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Epitomizing mercury concentrations in incenses as a potential marker to respiratory ailments

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Abstract

Recent years witnessed the use of incense in aromatherapy, religious festivals, warding negative vibes, and indoor air refreshers at home. Their consequences to respiratory ailments over a long period in relation to pollution from trace metals were least studied. The present study aimed to analyze the elemental mercury (Hg) concentrations directly and indirectly in different marketed incenses and validated their effect on respiratory ailments in residents. Sixteen common brands of incense of pollution interests from the local markets were analyzed using a direct mercury analyzer that measured samples from 0.0015ng/g onwards with precise and reproducible results. Subsequently, residents apportioned in six Governorate areas of environmental interest were provided with questionnaires and sought responses to the use of incenses and their health issues. Analysis revealed high Hg concentrations in the perfume-soaked incenses compared to the non-perfume-soaked incenses besides their significant site-wise variations. The questionnaire from 60 respondents who used 'Bokhour' often and were exposed to smoke for >8h showed mild to severe respiratory ailments in line with the indoor-outdoor air quality. Despite the beneficial effect of incenses described in the past, Hg concentration was observed high in the incense that caused varying respiratory ailments which were attributed to the native's selectivity, regional specificity, and recurrent uses of incenses. This study labeled Hg in incense as an additive bio-indicator to indoor pollution. Furthermore, restricting the burning of unmonitored locally available incense is recommended to prevent health issues and subsequent indoor pollution.

Keywords: Bokhour; frankincense; indoor pollution; Kuwait; mercury.

1. Introduction

The custom of burning incenses namely, the perfumed and non-perfumed scented wood ('Bokhour') and naturally available resin (Frankincense) is a customary practice of the residents of many countries. They are smoldered to disperse the aroma to their clothes and rooms besides, their use in aromatherapy and health rejuvenation (Ahmed *et al*., 2020; Mfarrej *et al*., 2020; Shen *et al*., 2017; El-Sayed *et al*., 2016; Ali *et al*., 2016; Wolter,2015). Evidence indicates the extraction of aromatic oils from the best *Boswellia sacra* resin of Salalah and Dhofar Valley of Oman added in 'Bokhour'. Incense materials are available in various forms and vary with personal choices, culture, and tradition. Direct burning of incense involved direct ignition by a flame or a heat source like charcoal and indirect burning of incense utilized electricity (Ahmad & Balkhyour, 2020). This

incense varies in the duration of its burning with the texture of the material. Finer ingredients tend to burn more rapidly, while coarse ground burns gradually as they have a less total surface area (Incense, 2018).

Many investigations (Lorena 2020; Geng *et al*., 2019; Al-Yasiry *et al*., 2016; Vudanna *et al*., 2016; Al-Hararasi *et al*., 2014; Zarshenas *et al*., 2013) observed these incenses (a) to alleviate stress and emotion, (b) boost and balance immune and hormone system, (c) anti-aging properties, (d) catalyze the secretion of digestive enzymes and, (e) decrease inflammation. Contrastingly, studies (Ahmed *et al*., 2020; Mfarrej *et al*., 2020; Tran *et al.,* 2020; Hussain *et al*., 2018; Seow & Lan 2016; Al-Busaidi *et al*., 2015; Jankowich & Rounds 2012; Orecchio 2011) showed the harmful effects of hazardous smoke that included organic compounds and heavy metals from such incenses causing respiratory ailments to humans. Interestingly, investigators (Abdu Alrasool *et al*., 2018; BuHamra *et al.,* 2018; Višić, *et al*., 2018; Tsiouri *et al*., 2015; Zhou *et al* 2015; Lui *et al*., 2016; Kumar *et al*., 2014) showed that the particulates (PM_{10}) in the incense smoke exceeded the standard values of tobacco smoke emission described by the statutory bodies besides, the synergism between the incense (Courtes *et al*., 2018; Wu *et al*., 2012), and lung cancer. Evidence (Courtes *et al*., 2018; Azevado *et al*., 2012; Amoatey *et al*., 2018) showed high mercury (Hg), concentrations with increasing temperature in the indoor environment indicating the possible elevation of respiratory ailments besides, mood swings, headache, and insomnia. Such health issues evinced further interest to persevere an in-depth study.

In the six Kuwait Governorates, the practice of burning 'Bokhour,' frankincense, incense stick, and the use of herbal aromatic oil are on the rise over a few decades. 'Bokhour' and Frankincense in the Kuwait market originate from the State of Oman, Saudi Arabia, Yemen, and the United Arab Emirates. Air contaminant standards were set by statutory bodies (Azevado *et al*., 2012). However, the local statutory bodies did not undertake any precautionary measures or standardized regulations to burn incense. Nonetheless, the effects of burning such incenses in Kuwait were least described (Wolter, 2015; Geng *et al*., 2019; Amoatey *et al*., 2018; OSHA, 2017; Yuan *et al*., 2020; Bahloul & Gevao,2014; Wu *et al*., 2012).

Based on the earlier findings, this novel study (2018-2020), fulfilled the lacunae on the possible pollution impact of Hg from various imported incenses distributed in the local markets of the six Kuwait Governorates by (a) directly analyzing the Hg in the perfumed and non-perfumed incenses, (b) perfecting the technology using a direct mercury analyzer, and (c) indirectly validating the responses to questionnaire from the residents in relation to the frequent use of incenses and their effect to respiratory ailments.

2. Materials and methods

2.1 Sample location

Three distinct markets each, from the six areas (Figure 1) of pollution importance (vicinity to thermal and coal plants, oil sector, small and large-scale industries, thickly populated residential area, waste treatment plants) was selected besides, the availability of the incense throughout the study period (2018-2019).

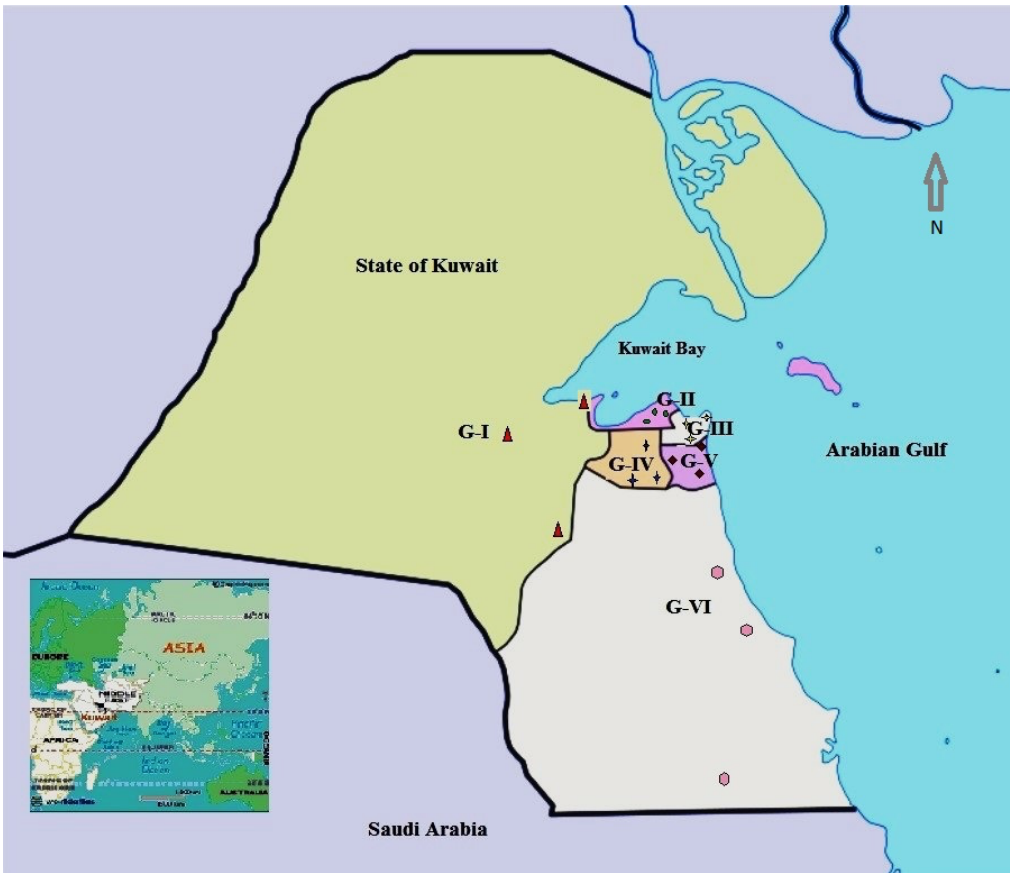

Fig. 1. Six Kuwait Governorates selected for sampling
G-I to GVI: Governorates: Al-Jahra, Al-Asimah, Al-Hawalli, Farwaniya, Mubarek Al-Kabeer, Al-Ahmedi

2.2 Sample analysis

Eight non-perfume-soaked incense samples (six Frankincense resin, two Oudh wood-*Aquilaria* species) and Eight 'Bokhour' (perfume soaked) samples collected separately in sterile plastic containers were analyzed in the laboratory. Replicates (5g) of vended incense samples collected from three areas were, dried in an oven (GallenKamp-II) at 45^{o}C for 12h, powdered and sieved in a #18 mesh of 1.0mm size to enable the uniformity of the sample (WHO, 2012). The Direct Mercury analyzer (DMA-80, Milestone, Italy, Inc.) offered a lower detection limit value of 0.0015ng/g for a powdered samples (0.2 g) for Hg. Quality assurance followed using blanks, triplicate samples, controls, spikes and standard reference material [SRM 1575A: Pine needle from National Institute of Science and Technology (NIST), US]. Mercury with recovery (>95%) in the samples with that of the SRM confirmed the precision of the instrument, consistency, and reproducibility of the experiments (Ahmed *et al.,* 2020). Following OSHA (2017), questionnaire was distributed to ten residents from each Governorate areas and prior to the mutual consent of response and privacy by the residents and assessor, respectively. The questionnaire detailed the information on the respondent's inhabitation in the indoor environment, the size of the rooms, hours spent while burning the incenses, the type of direct or indirect burning and their general ailments.

3. Results

Classification of the eight non-perfumed incenses revealed high Hg concentrations in the Oudh wood of Somalia (0.23ng/g) and the least in Cambodia Bokhour wood (0.10ng/g) as well, the least Hg concentrations in frankincense from Dhofar-Oman. However, the high Hg concentrations in the perfumed incenses were observed in the Cambodia Bokhour wood chips (0.50ng/g) and the least in the Indonesian grey wood (0.14ng/g) chips (Figure 2). Analysis revealed the Hg concentrations >1.5 to 2.0 times more in the perfume-soaked Bokhour wood than in the non-perfumed incenses. Furthermore, the percentage of essential oil content indicated by the merchandiser was high in the perfumed incenses compared to the non-perfumed incenses (Figure 2). Statistically, the test of ANOVA validated their effect (Table 1). The wood chips soaked with high concentrations of aromatic oils or perfumed alcohol base for a longer period revealed high Hg contamination in the samples. This was validated by the statistical test of ANOVA (Table 1). The mean site-wise analysis showed high Hg concentrations in the sequence of GI >GIV >GVI >GII >GIII >GV and GI >GIV >GVI >GIII >GII >GV in the non-perfumed and perfumed incenses, respectively (Figures. 3a-3b).

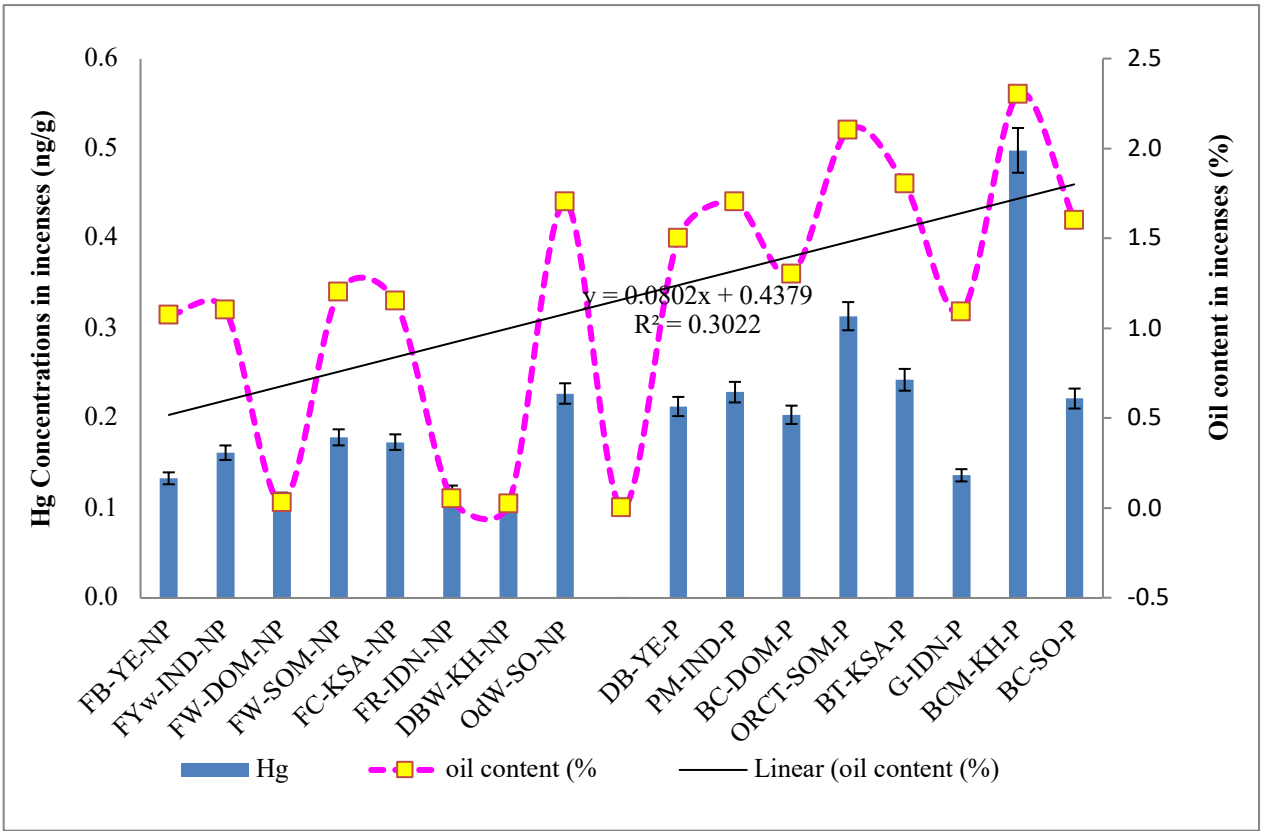

Fig. 2. Countries-wise mean Hg concentrations in the marketed non-perfumed and perfumed incenses

NP: non-perfumed; P: perfumed; IDN: Indonesia, YE: Yemen, SO: Somalia, IND: India, OM: Oman, KH: Cambodia, KSA: Saudi Arabia; G: grey wood, DB: black wood, BC: black cone, PM:powder mix, ORCT: Flower mix, BCM: brown chips, BT: black top; FB: frankincense , FYw: frankincense yellow; FWD: Dohar frankincense, FW: white incense; FC: coated incense coated; FR: red incense; DBW: brown wood, OdW: Oudh wood

Table 1. ANOVA test on the country-wise and site-wise non-perfumed and perfumed incenses

Summary	Count	Sum	Average	Variance		
FB-YE-NP	6	0.798	0.133	0.002		
FYw-IND-NP	6	0.969	0.161	0.006		
FWD-OM-NP	6	0.669	0.111	0.008		
FW-OM-NP	6	1.071	0.178	0.008		
FC-KSA-NP	6	1.040	0.173	0.017		
FR-IDN-NP	6	0.714	0.119	0.002		
DBW-KH-NP	6	0.616	0.102	0.006		
OdW-SO-NP	6	1.364	0.227	0.005		
G-IDN-P	6	0.818	0.136	0.006		
DB-YE-P	6	1.278	0.213	0.001		
BC-SO-P	6	1.331	0.221	0.003		
PM-IND-P	6	1.373	0.228	0.006		
ORCT-OM-P	6	1.880	0.313	0.044		
BCM-KH-P	6	2.987	0.497	0.060		
BC-OM-P	6	1.222	0.203	0.007		
BT-KSA-P	6	1.456	0.242	0.004		
GI	16	5.479	0.342	0.036		
GII	16	2.522	0.157	0.005		
GIII	16	2.571	0.160	0.009		
GIV	16	4.121	0.257	0.013		
GV	16	1.492	0.093	0.004		
GVI	16	3.406	0.212	0.010		
Source of Variation	SS	df	MS	F	P-value	F crit
Incenses	0.84	15	0.06	12.57*	0.0001	1.80
Sites	0.61	5	0.12	27.50*	0.0001	2.33
Error	0.34	75				
Total	1.79	95				

GI-GVI: Kuwait Governorates; NP: non-perfume incense, P: perfumed incense; F: frankincense, B:Bokhour; YE: Yemen, IND: India, OM: Oman, KSA: Kingdom of Saudi Arabia, IDN: Indonesia, KH: Cambodia, SO: Somalia; Yw: Yellow, W: Bokhour wood; D-OM: Dohfar Oman; C: coated wood; R: red Bokhour; DB: dark brown; OdW: Oudh wood; G: grey; BC: brown chips; PM: powder mix; SS: sum of squares, MS: mean square, F: calculated F ratio, F Crit: F critical table value; * significance P=0.0001

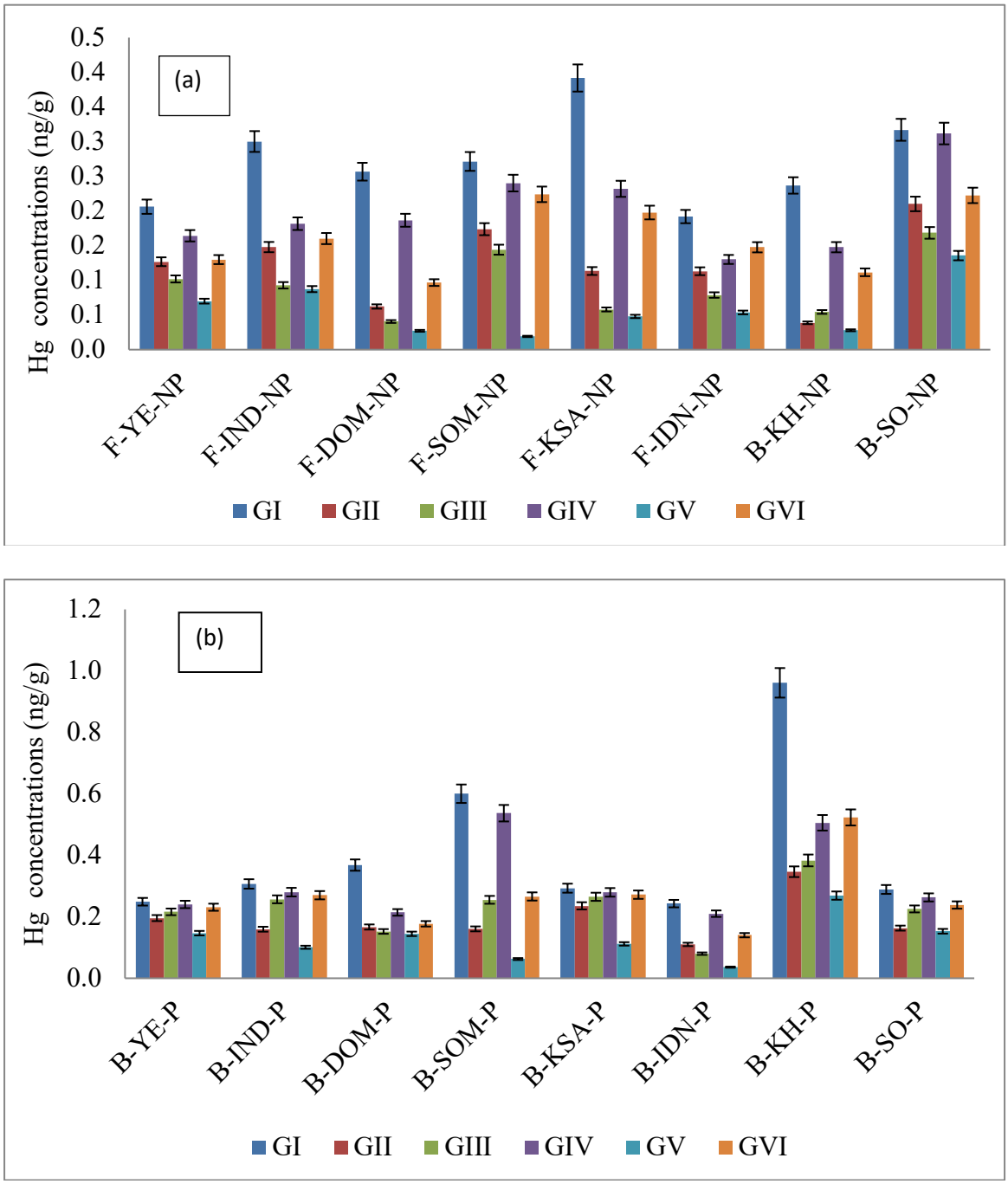

Fig. 3. (a) Spatial distributions of Hg concentrations in non-perfumed marketed incenses
GI-GVI: Kuwait Governorates; NP: non-perfume incense, F: frankincense, B: Bokhour; YE: Yemen, IND: India, OM: Oman, KSA: Kingdom
of Saudi Arabia, IDN: Indonesia, KH: Cambodia, SO: Somalia
(b) Spatial distributions of Hg concentrations in perfumed marketed incenses
GI-GVI: Kuwait Governorates; P: perfumed incense; F: frankincense, B:Bokhour; YE: Yemen, IND: India, OM: Oman, KSA: Kingdom of
Saudi Arabia, IDN: Indonesia, KH: Cambodia, SO: Somalia

The response to the questionnaire revealed a higher respiratory illness in Kuwait respondents subjected to the daily use of incenses smoldered in smaller-sized rooms than in larger-sized rooms. The incense burning on a charcoal base revealed high mercury concentration than when burnt on an electric burner or direct flame (Table 1). Furthermore, this study revealed dermatitis, Chronic Obstructive Pulmonary Disease (COPD-2), and Emphysema ailments in respondents regularly using (a) body sprays and cloth sprays and, (b) perfume soaked Bokhour or a combination of Bokhour mixture (e.g., Jasmine-Oudh-Musk aromatic flavor) especially when burnt on a charcoal burner. The responses to incenses smoldered in electric burners revealed respiratory ailments only with breathing difficulties (BD) and Chronic Obstructive Pulmonary Disease (COPD-1) and when residents were exposed for >6-8h in small rooms. Statistically, the test of ANOVA confirmed the significant difference between the Governorate-wise perfumed and non-perfumed incenses.

4. Discussion

Earlier studies witnessed the use of frankincense and 'Bokhour' in the Middle East countries (Vuddana *et al*., 2016; Wolter, 2015). Among the eight marketed non-perfumed incenses apportioned in Kuwait (Figure 1), the high Hg concentrations in the Oudh wood of Somalia attributes to: a) the absorption and translocation of pollutants through the various parts of the Oudh wood as well, in the resin of frankincense trees from the atmosphere, b) the contamination of Hg during the collection of wood and resin, storage and, c) species specificity and quality of the resin that retains Hg concentrations (Figure 2). These findings agreed with the earlier studies (Lorena 2020; Shen *et al*., 2017; Ali *et al*., 2016; Zarshenas *et al*., 2013). The low Hg concentrations in Cambodia Bokhour and in frankincense from Dhofar-Oman attributes to the contrary effect described with Oudh wood from Somalia. ANOVA tests revealed significant difference between the country-wise perfumed and non-perfumed incenses (Table 1). The increasing Hg concentrations by site-wise analysis in G1, G4 and G6 (Figures 3a-3b) in the marketed incenses could be attributed to a) incenses wood chips stored in exposed bags and sold in small quantity in loose packing b) low grade quality sold for economic viability besides, c) the influence of outdoor and indoor pollution composed of particulates, PAHS and Hg impurities that adds to the inhaler while burning these incenses. This agreed with the earlier findings (Višić, *et al*., 2018; El-Sayed *et al*., 2016; Orecchio, 2011). The high Hg concentrations in the perfumed Bokhour wood than in the non-perfumed incenses attributed to the influence of the additive external and internal contaminants in the perfumed incenses. Geng *et al*. (2019), Al-Yasiry and Kiczorowska (2016) and Tsiouri *et al*. (2015) revealed such additive pollutants in the incense with organic constituents. Furthermore, the high percentage of essential oil content attributed to the Bokhour soaked with perfume in correlation with the volume, duration and storage process of such perfumed incenses when compared to the absence of such attributes in the non-perfumed incenses (Figure 2). This was in line with the earlier studies of Al-Harrasi (2014). This study also revealed the Hg concentrations in these incenses exceeding the limits of statutory bodies (OSHA, 2017) thus, indicating the need to curb such hazards of burning such incenses.

The indirect assessment on the incenses smoldered in small-sized rooms causing respiratory illness in the respondents of Kuwait attributed to the regular use of incenses, the extent of suffocation and, dispersion of smoke containing these trace metals compared to such effects in the larger-sized rooms. This validates the earlier findings (Mfarrej *et al*., 2020; Yuan *et al*., 2020; Abdu alrasool *et al*., 2018; BuHamra *et al.,* 2018; Zhou *et al*., 2015; Kumar *et al*., 2014; Wu *et al*., 2012) revealing the detrimental respiratory illness in residents who inhaled incense smoke over a continuous and longer exposure period than the occasional cigarette smokers. The incense burning on a charcoal base revealed high mercury concentrations dispersion than other burners because charcoal attributed the addition of carbon, impurities and trace metals that resulted in respiratory illness, asthma and, cancer (Ahmad and Balkhyour, 2020; Hussain *et al*., 2018; Al-Harbi *et al*., 2016; Ali *et al*., 2016; Al-Busaidi *et al*., 2015). Furthermore, the cause of ailments as categorized earlier in this study attributes to the (a) daily use of perfumes, body sprays and cloth sprays, (b) when perfume (>5ml at 90-100% concentrations) was soaked in Bokhour either individually or in combinations, and (c) when such incenses were burnt regularly on a charcoal burner with more than 2-4h exposure period. Towards the lighter effect, the responses revealed the ailments from BD, intermittent cough and moderate Chronic COPD-1 because of occasional smoldering of incenses. Furthermore, the sites assessed for outdoor and indoor pollution revealed the synergistic effect of Hg causing respiratory illness that was in line with the effect of organic constituents observed earlier (Shen *et al*., 2017; El-Sayed *et al*., 2016; Seow & Lan, 2016; Bahloul & Gevao, 2014; Jankowich & Rounds, 2012). Thus, in an overall view, the present study recommends not to use low quality incenses continuously despite their aromatic and beneficial traditional purposes.

5. Conclusions

This study revealed the effect of Hg from different incenses to residents, inhabiting the indoor environment and, their detection from trace concentrations that was unheeded by other researcher for want of a precision instrument like the DMA-80. This instrument detected samples at trace Hg concentrations from 0.0015ng/g onward and yielded high precision consistent results over the earlier instruments. This study showed the raw incenses exceeding the permissible limits of Hg concentrations in the environment compared to the standards of statutory body. Interesting factors that were ignored by earlier investigators was observed during this study namely, the increasing Hg concentrations in incenses soaked with perfumed oil, burnt on a charcoal burner and in a limited area, and burnt in residences that had excess inmates (6 people/100sq.ft) against the locally prescribed standard space to inhabitants (2 people/100sq.ft). The indirect method of assessment validated the effect of different kinds of incenses and characteristic variables causing different intensity of respiratory ailments. Thus, this study suggests to substantially reduce: (a) the addition of perfumes and their combination at high concentrations in the preparation of ‘Bokhour incenses, (b) incessant exposure to incenses during their preparation and while smoldering them and, (c) the inexhaustible use of incenses in habitat already subjected to indoor and outdoor pollutants that is in synergism to human ill-health.

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