



Original article

Cigarette waste: Assessment of hazard to the environment and health in Riyadh city

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ABSTRACT

Cigarette waste/litter is considered a major environmental contamination problem worldwide as trillions of cigarettes are smoked worldwide and a large part of that, cigarette waste, is disposed of in the open areas including roads, parks, and streets, etc. cigarette litter is the most commonly found litter. It is mainly cigarette filter, made of cellulose acetate, and unburnt part of the tobacco filler. Filters from smoked cigarettes contain a significant amount of tar trapped in it. The tar contains thousands of chemicals and heavy metals. Both of these organic and inorganic constituents have been reported to be toxic to humans and cause a variety of diseases including inflammatory lung diseases, cardiovascular diseases, and cancers. Cigarette litter is a significant environmental concern as the chemicals and heavy metals can leach into the soil or water sources and pose threat to animals and plants, from there they can enter into the food chain as well. Several reports indicate toxicities to aquatic and terrestrial animals as they consumed cigarette litter. In the present investigation, cigarette litter was collected from 28 randomly selected locations in the Riyadh city to assess the risk to the environment. Cigarette litter, in the form of cigarette butts, was collected, counted, weighed and analyzed for heavy metal content. Data indicate the presence of a significant amount of cigarette litter on roadsides, streets, and parks in the Riyadh city. However, the investigation had its limitations as it did not focus on the absolute amount of cigarette litter vs the time. It also did not consider the amount of cigarette litter percent in the total waste discarded. The investigation presents the results of the screening of the cigarette litter present on the Riyadh city roads, streets, and parks. The findings raise concerns regarding the hazards the cigarette litter poses to the environment and human health. The investigation sheds the light on this unexplored aspect of smoking-associated issues in the Kingdom of Saudi Arabia.

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1. Background

Cigarette litter or waste is found in the form of burnt remains of cigarettes thrown away after smoking cigarettes; it is called 'cigarette butt'. A cigarette butt comprises mainly of cellulose acetate filter which is a plastic and non-biodegradable, paper and a part of

unburnt tobacco (Novotny et al., 2009; Novotny et al., 2015). However, in butts, the filter also contains the trapped amount of tar generated after tobacco burning. The tar is reported to contain thousands of chemicals including 70 known carcinogens (Society, 2018).

Problems arising from waste are a common issue in urban areas. Plastic bags, bottles and other disposable items along with other waste make it challenging to dispose of non-biodegradable waste. They also pose a threat to the environment. Cigarette waste is reported to be a major part of urban waste (Seco Pon and Becherucci, 2012). The chemical leached out of cigarette butts may be presented as an environmental and health hazard. A published report indicated that cigarette butts comprise an estimated 25–50 percent of all the litter collected from streets and roads. All the hazardous chemicals including carcinogens, pesticides, and

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nicotine present in the tobacco that makes it the leading cause of preventable death worldwide, are also present in the cigarette butts that are dumped by the trillions (5.6 trillion and counting) into the environment globally each year (Healton et al., 2011).

A high percentage of smokers have been reported among the Saudi population (Bassiony, 2009; Al-Mohamed and Amin, 2010) and this is directly correlated with the number of cigarette butts added to the waste every day. “More than 20,000 children (10–14 years old) and 3,352,000 adults (15+ years old) continue to use tobacco each day” (Tobacco Atlas, 2018). The latest WHO data present the percentage of smokers in Saudi Arabia aged 15 years or older as 13.6% (World Health Statistics Data, 2016). This adds millions of cigarette butts into the waste on a daily basis.

Most of the cigarette butts are dumped on the roadside and remain there for a longer time as compared with other kinds of litter. Due to its low or non-biodegradable nature, the filters of the cigarette take years to be naturally removed from the environment. During all this time period it releases hazardous chemicals into the soil and poses a threat to organisms and the environment. Bonanomi et al. reported 30–35% mass decomposition of cigarette butts in controlled laboratory conditions took 720 days in grassland soil. The decomposition in sand dune soil was found to be slower (Bonanomi et al., 2015).

In absence of any investigation regarding environmental and health risk due to cigarette waste in the Kingdom of Saudi Arabia, the present investigation focused on the screening of environmental risks due to cigarette waste in Riyadh city, Kingdom of Saudi Arabia.

2. Methodology

2.1. Cigarette waste/litter collection

Cigarette butts that mainly constitute the cigarette waste or litter were collected from 28 randomly selected locations in Riyadh city at any random time point. Cigarette butts were collected in plastic bags labeled with location name and sealed. An arbitrary 5 min. the time period was set for the cigarette waste collection from any given location. The cigarette waste was collected from roadsides, streets, and parks. However, most of the locations were dry, wet spaces were avoided for sample collection. Cigarette waste was not collected from the garbage bins.

Cigarette waste was collected from a total of 28 randomly selected locations in Riyadh City, Kingdom of Saudi Arabia during the period from October to November 2019. The locations were from East, West, North, and South of Riyadh City.

2.2. Cigarette count and weight

All the samples were weighed using an analytical balance and cigarette butts counted for each location. Pieces of plastics and other sorts of garbage than cigarette butts were carefully removed before weighing the samples collected from different locations. Samples found to be wet or moist were not weighed and were discarded

2.3. Heavy metal analysis

The elemental analysis was done by Inductively Coupled Plasma-Mass Spectrometry (ICP-MS, ELAN-9000, Perkin Elmer, USA) and the targeted elements included cadmium, lead, arsenic, cobalt, chromium, nickel, vanadium, thallium, silver, barium, and copper. The instrumental setting details for the analysis done are given in Table 1. 200–300 mg of cigarette waste samples were

Table 1

ICP-MS instrumental setting (ELAN-9000, Perkin Elmer) for the elemental analysis of cigarette waste.

ELAN-9000, Perkin Elmer parameters	Values
RF Power	1500 W
Plasma Gas Flow	15 L/min
Auxiliary Gas Flow	1 L/min
Nebulizer Gas Flow	0.83–0.88 L/min
Peristaltic Pump Speed	0.5 ml/min
Nebulizer/Spray Chamber	PFA-ST/Peltier-cooled cyclonic
Spray Chamber Temp	2 °C
Detector Mode Dual Lens/AutoLens	Enabled
Sampler/Skimmer Cones	Nickel
Scanning Mode	Peak Hopping
Number of Points/Peak	1
Number of Sweeps/Reading	10
Number of Readings/Replicate	1
Number of Replicates	3

digested using the microwave in a total volume of 20 ml containing 2 ml H₂O₂, 2 ml HNO₃, and deionized water.

2.4. Data analysis

All the raw data were analyzed using GraphPad InStat (USA). Different calculations were performed using MS Excel.

3. Results

3.1. Cigarette waste/litter in Riyadh city

Cigarette litter was collected from 28 randomly selected locations. A total of 71.892 ± 5.354 cigarettes were collected within 5 min. of the set time. The weight of the cigarette butts from the locations was 19.093 ± 1.44 g with an average weight of each cigarette butt of 0.2669 ± 0.0065 g (Table 2).

3.2. Heavy metals

ICP-MS analysis reveals the presence of heavy metals of high concern in cigarette butt samples from different locations, including cadmium (Cd) (10.405 ± 1.62 ppm), lead (Pb) (52.458 ± 9.19 ppm) and arsenic (As) (170.613 ± 8.75 ppm) (Table 2). Other than these three, cobalt (Co) (109.415 ± 6.43 ppm), vanadium (V) (112.249 ± 11.99 ppm), nickel (Ni) (353.798 ± 17.31 ppm), barium (Ba) (954.746 ± 175.66 ppm), copper (Cu) (848.249 ± 210.47 ppm) and chromium (Cr) (366.684 ± 24.49 ppm) were found to be present with significant concentration in cigarette butts. Thallium (Tl) (1.179 ± 0.08 ppm) and silver (Ag) (1.987 ± 0.15 ppm) were found to be in the lowest concentration among the metals analyzed in all the samples (Table 3).

4. Discussion

Since decades tobacco products have been recognized as very harmful for human health. These products are available in various forms including cigars, cigarettes, shisha, chewing tobacco, and sniffs, etc. The harmful effects can be attributed to a large number (hundreds to thousands) of toxic chemicals in the tobacco products, however, they are used to get the nicotine that has stimulant effects. Other than the nicotine, no other chemical has been recognized in tobacco that has similar stimulant effects. Nicotine itself has been reported to have toxic manifestations on human health (Mishra et al., 2015).

The cigarette is the main tobacco product that is popular and consumed worldwide (Soneji et al., 2016; Navas-Acien, 2018).

Table 2

Cigarette litter containing cigarette butts were collected, counted and weighed.

Cigarette waste	Mean \pm SEM	Median	Minimum	Maximum	95% CI		P value	Normally distributed?
					From	To		
Number of Cigarette Butts (N = 28)	71.892 \pm 5.354	69.5	19	122	60.907	82.879	>0.10	Yes
Weight of Cigarette (g) Butts (N = 28)	19.093 \pm 1.44	18.515	4.410	34.160	16.137	22.050	>0.10	Yes
Weight (g)/Cigarette Butt	0.2669 \pm 0.0065	0.27	0.2160	0.3685	0.2536	0.2803	>0.10	Yes

Table 3

Statistical analysis of the concentration data of different elements in cigarette waste obtained by ICP-MS.

Heavy metals in cigarette samples	Concentration (ppb) Mean \pm SEM	Median	Minimum	Maximum	95% CI	
					From	To
Cd	10.405 \pm 1.62	8.585	3.718	33.275	7.005	13.807
Pb	52.458 \pm 9.19	41.022	19.372	200.91	33.209	71.709
As	170.613 \pm 8.75	164.53	101.18	247.62	152.28	188.95
Co	109.415 \pm 6.43	106.21	61.935	156.73	95.957	122.87
V	112.249 \pm 11.99	95.332	42.909	229.57	87.137	137.36
Ni	353.798 \pm 17.31	349.25	214.78	504.92	317.56	390.04
Tl	1.179 \pm 0.08	1.144	0.677	2.133	0.995	1.364
Ag	1.987 \pm 0.15	1.773	1.045	3.932	1.655	2.320
Ba	954.746 \pm 175.66	645.43	211.92	2656.1	587.08	1322.4
Cu	848.249 \pm 210.47	354.16	161.27	3183.4	407.74	1288.8
Cr	366.684 \pm 24.49	331.33	205.19	623.62	315.41	417.96

The consumption is so huge that it has emerged as one of the most common preventable cause of death globally. Cigarette smoking is associated with different serious health problems including cardiovascular diseases (CVDs), chronic obstructive pulmonary disease (COPD) and cancer (Mainly lung cancer).

Cigarette smoke is mainly made of aerosols of tar (a brownish sticky substance). A large amount of the tar is trapped in cigarette filters and contains most of the chemicals released from the burning tobacco, it also contains heavy metals including lead, cadmium, mercury, and arsenic.

A large number of cigarette smoking does not only contribute to human health issues but also is a problem for the environment (Rath et al., 2012). The health issues are mainly attributed to the firsthand and secondhand smoke of the cigarette that contribute primarily to lung associated diseases including chronic inflammatory diseases and cancer. On the other side environmental problems associated with smoking mainly arise from cigarette waste, the remaining part of the cigarette discarded during and after completion of a smoking session. This includes ashes and the major part cigarette butt. The noxious chemicals and heavy metals present in the cigarette waste are released into the environment. These toxicants released into the soil or water bodies can adversely affect flora and fauna of the region and disturb the ecosystem.

Several studies reported the contribution of trillions of cigarette butts in environmental contamination (Novotny et al., 2009). It is the most commonly found litter around the world and the hazardous nature of the cigarette poses a problem for the environment. In the present investigation, cigarette butts were collected from different locations in Riyadh city, Kingdom of Saudi Arabia. The litter was collected from the roadsides of the streets and not from the dust bins. It was found to be easier to see and collect the cigarette litter as a visibly large number of cigarette butts was scattered throughout the roadsides. They were found on pavements or mingled with roadside sand or dust. However, the study had its limitation that it could not find out the exact amount of cigarette litter per day, per month or per year, it clearly gives an indication of how common this cigarette litter is on Riyadh city roads, parks, and streets. The observations were found to be consistent with other reports published elsewhere (Rath et al., 2012;

Wallbank et al., 2017) that reported the commonality of cigarette litter in overall waste.

The disposal of cigarette waste in open public places is a matter of discussion for regulation. Suggestions have been proposed to regulate cigarette waste disposal in a way similar to the regulation of other hazardous items like tires and automobile batteries (Barnes, 2011) or any such items that pose contamination threats to the environment and human health. According to Institute of Hazardous Materials Management (IHMM) "A hazardous material is any item or agent (biological, chemical, radiological, and/or physical), which has the potential to cause harm to humans, animals, or the environment, either by itself or through interaction with other factors" (Institute of Hazardous Materials Management, 2019). USEPA states "a hazardous waste is a waste with properties that make it dangerous or capable of having a harmful effect on human health or the environment. Hazardous waste is generated from many sources, ranging from industrial manufacturing process wastes to batteries and may come in many forms, including liquids, solids gases, and sludges." Cigarette waste fits this category and needs attention from regulatory bodies globally (USEPA, 2019).

The heavy metal analysis also revealed the presence of hazardous metals including lead, arsenic, and cadmium that are included in WHO's "Ten chemicals of major public health concern" (International Programme on Chemical Safety) (Ten Chemicals of Major Public Health Concern, 2019). The WHO list of ten hazardous chemical includes four heavy metals; lead, arsenic, cadmium and mercury, the remaining six are dioxins, air pollution, asbestos, benzene, highly hazardous pesticides, and inadequate or excess of fluoride. However, previous studies published elsewhere have reported the presence of heavy metals in and their leaching from cigarette litter into the ambiance (Moerman and Potts, 2011), the present investigation was done to confirm the same in the samples collected from the Riyadh city. As far as the leaching is concerned, reports indicate that heavy metals may enter into the food chain through contaminated soil (Yang et al., 2018). Bioaccumulation is the process of accumulation of heavy metals and chemicals with lipophilic nature in biological systems after exposure mainly in the form of consumption. In a food chain when a predator con-

sumes the prey or a higher level animal to a lower level animal contaminated with accumulated toxicants, the toxicant in the predator body accumulates in higher concentration, to several magnitudes as compared with the prey. This is called biomagnification. In several cases, this high concentration of toxicants may reach to the humans who present themselves on the top of the food chain. Fish consumption is an example of the toxicant movement through the food chain and affecting human health.

Leaching of chemicals and heavy metals into the soil of a region where episodes of sandy winds are common may contribute to the health problems associated with airborne contaminants. Several reports indicate presence of heavy metal contaminants in the natural dust and the exposure causing immunosuppressive effect (Keil et al., 2018). Presence of heavy metals including lead (Pb), cadmium (Cd), arsenic (As), mercury (Hg), and chromium (Cr) has been reported in natural airborne dust (Pirsaheb et al., 2014). A study conducted by Kim et al. (2016) found that different areas in an urban set up have different heavy metal contamination in urban dust (Kim et al., 2016). This variable distribution of heavy metals depends on the anthropogenic activities in a particular area, for example highway or a market. The cigarette waste can contribute significantly in contamination of urban airborne dust or soil as a whole. Cigarettes may contribute to food crop contamination with heavy metals (Onakpa et al., 2018; Rai et al., 2019). In the very similar way cigarette waste may directly influence contamination level in urban soil and dust and may affect the health status of residents of an urban area.

The present investigation presents a concern associated with cigarette smoking and till now remained unexplored in the Kingdom of Saudi Arabia where the number of smokers is high. With the screening of Riyadh city roads, streets and parks for cigarette litter the investigation paves a path for further detailed investigation in this regard to find out the actual impact of cigarette litter in the region. The exploratory nature of the investigation appears to be fruitful as it clearly making a base for further exhaustive studies involving cigarette litter and its impact on the environment and human health in the Kingdom of Saudi Arabia.

Declaration of Competing Interest

The authors declare that there is no conflict of interest.

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