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Impacts of Used Cigarette Butts on Soil Properties and Local Plants Growth

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A B S T R A C T

Cigarette butts (CBs) are the most common litter item on Earth but no long-term studies evaluate their fate and ecological effects. They are prevalence wastes in the environment and hazardous wastes usually littered by smokers. The present study aimed to investigate the impacts of used cigarette butts on soil properties and local plants growth. A petri-dishes germination experiment was carried out under controlled laboratory conditions to examine the effects of cigarette's butts extract (0, 30, 60 & 90%) on seed germination of some types of ornamental and wild plants (*Moringa oleifera, Dodonaea viscosa, Melilotus officinalis, Chrysanthemum indicum*). Results reflected significant changes and impediments to germination by increasing butts extracts concentration. Cigarette butts inhibited bacterial community, where the higher reading was recorded with control ≥ 3.00×10^{-7} CFU/ml, followed by 2.81×10^{-7} CFU/ml for 30% butts extracts, 2.29×10^{-7} CFU/ml for 60% treatment and the lowest was 4.00×10^{-5} CFU/ml for 90%. One-month plant species (*Melilotus officinalis*) was grown in Clay loam soil pots treated with 0, 1, 6 & 9 cigarette butts to examine their effects on soil characterization. The results indicated that cigarette butts able to affect the soil physico-chemical properties, where they increased the pH, EC & Soil alkalinity in tested soil. Sodium concentration were increased from 11.9 to 103.0 mg/kg.

1 Introduction

Cigarette butts (CB) as an environmental and public health hazard is relatively new fields of study Butts litter are one of the most littering objects in the world and pose unique challenges to ecosystems due to their ubiquity, persistence and potential damage. Studies show that 76–84% of smokers throw CBs into the environment instead of the trash; resulting in more than 4.5 trillion CBs being thrown into the environment each year (Lucia *et al*., 2023) estimated that one in three CBs ends up in the environment. The Berlin study found that the average density of CB in cities, parks and, public CB contain a variety of toxic compounds accumulated during smoking such as benzene, polycyclic aromatic hydrocarbons, pyridine and heavy metals, which can leach into the environment and affect all ecosystems. Moreover, practical operational aspects are lacking at the regulatory level as the current disposal systems for CB are landfilling and incineration, which are unsustainable and release hazardous contaminants to the environment. Environmental impacts are currently linked to smoking cigarette behavior, as cigarette butts (CBs) represent the most common litter item in natural areas. Filtered cigarettes are the major form of cigarette smoking. Filtered cigarettes were added in order to trap the poisonous compounds present in cigarettes. The production of this type of cigarette has gripped much attention over the recent decades; more than 5 trillion filtered cigarettes are produced annually over the world. As a result of smoking, filtered cigarette known widely as cigarette butt (CB) is generated. This waste consists of three main parts, including the filter,

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wrapping paper and the remaining burned tobacco on the filter (Chevalier *et al*., 2018). Unfortunately, a large part of CBs is not properly disposed by smokers and discarded directly into the environment as a litter. It has been estimated that annually, approximately 4.5 trillion CBs are disposed as litters, worldwide (Yousefi *et al*., 2021). In urbanised terrestrial habitats, such as cities, parks and public green spaces, cigarette filters are commonly littered. In soil ecosystems, Nicotine has been detected in several plant products, including; food crops, teas and spices, and research shows that plants can take up nicotine either from tobacco smoke or from soil littered with commercial tobacco (Selmar *et al*., 2018). Despite their prevalence as waste in terrestrial habitats, the effects of littered cigarette filters on plant germination, growth and chlorophyll content remains largely unknown. The filters found in cigarette butts contain a micro plastic, cellulose acetate, as well as toxic metals and metalloids which are responsible for pollution in the environment. There is a lack of research on the adaptation of CBs to the environment and what impact they have on vegetation. Therefore, the present work aimed to understand the toxicity of smoked CBs. It is very important to obtain information about the effects of smoked cigarette butts on soil properties. Although this paper focused on soil environments, several previous studies have investigated the lethal impact of butt leachates in environment ecosystems (Akhbarizadeh *et al*., 2021). However, studies of impacts of cigarette butts in terrestrial systems are limited (Green *et al*., 2022).Amongst terrestrial biota, three studies to date have focused on plants. Most ecotoxicological studies have focused on the chemical component of cigarette butts, using extracted leachate. The objectives of this study were, therefore, to elucidate the impact of smoked cigarette butt leachates on growth of some local plants and soil microbial communities as well as to determine the impact of smoked cigarette butt on Soil properties.

2 Materials and Methods

The study was carried out at the Department of Environmental science, Faculty of Environmental and neutral resources- Wadi Alshatii University, Libya, in 2022. Smoked cigarette butts were collected from Brack, Al-Shatti, to represents the butts of the various types of cigarettes circulating in the area. Seeds of ornamental and wild plants were collected as follows: *M. oleifera*, *D. viscosa*, *M. officinalis* & *C. indicum*. Soil was collected from the uncultivated area from Brack Al-Shatii, top soil was collected from 0-20 cm regarding standard soil sampling procedure. Following (World Health Organization, & WHO Tobacco Free Initiative, 2012), smoking cigarette filter was mouth end cut and paper wrapper removed. Butts extracts were prepared by soaking 75 g of cigarette butts in sterile glass bottle contain 1.0 L of deionized water and kept for a week at room temperature. Cigarette butt extracts were filtered using Whitman filter paper No. 41. Concentrations of: 30, 60 & 90% were prepared. Impacts on seeds germination, using petri-dishes lined with whatman-40 filter paper under sterile control environmental condition. Five seeds per petri-dish of each; *M. oleifera*, *D. viscosa*, *M. officinalis* & *C. indicum* were placed over filter paper, which were already specified with specific concentration of butts extract. Incubated for one week, number of germination was counted daily. Seedlings were harvested after 7 days. Seed germination (SG) was as calculated according to:

$$SG=\frac{number\ of\ germination\ seeds}{total\ number\ of\ seeds} \times 100$$ (Luo *et al*., 2018)

Data about CBs effects is limited, to fill these gaps; a greenhouse experiment was set up simulating littered cigarette filters. Three replications of one kilogram of desert soil were placed in plastic pots and homogenized. four treatments used to test plants, T1, control, T2, one cigarette butts, T3, six butts and T4, 9 butts were added. The pots were irrigated by enough water equal to field capacity. *M. officinalis* was cultivated as a test plant on soils treated with cigarette butts agronomic practices. Six seeds per pot were planted, set of 3 replicates in randomized design, harvested 4 weeks after planting. Soil samples were collected, air-dried and sieved through 2 mm mesh sieve. Soil pH was measured using a 1:1 (w:v). Soil organic matter was determined using Walkley-Black method (Nelson and Sommers, 1982). Pipette method was used to determine soil texture (Kettler *et al*., 2001). The pycnometer method was used to measured soil particle density (Aishah and Elssaidi, 2020). Particle density of soil is expressed the ratio of total mass of soil to their volume (g.cm3) and porosity was calculated according to Chitra *et al*., (2022), ***Porosity (%) = [1- (Bulk density/Particle density)] × 100***. EC was determined in water solution (1:1) in dS/m unit at 25°C following Aishah *et al*., (2021. Exchangeable bases, Sodium, Magnesium, Potassium & Calcium concentration were determined by flame spectrophotometer, according to Chitra *et al*., (2022). Cation Exchange Capacity (CEC) was determined according Aishah and Elssaidi, (2019). Field capacity determined as described by Colman (1947). SO_4 determination following Ajwa and Tabatabai, (1993).

3 Results

Soil Physico-chemical properties

The Physico-chemical characteristics of the studied soil before planting are shown in Table 1. The percentage (%) sand, silt also clay of the soil before use of amendments was 22.5, 46.5and 31 % respectively that indicating the Clay loam soil according to the United States Department of Agriculture (USDA) soil texture classification (Staff Soil Survey**,** 2014**)**. As stated by Wang *et al*., 2021), soil texture is an important soils physical property. The pH of the soil was 8.3 indicate the alkaline soil which is very common in arid and semi-arid regions (Aishah and Elssaidi, 2020). Low water holds capacity value (WHC) 10.10%. Bulk density (ρ_b) of soil was 1.70g cm^{-3}; ρ_b is an important physical attribute in reproducing the field condition of soils in the laboratory. Particle density (ρ_s) was 2.5 g cm^{-3}; particle density and bulk density data were used to calculate the porosity (P), whereby P of tested soil was 32.4%. EC was 2.00 dS/m indicating non-saline .The exchangeable Na, K, Ca, Mg content of the soil was 11.9,13.4 , and 19.9, 10.3 mg/kg. However, the amount of Na, Ca, K, Mg, and OM in this soil was very low and the pH of the soil indicates that it is alkaline. The SO_4, Cl, HCO_3content of the tested soil were 80.3, 14.9 and 9.12 mg/kg.

Table 1. The Physico-chemical characteristics of the studied soil

WC	WHC	ρ_s	ρ_b	P	Sand	Silt	Clay	pH	EC	OM	Na	K	Ca	Mg	SO_4	Cl	HCO_3	CO_3
%	mL	g/Cm^3	g/Cm^3	%	%	%	%		dS/m	%	.... mg/kg......................							
22	10.1	2.5	1.7	32.4	22.5	46.5	31	8.3	2.00	0.6	11.9	13.4	19.9	10.3	80.3	14.9	0.3	0.00

WHC= water holding capacity, **ρ_b =** Bulk density**, ρ_{s}=**Particle density **P**= porosity, **OM**= Organic matter

Cigarette butts extracts impact on Plants Germination:

Seeds of *Moringa oleifera, Dodonaea viscosa, Melilotus officinalis, Chrysanthemum*, were tested for abiotic stress caused by supplementation with cigarette butts extracts (0%, 30%, 60% and, 90% smoke butts extracts). A significant effect of cigarette butts was observed on seed germination, (Table 2). SG for *Dodonaea viscosa* in the control oscillated between 30% and 0%. The higher value was for 7days.These findings confirm that the highest concentration of CBs in the solution had the most inhibitory effect on the SG. On other hand, SG of *Moringa oleifera* was higher in the 30% butts extracts at 7 days, this is in line with Koroleva *et al*., (2021) who thought that the some CB compounds can positively influence plant germination at low doses and be toxic in higher doses of CB. It is worth pointing out that among the four tested plant species *Melilotus officinalis* have low Germination ratio. The lowest SG values were 0% recorded for *Melilotus officinalis* at the 90% butt's extracts treatment. These findings confirm that the highest concentration of butt's extracts had the most inhibitory effect on the SG of plants, owing to its lowe-stress tolerance, our results record significant changes and impediments to germination with increasing butt's extracts concentration. This study indicates the potential for cigarette filters to reduce germination of terrestrial plants.

Table 2. Impact of Smoked Cigarette butt's extracts on tested Plants Germination:

	Dodonaea viscosa				*Moringa oleifera*				*Melilotus officinalis*				*Chrysanthemum*			
Treatments	**0**	**%30**	**60 %**	**90 %**	**0**	**30 %**	**60 %**	**90 %**	**0**	**30 %**	**60 %**	**90 %**	**0**	**30 %**	**60 %**	**90 %**
Day					**% .... Germination...**											
th1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
^{end}2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
rd3	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0
th4	0	0	0	0	50	0	0	0	20	30	30	0	20	30	10	0
th5	20	10	10	0	100	30	10	10	30	30	30	0	50	40	30	20
th6	20	20	20	10	100	60	20	20	30	30	40	0	60	40	40	20
th7	30	30	30	30	100	100	20	30	40	40	40	0	80	40	40	30

Cigarette butts extracts effect on soil bacteria

Cigarette butt litter is prevalent in many soils; research on the effects of these cigarette butts is limited. As results shown in Table (3).However, the microbial activity was higher in the Control (0% cigarette butts extracts) when compared with all cigarette butts, where the higher number was recorded ≥300×10^{-5} Bacterial colony/1ml for 0% cigarette butts extracts treatment, followed by 281×10^{-5} (CFU) Bacterial colony/ ml for 30 % cigarette butts extracts treatment, 229×10^{-5} Bacterial colony/1ml for 60% cigarette butts extracts treatment and 4 ×10^{-5} (CFU) Bacterial colony/ ml for 90 % cigarette butts extracts treatment , this results are in line with Malayil *et al*., (2022). The microbial communities the soil-borne microbiota of soils are stimulated by cigarette butts extracts treatment. The application of cigarette butt's extracts treatment has decreased microbial activity in comparison to the control soils It has been proven that high cigarette butt's extracts have negative effects on microorganisms, CBs are common waste in the environment; that can cause air, soil and water pollution as well as pose a threat to living organisms (da Costa Araujo and Malafaia, 2021); (Farzadkia *et al*., (2022). Significantly affect bacterial communities in soil as a result of the leaching of significant quantities of certain elements into the surrounding soils. Several studies have detected the presence of numerous metals and metalloids in cigarette butts including varying concentrations of Al, As, Ba, Cd, Cr, Cu, Co, Fe, Hg, Pb, Mn, Ni, Se, Sr, Ti, and Zn which known for their toxicity to living organisms (Chevalier *et al*., 2018; Koutela *et al*., 2020 and Mansouri *et al*., 2020). The harmful effects can be attributed to a large number of toxic chemicals in the tobacco products. Our results suggest that biodegradable and non-biodegradable cigarette butts can significantly affect bacterial communities in soil as a result of the leaching of significant quantities of certain elements into the surrounding soils.

Table 3. Effect of cigarette butts extracts on the total number of bacteria in the soil

	Smoked cigarette butts extracts			
	Control	%30	%60	%90
Bacterial colony (CFU)×10^{-5}	≥300	281	229	4

Cigarette butts effect on soil characterization

The filters found in cigarette butts contain a micro plastic, cellulose acetate, as well as toxic metals and metalloids which are responsible for pollution in the environment. Although cigarette butt litter is prevalent in many soils (Koroleva *et al*., (2021). In our study, selected plant species (*Melilotus officinalis*) was grown for one month in Clay loam soil pots treated with 0, 1, 6 and 9 smoked cigarette butts. Then harvested and oven dried before used for analysis. The results revealed that, the applied smoked cigarette butts resulted in soil pH changes. Soil chemical parameters were changed due to Smoked cigarette butts applied (Table 4), that might be able to affect the soil quality owing to the presence of salts, where the EC increases from 2.00 to 6.4 dS/m. Generally, Smoked cigarette butts treatments increased the pH and EC in tested soil, especially, that iterated with 9 Smoked cigarette butts, which showed higher value than others (control). Smoked cigarette butts affected the Clay loam soil characteristics slightly. As the results show, the soil alkalinity was considerably increased because of significant increase in pH for all treatments. There was a considerable increase in the Na from 11.9 to 103.0 at 9 smoked cigarettes butts treatment. Also, it was observed that K, Ca and Mg were increased under 9 Smoked cigarette butts treatment. Selmar, et al, (2018) demonstrated that nicotine alkaloid is leached out from cigarette butt waste into the soil and uptake by plants, further was showing a direct effect of Smoked cigarette butts on soil chemical characterization. The SO_4, Cl, HCO_3, were increased under Smoked cigarette butts treatments, over the control treatment. Several studies reported the contribution of cigarette butts in environmental contamination (Kurmus and Mohajerani, 2020). Smoked cigarette butts influenced the values of CEC, the higher number of Smoked cigarette butts application (9 smoked cigarette butts) resulted in a greater value of CEC 2.2 cmol kg^{-1}

Table (4): Tested soil proprieties before treatments and After treatments

Treatments (number of Smoked cigarette butts/ Pots)	**pH**	**EC** dS/m	**Na**	**K**	**Ca**	**Mg**	**SO_4**	**Cl**	**HCO_3**	**CO_3**	**CEC** cmol kg^{-1}
			....mg/kg..								
0	8.3	2.00	11.9	13.4	19.9	10.3	80.2	14.9	0.3	0	1.5
1	8.4	4.00	49.0	15.4	35.0	20.3	88.3	27.00	9.12	0	1.9
6	8.5	6.01	81.0	17.4	49.0	30.3	200.00	31.9	16.0	0	2.1
9	9.0	6.4	103.0	30.0	81.0	40.3	400.3	64.00	18.12	0	2.2

Cigarette butts impacts on tested plant

Melilotus officinalis is an herbaceous legume species, it has been widely introduced and can currently be found naturalized across Europe, Asia, Africa, the Americas, the West Indies, Australia and New Zealand. This species has a symbiotic relationship with certain soil bacteria; these bacteria form nodules on the roots and fix atmospheric nitrogen. Some of this nitrogen is utilized by the growing plant but some can also be used by other plants growing nearby (Stokes, 2021). As our results (Table 5), the highest average shoot length values were recorded in the absence of CBs addition (7.7 cm), while the lowest (4.5 cm) was recorded in the case of 9CBs. Chrysanthemum responded negatively to increase CBs. Cigarette butts (CBs) have only recently begun to be considered as environmentally harmful waste. The soils contaminated by heavy metals (HM) are also a serious problem, as they because impairment of plant growth parameters such as germination index, root length, and shoot biomass (Jakimiuk *et al*., 2022). Excess of Ni decreases plant metabolism, inhibits photosynthesis and transpiration, as well as leads to ultrastructural changes and oxidative stress (Montalvão *et al*., 2019).In various studies (Jakimiuk *et al*., 2022), nevertheless, as the concentration of toxic compounds increases, the plant response changes, and the high dose of the toxic compound begins to have an inhibitory or toxic effect. The smoked cigarette butt and the continuous leaching of toxins into the limited available water system would have probably created a highly concentrated leachate solution (Joly and Coulis, 2018). Cigarette waste may directly influence contamination level in soil. The toxic leachates that disperse from the discarded butts pose a potentially serious threat to the surrounded environment. Metals and other toxic residues contained in the butts can affect plant growth cause the environment around it to become toxic and potentially disrupt the soil ecology (Joly and Coulis, 2018; Green *et al*., 2019).

Table (5): Mean Stem Length of Melilotus officinalis during the Experiment Period (cm)

Duration	**Treatments** (number of cigarette butts/ Pots)			
	0	**1**	**6**	**9**
1^{th} week	0	0	0	0
2^{nd} week	1.8	1.6	1.3	1
3^{rd} week	5.6	5.9	3.7	2.4
4^{th} week	7.7	7.2	7.4	4.5

4 Conclusions

This study has shown beyond doubt the ability of smoked cigarette butts to affect the soil properties and growth of some local plants. As a result of its various effects on the physical, chemical and biological soil characteristics, smoked cigarette butts effects plants growth and stabilization. All discarded butts contain the chemicals used in tobacco production, absorbed by the fibres during the smoking process. The influence of soil properties was evidenced by the increase in soil pH, EC, CEC, exchangeable bases, SO4, resulting from smoked cigarette butts application. Besides, cigarette butts extracts treatment has decreased microbial activity. Chrysanthemum responded negatively to increased smoked cigarette butts. Although evidence exists highlights the potential impacts of discarded cigarette butts, there is a need for further research similar to that carried out else. Future studies should focus on reducing cigarette butt pollution and the amount of pollutant leakage from them.

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