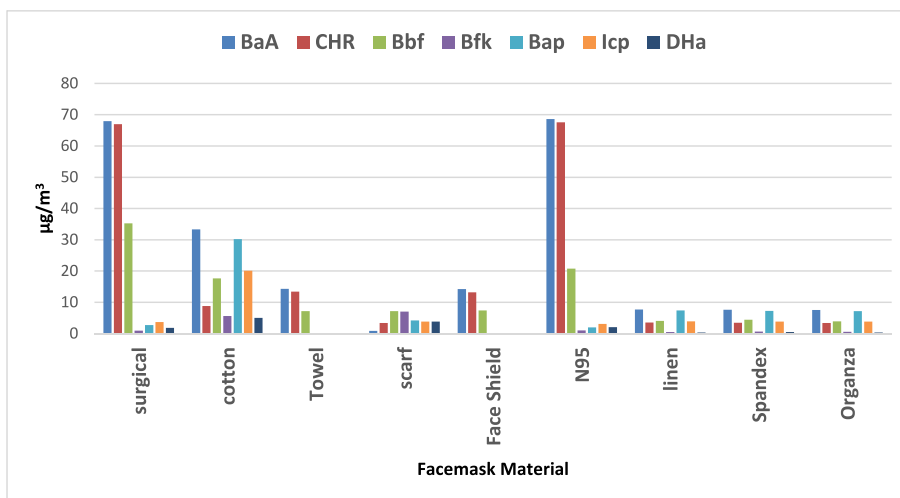


Fig. 2. Distribution of Carcinogenic PAHs.

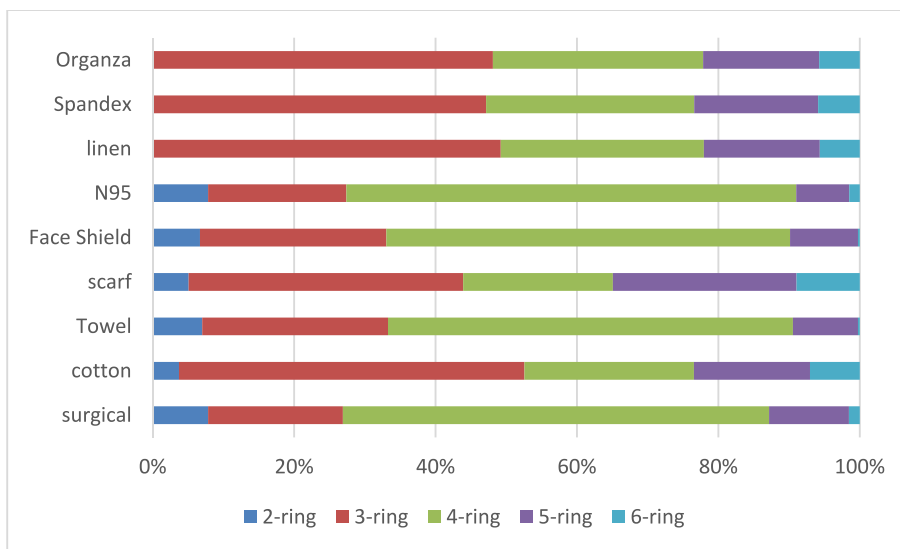


Fig. 3. Distribution Based on PAHs ring.

Rostami et al., 2019; Adesina et al., 2021). 2-ring PAH compounds are the least dominant in all the materials contributing between 2 and ~8%. This implies the PAH emission from the burning of used facemasks is mostly in the particulate phase. while 6-ring PAHs contribute between 1 and 9 %. 3-ring, 4-ring, and 5-ring PAHs are in high concentration this could only be linked to the low temperature at open burning occurs (Prakash and Singh, 2011; Zhang et al., 2011). PAHs are also classified as Low molecular weight (LMW), 4 ring PAHs are middle molecular weight (MMW) while high molecular weight (HMW) consist of 5 and 6-ring PAHs (Chen et al., 2017; Rostami et al., 2019; Adesina et al., 2021). Fig. 4 shows the distribution of PAHs based on molecular weight. Generally, MMW and HMW PAHs are in the highest concentration due to temperature and airflow during the burning of these materials. It is however of great concern because MMW and HMW PAHs are the most hazardous.

3.1. Risk assessment

Toxicity equivalent (TEQ) is used to assess the toxicity of the individual PAHs (Nisbet and Lagoy, 1992). TEQs of PAHs emitted from open burning of facemasks are shown in Table 2. Bap has the highest toxicity with the range of 0.11–7.39 $\mu\text{g}/\text{m}^3$. Other compounds with high toxicity are BaA and CHR with the range of 0.09–6.86 and 0.34–6.80 $\mu\text{g}/\text{m}^3$. The total toxicity equivalent TTEQ is the summation of all TEQs of various PAH compounds. The result showed surgical face mask has a TTEQ of 25.45 $\mu\text{g}/\text{m}^3$. Other materials with high TTEQ are N95 and cotton face masks with values of 23.72 and 20.62 $\mu\text{g}/\text{m}^3$, respectively. This implies that emissions from open burning of surgical, N95, and cotton facemasks have a higher tendency to cause harm than other locally made facemasks.

The incremental lifetime cancer risk (ILCR) from inhalation of PAHs emitted from open burning of facemask was calculated using adult and children USEPA cancer Unit Risk factor of (6×10^{-4}). This implies 6 cancer cases per 10,000 people with chronic inhalational exposure to BaPeq (1 ng/m^3) within their lifetime of 70 years (Rostami et al., 2019). The calculated ILCR and HQ are shown in Table 3. The calculated ILCR based on the USEPA cancer Unit Risk factor range 5.06×10^{-6} – 2.48×10^{-5} for towel and N95 face mask, respectively for adults, while ILCR calculated for children range 5.56×10^{-6} – 3.00×10^{-5} for face shield and surgical face mask, respectively. Using the WHO cancer risk factor, the ILCR values for adults range from 7.00×10^{-4} – 3.90×10^{-3} for towel and surgical facemasks, respectively while ILCR for children 8.00×10^{-4} – 4.30×10^{-3} for towel and surgical facemasks,

respectively. It is however worrisome that the values of ILCR obtained are all higher than the permissible limit of 10^{-5} and 10^{-6} , respectively for WHO and USEPA. Also, the calculated HQ range was 4.40–22.19 for Adults while the 4.70–24.86 was obtained for children. The high HQ implies high non-carcinogenic risk is associated with inhalation of emission of PAHs from open burning of facemasks.

3.2. Spatial distribution

Fig. 5 (a) shows the dispersion model of PAHs from the open burning of the facemask. The color ranges in legends show the distribution of PAH concentrations around the vicinity of the open burning of the facemask. The region with pink coloration revealed the presence of a high concentration of PAHs while the region with purple implies the lowest PAHs concentration. Generally, the effects of the emission of the burning are noticed within 600m of the eastern direction of the site. Within 1 h of emission (Fig. 5a) of PAHs from the burning of the masks PAHs highest concentration of PAHs is noticed around the northeastern direction from the burning source, this could only be linked to the prevalent wind direction around the burning site. At 8 hrs and 24 hrs (5b and c), a decrease in concentration within 100m from the burning site was observed due to the diffusion and dilution by the wind. Fig. 5d shows the Isopleth Annual Ground Level PAHs. It is observed that there is still the presence of an appreciable concentration of PAHs around the vicinity of the burning site even after a year, this is linked to the persistent nature of PAHs.

4. Conclusion

The study characterizes PAHs from open burning of different COVID-19 facemask materials and also calculated the risk associated with inhalation of PAHs emission using some health indexes. The result showed the concentration of PAHs emission ranged \sum PAHs 73.33–368.16 $\mu\text{g}/\text{m}^3$ while carcinogenic PAHs ranged \sum CarPAHs 26.79–179.74 $\mu\text{g}/\text{m}^3$. The result also showed the surgical and N95 facemask emits the highest concentration of PAHs. Proper disposal of these facemask using controlled medical incinerator is highly recommended. The value of ILCRs calculated is higher than the permissible limit of 10^{-5} and 10^{-6} , respectively for WHO and USEPA. The calculated HQ values are all greater 1, which implies associated high non-carcinogenic risk. The annual ground-level PAHs Isopleth reveals the presence of a high concentration of PAHs around the vicinity of the burning site after a year. Proper disposal of these facemask using controlled medical incinerator is highly recommended.

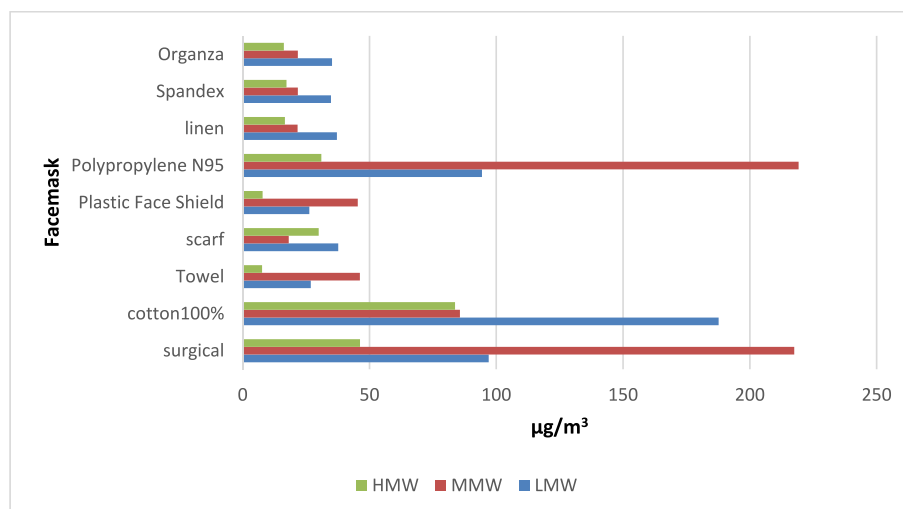


Fig. 4. Distribution of PAHs based on Molecular Weight.

Table 2
Toxicity equivalent of PAHs emission ($\mu\text{g}/\text{m}^3$).

	surgical	cotton	Towel	scarf	Face Shield	N95	linen	Spandex	Organza
Nap	0.282	0.132	0.057	0.044	0.053	0.270	0.001	0.001	0.001
Acy	0.018	0.277	0.004	0.064	0.000	0.010	0.051	0.050	0.051
Acen	0.404	0.214	0.097	0.070	0.089	0.395	0.060	0.047	0.045
Fln	0.110	0.479	0.042	0.082	0.042	0.104	0.100	0.092	0.095
Phe	0.083	0.624	0.389	0.040	0.040	0.083	0.123	0.121	0.124
Ant	0.735	1.512	0.339	0.770	0.382	0.830	0.375	0.375	0.360
Flt	0.129	0.353	0.039	0.070	0.042	0.124	0.078	0.080	0.080
Pyr	0.698	0.082	0.146	0.069	0.138	0.707	0.026	0.027	0.028
BaA	6.792	3.336	1.428	0.088	1.424	6.859	0.767	0.760	0.756
CHR	6.700	0.883	1.343	0.339	1.322	6.753	0.353	0.346	0.339
Bbf	3.523	1.763	0.721	0.717	0.742	2.074	0.406	0.445	0.389
Bfk	0.092	0.565	0.004	0.707	0.004	0.102	0.053	0.067	0.057
Bap	2.760	3.210	0.110	4.200	0.110	2.010	7.390	7.280	7.170
Icp	0.367	2.014	0.014	0.382	0.014	0.311	0.389	0.382	0.382
DHa	1.840	5.050	0.070	3.850	0.070	2.050	0.390	0.530	0.390
Bgp	0.919	0.127	0.014	0.516	0.346	1.039	0.004	0.004	0.004
TTEQ	25.451	20.621	4.817	12.008	4.818	23.720	10.565	10.606	10.271

Table 3
ILCR and HQ.

	Surgical	cotton	Towel	scarf	Face Shield	N95	linen	Spandex	Organza
ILCR Adult	2.7×10^{-5}	2.16×10^{-5}	5.04×10^{-6}	1.26×10^{-5}	5.04×10^{-6}	2.48×10^{-5}	1.11×10^{-5}	1.11×10^{-5}	1.08×10^{-5}
ILCR Children	3×10^{-5}	2.42×10^{-5}	5.65×10^{-6}	1.41×10^{-5}	5.56×10^{-6}	2.78×10^{-5}	1.24×10^{-5}	1.12×10^{-5}	1.2×10^{-5}
HQ Adult	22.19	17.99	4.20	10.47	4.20	20.69	9.22	9.25	8.96
HQ Children	24.86	20.14	4.70	11.73	4.70	23.17	10.32	10.36	10.03

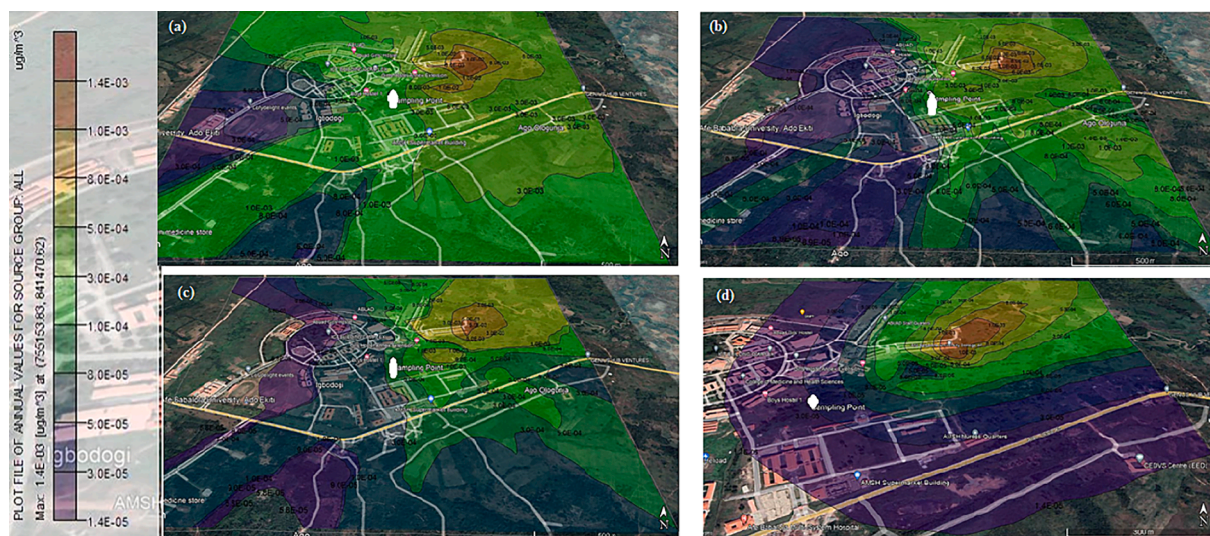


Fig. 5. Dispersion model of pahas from the open burning of facemask.

CRediT authorship contribution statement

Olusola Adedayo Adesina: Conceptualization, Methodology, Software, Data curation, Writing – original draft preparation, Writing – review & editing. **Raymond Opara:** conceptualization, Methodology, Software, Data curation, Writing – original draft preparation, Supervision. **Abiodun John Adewale:** Visualization, Investigation. **Mayowa Adeoye Lala:** Visualization, Investigation. **Jacob Ademola Sonibare:** Software, Validation, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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