Original Article

Arsenic Content of Cigarette Butt Leachate of Five Cigarette Brands into Water

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Abstract

Aims: Over 5.5 trillion cigarettes are produced annually. Based on the observations, 76% of these consumed cigarettes are littered in public areas instead of discarding in suitable bins. Rainwater drain system carries the water and other wastes such as cigarette butts from the ground and transfers them to the bigger aquatic media without any treatment in which hundreds of chemicals leach into animal's habitats and our water supply origin. The key purpose of this article was to measure the concentration of Arsenic (As) released into water from cigarette butts and to compare their levels among the different brands. **Materials and Methods:** Ten cigarette butts (comprising cigarette filter and remaining tobacco) of five cigarette brands named Winston, Bahman, Kent, Montana, and Magna were soaked into individual 100 ml of distilled water for 10 days. Five solutions were prepared for each brand, as was detected in all leachate of brands but with different quantities. **Results:** Arsenic levels were 53.51, 32.78, 55.33, 42.4, and 59.24 µg/l for Kent, Winston, Montana, Bahman, and Magna, respectively. **Conclusion:** As concentrations were placed in the following order: Winston < Bahman < Kent, Montana, Magna. Based on the present study, cigarette butt plays an important role in environmental pollution and its importance should not be ignored in terms of arsenic potential.

Keywords: Arsenic pollution, cigarette butt, nonpoint source pollution, waste tobacco products, water contamination

Introduction

The remaining un-smoked tobacco combined with a plastic filter is defined as a cigarette butt. Over 5.5 trillion cigarettes are generated every year.[1] More than 70% of smoked cigarettes become litter instead of disposal in the bin.[2] Cigarette butts make up over 35% of littered wastes in the environment in the light of numbers. In the mid-1950s, investigations on developing cigarette filters started toward the reduction of the detrimental health impact of smoking such as lung cancer. Researchers achieved synthetic cellulose acetate (a plastic of about 12,000 fibers with 20 µm in diameter each) as the best pick because of its cheapness and ease with massive manufacture. Even though it has been shown that the filters have little safety performance, their usage has continued. This trend has been leading to environmental contamination.[3] The disintegration of photodegradable cigarette butts only occurs under severe biological circumstances such as submersion in sewage.[4]

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Environmental pollutants including polycyclic aromatic hydrocarbons; heavy metals such as copper, chromium, cadmium, and lead; and other 4000 chemicals can be entered the filters during smoking and discharged into the water.[5-7] These chemicals originate from pesticides, insecticides, herbicides, and fungicides used in growing tobacco which are taken up from soil to tobacco.[3] It was identified that these chemicals are distributed among smoke and filter of cigarettes while smoking.[8]

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It is verified that heavy metals are toxic for both human and other living organisms, even in very low concentrations.[9] Metals such as Al, Ba, Cd, Cr, Cu, Fe, Pb, Mn, Ni, Sr, Ti, and Zn have been recognized to exist in cigarette butt leachates.[10] However, no research has shown if arsenic leaches into the water in the face from cigarette butts or not. Arsenic is a well-known carcinogen of the liver, skin, lungs, and bladder.[11] Arsenic has had growing vital importance in drinking water considerations and been top priority recorded by the World Health Organization, which its acceptable level has fallen.[12]

Rainwater drain system carries the water and other wastes such as cigarette butts from the ground and transfers them to the bigger water bodies without any treatment. Leached chemicals in the environment cause harmful effects on human and animals' health and accumulate in biological systems.[6,13] Furthermore, the leachability of cigarette butts makes them to be considered as hazardous wastes when disposing of in landfills because of their possibility to contaminate the groundwater.[13]

The key aim of this study was to compare the potential of arsenic releasing of different cigarette butt brands into the water.

Materials and Methods

Cigarette butt collection

To analyze arsenic amounts in the cigarette butt leachates, five cigarette brands called Kent (Silver 4), Montana (Light), Magna (Classic), Winston (Classic, red), and Bahman (Classic) were used. We had individual voluntary cigarette smokers who consume each cigarette brand. They collected the butts after smoking in glass containers. A cigarette butt is defined as a cigarette filter and about 1 cm remaining tobacco after it is smoked. The rate of smoking and type of cigarettes were not imposed on volunteers so they consumed our required amount of cigarettes as regularly and brand equally as they usually would do.

Cigarette butt leachate preparation

Ten smoked cigarette butts of each brand were submerged into 100 mL of distilled water in 200 mL glass vials and held outdoors and stirred several times in a day to simulate the environmental conditions. This procedure was kept up performing for 10 days. Moreover, these solutions were remained in shut vials to prevent any evaporation due to exposure to the sunlight. Five solutions were ready for each brand.

Heavy metal detection

Graphite Furnace Atomic Absorption Spectrometry (GFAAS) is also known as electrothermal atomization atomic absorption spectrometry which is used to detect trace elements. It is an atomic spectroscopic method that a small sample is put and heated inside a tube to obtain desolvation and atomization of the samples. Typically, the passing light which is absorbed by free analyte atoms is measured. The transient absorbance signal (taking 1–5 s) creates a transient peak whose underneath area is used for the calibration curve. This analytical technique is precise, accurate for detecting a variety of samples and elements.[14]

Each sample of a cigarette butt leachate was filtered to remove suspended matters from the liquid by a 0.22 μm nylon filter connecting to a syringe. Fresh filters and syringes were used for each specimen to prevent any contamination. Filtered solutions were spilled into another vial for detecting the arsenic concentration. Figure 1 illustrates the schema of sample preparation for GFAAS.

Statistical analysis

One-way analysis of variance (ANOVA) test and Duncan test, in SPSS 10 (Ver. 25., IBM Corp. Released 2017), were utilized to determine whether the means of arsenic between the different brands would be statistically significant. The mean differences were regarded as being statistically significant if $P < 0.05$.

Results

The highest, lowest, and average arsenic concentrations of different cigarette butt brands were achieved. These results are shown in Table 1 and Figure 2.

One-way ANOVA test, SPSS 10, disclosed that the mean difference of average concentration of arsenic among different brands was significant ($P < 0.05$). According to Table 1 and Duncan test, Winston has the lowest arsenic level among the selected brands. Furthermore, arsenic content of Bahman is more than that of Winston. Finally, Kent, Montana, and Magna have the highest arsenic amounts of brands. Nevertheless, differences among Kent, Montana, and Magna were not statistically significant. This comparison can be summarized in ascending order:

Winston < Bahman < Kent, Montana, Magna

Quantities of Table 1 have been calculated on μg/cigarette displayed in Table 2 for understanding how much each cigarette brand is responsible for arsenic leaching into the water.

Based on the International Union of Pure and Applied Chemistry Guidelines, the detection limit of the method was computed according to the triple of the standard deviation of the eleven runs of blank solution (10 μg/l). The limit of

Table 1: Discharged arsenic concentration of picked cigarette brands, μg/l

Cigarette brand	Minimum	Maximum	Mean±SD	Repetitions. (*n*)
Kent	45.21	59.17	53.51±6.86	5
Winston	21.97	43.13	32.78±9.73	5
Montana	50.75	63.46	55.33±5.06	5
Bahman	32.96	54.03	42.4±8.12	5
Magna	48.09	71.16	59.24±8.4	5

SD: Standard deviation

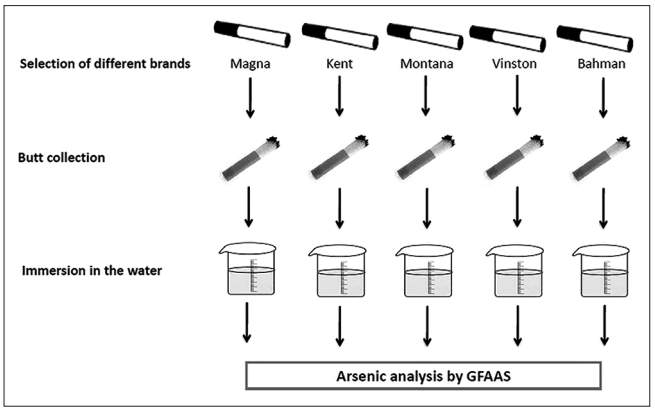

Figure 1: Schema of sample preparation for graphite furnace atomic absorption spectrometry

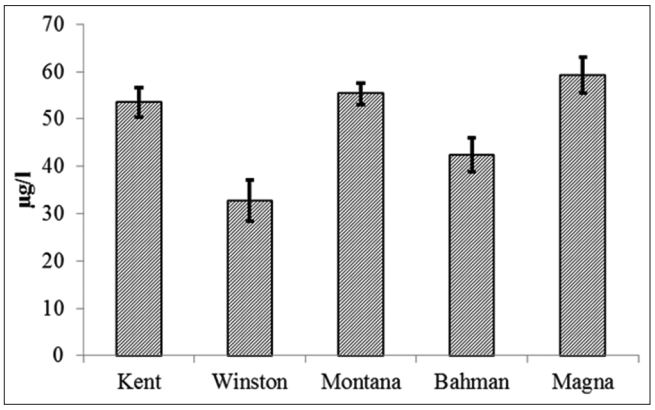

Figure 2: Arsenic concentrations of selected brands

detection (LOD), limit of quantitation, and the relative standard deviations of this method were 0.1 µg/l, 0.3 µg/l, and lower than 10%, respectively. They showed the good precision for the analysis of As in solution samples.

Discussion

Cigarette butts are the most common kind of litter all over the world. It is estimated by the United States Department of Agriculture that in 2004, over 5.5 trillion cigarettes (approximately equivalent to 1.2 million tons of cigarette butt waste annually) were manufactured worldwide. These amounts are supposed to have doubled by 2025 according to the global population increase in the American Cancer Society's estimation. It is estimated that more than 25 billion cigarettes will be then smoked per year that 7 billion of them would become litter.[13] Approximately six million dollars in 2009 were spent to clean up cigarette butts.[8] Hence, one single cigarette butt may not be harmful; such mentioned levels do jeopardize the environment.[3]

About 90% of all cigarette filters are made of cellulose acetate, but in Japan, Venezuela, South Korea, and Hungary, the cigarette butts build up because of the poorly biodegradable trait of the cellulose acetate filter.[13] Although cellulose acetate is photodegradable (not bio-degradable) and broken down into smaller pieces by ultraviolet rays from the sun within 12 years,[15] its original material and captured elements never go away.[16] The degradation rate of cellulose acetate fluctuates from within 36 months or more under the poor condition, 12 months in fresh water, 6–9 months in soil, and 1–2 months under anaerobic conditions.[13] Since the early 1980s when health impacts of secondhand smoke exposure were discovered, indoor smoking has been forbidden so that smokers have come not to be allowed to smoke cigarettes indoors. These prohibitions have resulted in cigarette remnants to be taken to the environment.[16] It is found that the most reasons for littering cigarette butts are laziness and lack of suitable bins.[17]

Cigarette butts are swept up and conveyed by stormwater to watercourses, and finally, the ocean and rivers where

Table 2: Arsenic quantities leached from each cigarette butt of the different brands into the water, (µg/cigarette)

Cigarette brand	Arsenic level (µg/cigarette)
Kent	0.5351
Winston	0.3278
Montana	0.5533
Bahman	0.424
Magna	0.5924
Mean	0.4845

their leached chemicals pose a threat to the freshwater and marine environments' organisms.[13] A study on the toxicity of cigarette butts found that the LC_{50} for cigarette butt leachate was about 1.1 cigarette butts/L for both the marine topsmelt (*Atherinops affinis*) and the freshwater fathead minnow (*Pimephales promelas*).[18] Children, toddlers, and animals that easily pick up cigarette filters (mistaken for food) could be poisoned by the ingestion.[3] Moreover, with regard to the growing concern from inadequate landfill places as well as leachability of cigarette butt waste leading to groundwater contamination and the increasing environmental alert over toxic emissions of incinerators, there is a vital need for a new way for the disposal of cigarette butt waste.[13] These mentioned financial, social, and environmental consequences are a tremendous emphasis on the need to decline cigarette littering. This study finds that cigarette butts are a potential source of arsenic in the environment, and different cigarette butt brands release different arsenic quantities into the water. Scientists relate these changes with this fact that cigarettes are a complex mixture of different tobacco origins[19] and different agronomical circumstances such as production methods, the water supply quality, and characteristics of soil that impact on tobacco leaves' content of heavy metals.[20]

Other almost similar studies found that heavy metals such as Al, Ba, Cd, Cr, Cu, Fe, Pb, Mn, Ni, Sr, Ti, and Zn are leached out from smoked cigarette butts.[10] We found that arsenic is leached from cigarette butts into water too. Another research found that heavy metal content of cigarette butts such as Cd, Zn, Cu, and Mn differ among different tobacco leaves.[19] We

also detect different arsenic content in different brands of cigarette butt leachates.

According to Table 2, although it might lead to judge that contamination induced by cigarettes butt is not noticeable, heavy metal yield entered the aquatic environment is remarkable with regard to annual cigarette production worldwide. Based on the annual cigarette consumption in Iran that is 55 billion cigarettes per year and the mean level of a cigarette butt (0.4845 µg/cigarette) [Table 2], it is computed that 26.64 kilograms of arsenic enter Iran's aquatic environment only within 10 days if they find their way to water bodies. In addition, cigarette butts keep releasing arsenic for >10 years so that actual levels could be more.[10] In addition to cigarette butt transference by wind, runoff takes street sediments to the stormwater systems which is a temporary place to convey wiped remnants to the waterways and bigger ecosystems where toxic substances enter our food chain.[6,17] Even if they fail to reach bigger waters, they are toxic to animals and children who mistake them for food and do not disappear from the environment.[21,22]

Besides that, cigarette butt ought not to be regarded as a local issue since they and their leached chemicals are able to travel worldwide by current.[23] However, the certainty of the real toxicity of these substances is with the shadow of a doubt because of the dilution process and different local factors such as rainfall intensity, kind of land use, and sediment features.

Conclusion

This article shows that cigarette butts pose an environmental problem due to freeing arsenic into the water. It was also demonstrated that different brands discharge different proportion of arsenic. Despite small levels of arsenic at the first glance, a large number of cigarettes have been being smoked on a global scale. More studies can be conducted to understand the percentage of arsenic leaching of cigarette butts into the water by comparing metal level in remnant with those leaching into the water as well as a study on arsenic-induced risk assessment of different areas.

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Ethical issue

In this study, the rate of smoking and type of cigarettes were not imposed on volunteers, so they consumed our required amount of cigarettes as regularly and brand equally as they usually would do.

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Conflicts of interest

There are no conflicts of interest.

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