Project Report

Background information on cigarette butt littering and portable ashtrays (updated version)

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Cigarette butts – associated risks for the environment

Background- littering and related effects

Cigarette butts and other tobacco product wastes (TPWs) are seen as an important contribution to littering in public spaces and are the most common items picked up in urban and beach clean-ups worldwide (Rath et al. 2012). The total amount of deposited butts can only be estimated; some researchers assume that it was around 4-4.5 trillion per year in 2009, that is 66-75% of the total amount of cigarettes consumed (Novotny and Slaughter 2014).

A research group from San Diego in California, where smoking in public areas is restricted, targets tobacco waste products in several investigations. The researchers report that cigarette butts contributed a relevant part of the waste that is collected from beaches and in cities. Examples of littering with cigarette butts have been reported also from many other places in the world including the United States (Chicago), Berlin in Germany, Bogota in Colombia and from coastal areas on the Persian Gulf. Discarded cigarette filters are a global challenge. For an overview, see also references at the end of this document and follow the links (Lozano-Rivas et al. 2015, Dobadaran et al. 2017).

Cigarette butt litter is found everywhere in public areas including recreational areas such as beaches, forests, parks, but also on pavements and roads. Cigarette litter along roads is caused by pedestrians and drivers. In Bogota, cigarette butts were collected in nightlife districts; peak days with high amount of littering were found on Saturdays and Fridays, with peak hours in the evenings. The study found that like in many places worldwide, indoor smoking is not permitted, while the number of ashtrays outside is not enough and the distance between ashtrays is longer than smokers accept. After bans on indoor smoking took effect, residents, business owners, and politicians have observed an increase in the quantity of littered butts. This is difficult to quantify; a group in the United Kingdom estimated an increase of 43% (Novotny and Slaughter 2014).

The potential amount of cigarette butt litter in Sweden can be estimated based on consumption data and population data. The average consumption per capita is low compared with many other developed countries and is around 716 cigarettes per year in 2018. https://tobaccoatlas.org/country/sweden/. With a population of estimated 10,3 million people (Statistics Sweden, https://www.scb.se/en/finding-statistics/statistics-by-subject-area/population/population-composition/population-statistics/), that means 7,37 billion cigarettes are consumed in 2018. 20 cigarette butts equal 3.4 g (Novotny and Slaughter 2014), which means that in total an amount 1,25 million kgs of waste cigarette butts is caused by cigarette consumption in Sweden. Based on the assumption that about 25% of the filters from cigarettes are littered, that means at least 300.000 kgs of cigarette butts can end up in the environment.

Cigarette butts are often seen as an esthetical problem (“butt ugly”). Additionally, they contain numerous toxic chemicals that are harmful to the environment and are released when the cigarette filter is exposed to water. The chemicals include pesticides (herbicides, insecticides, fungicides, rodenticides) that are used when growing tobacco to protect the tobacco plant. Tobacco itself contains nicotine,

which is a powerful pesticide itself, also polyaromatic hydrocarbons (PAH), nitrosamines, ammonia, acetaldehyde, formaldehyde, phenol, pyridines, acetone, and heavy metals. The heavy metals, among which are cadmium (Cd), lead (Pb), arsenic (As) and nickel (Ni); are taken up from the soil where the tobacco plant is cultivated. They are bio-accumulative and along with the tar and nicotine, cause serious impacts on water sources. All chemicals that are transferred from tobacco to the smoke are potentially retained or trapped by the filter. Many of the listed chemicals are hazardous substances and limited.

Cigarette butts altogether are a source of toxic substances and compounds. If they are carelessly dropped on the ground, there are several paths how they can directly damage humans and wildlife. They can be ingested directly by small animals in nature or by pets and even by playing children, which leads to toxic effects that are reported to poison control centres (Novotny TE et al. 2011). Many of the hazardous substances are also water-soluble and can be washed out with rainwater and end up in water resources such as groundwater and marine water.

That means, even wildlife and organisms that are located far from the original littering area are threatened, also through bioaccumulation in the food chain. For several fish species, a lethal concentration was already reached when one cigarette butt (smoked filter and attached tobacco) was added to one litre of water. This was enough to kill 50% of the sample population (LD50). Moreover, acute toxic effects were observed for water organisms (Slaughter et al. 2010). The results were different for different cigarette brands and showed that cigarettes with a high tar content had a worse effect on test organisms. For a marine worm species that is found in coastal sediments, observed effects were a significant weight loss and increase of DNA-damage. It is assumed that the worms ingested fibres from deteriorated filters with a high content of heavy metals and nicotine (Wright et al. 2015). On the coast line of the Persian Gulf, cigarette butts have been reported as a relevant contribution to contamination with the heavy metals lead and mercury (Dobadaran et al. 2018).

A laboratory experiment at the University of Georgia in Atlanta used cigarette butts from ashtrays and determined the concentration of heavy metals in the leachate with a pH value similar to rain water (Moerman and Potts 2011). The experiment resulted in a concentrate with high amounts of cadmium, lead and nickel. A comparison with the recommended limit values for drinking water in the EU shows that 7 grams of the concentrate pollute drinking water to the recommended limit value; for cadmium, the limit value is reached with 35 grams of concentrate and for Nickel it is reached with 67 grams.

Direct effects have also been observed when cigarette butts are dropped on soil. A study in Cambridge found a potential for littered cigarette filters to reduce growth and alter short-term primary productivity of terrestrial plants (Green et al. 2019).

Attitudes and behaviours

Cigarette butts are still “one of the most socially accepted and common forms of litter”. A reason for littering is the absence of ashtrays nearby (Rath et al. 2012). New rules on smoke-free outdoor environments are in place in Sweden since 1 July 2019. As a consequence, ashtrays near restaurants and public transport

stations have been removed; the CEO of the foundation Håll Sverige rent, Johanna Ragnartz, expected an increase in littering before the law was implemented, see also https://www.svt.se/nyheter/lokalt/sormland/nya-rokforbudet-kan-leda-till-fler-fimpar-pa-gatan-1. No empirical studies have been carried out yet, but an increased littering has been observed, for example on the island of Gotland in Visby by Isak Malm and Lennart Othberg, responsible for the regional maintenance activities including street-cleaning (Region Gotlands teknikförvaltning; report in Swedish https://sverigesradio.se/sida/artikel.aspx?programid=94&artikel=7279716).
But even in a car that has an inbuilt ashtray, some smokers prefer to throw the butts out of the window as the odour of cold ashes is unpleasant. Acceptance of portable ashtrays that need to be emptied is also limited because of the odour. Moreover, based on the documented effects on water organisms, ashtrays should not be rinsed out but wiped with paper towel that is then put into a waste bin.

Countermeasures

Stopping smoking is certainly the most effective way to reduce the impact of cigarette butts and nature and wildlife. However, for smokers who do not manage to quit an option to reduce the by-effects of smoking should be provided. As a conclusion, it is recommended to break the chain – prevent humans and organism from exposure to toxic ingredients in cigarette butts by making sure that the butts are collected and enter waste treatment or, when it will be available and viable in the future, a treatment to recycle the material and turn it into useful products.
Portable ashtrays come in different forms. A small pouch that can be carried with a cigarette pack or in a pocket helps to make sure that the ashtray is available when needed and actually used to full effect, as it is convenient and encloses the odour. This is the idea behind the pouch “Ciggrid”.
The suggested pouch “Ciggrid” is made from several materials such as polyethylene and aluminium foil to provide a safe containment. Though it was initially intended for a single use, feedback from users indicate that the pouch is large enough to contain three cigarette filters and also that it can be opened and closed several times and still provides a safe containment for filters and their characteristic odour. As a consequence, “Ciggrid” will also be modelled as a pouch for three cigarette filters, Models that are intended for several uses are available from different suppliers and can be ordered from online shops. They are regularly produced in China and according to product description are usually based on PVC (or polyester), aluminium foil and polyurethane foam (or PVC foam). One single sample was analysed in the laboratory with screening techniques (XRF and IR). Other products might contain different types of polymers; this is however not always transparent for the customer. This type of pouch can be emptied and reused. The overall product quality is rather low, and it is likely that the material will take on the odour. It can therefore be assumed that the reusable pouch is used for approximately 10 cigarette butts by an average user.
Other pocket ashtrays are made of steel sheet metal and are of higher quality. One model developed in Switzerland separates the butts in a closed containment so that the user is not directly exposed to odour. It is assumed that this type of

ashtray can be used for a higher number of cigarette butts and are useable for several years. This requires a higher material use, and the ashtray has a weight of 35-40 g. To avoid contamination of water, they should by wiped out with a paper towel and not be rinsed out.
Simplified material lists were used to calculate the material demand for Ciggrid, a reusable pouch and a steel plate model. The lists were used in an LCA program (SimaPro 9 with background data from Ecoinvent) to calculate environmental impacts related to the production of the materials and the products. The impact categories are selected from the set of ILCD impact+ 2011, which are recommended by the European Union's joint research centre.

Climate impact

Global warming, or climate impact, is measured as kilogram CO_2-equvivalents. Global warming is the gradual increase, over time, of the average temperature of earth's atmosphere and oceans sufficient to induce changes on the earth's climate. This increase on earth's temperature is related to the increase of the emission of gases, such as, CO_2, methane, water vapour, nitrous oxide and CFCs, among others, from anthropogenic (man-made) sources, mainly from the burn of fossil fuels. Europe´s emissions in 2005 corresponded to 11200 kg CO_2 equivalents per person[1]. Burning 1000 litres of petrol in a car generates approximately 2500 kg CO_2-eq as a comparison. To avoid unwanted global warming effects requires global yearly emissions to be reduced by between 50 to 85% by 2050 on current levels, according to the Intergovernmental Panel on Climate Change[2]. This would translate to approximately 1000 kg CO_2-eq per capita world average.

Acidification

The most important man-made emissions of acidifying gases are sulphur dioxide (SO_2) and nitrous oxide (NO_X) from combustion processes. Thus, acidification is measured in equivalents of sulphur dioxide SO_2. Acidification, or acid rain, is best known for the damage caused to forests and lakes. Less well known are the many ways acid rain damages freshwater and coastal ecosystems, soils and even ancient historical monuments, or the heavy metals these acids help release into groundwater. Europe's emissions in 2005 corresponded to 57 kg SO_2 equivalents per person[3].

Freshwater eutrophication

Eutrophication is measured as equivalents of PO_4. Nutrients like phosphor or nitrogen released in a lake leads to an increased production of planktonic algae.

[1] European Environment Agency, 2005. The European Environment, State and Outlook 2005. Copenhagen.

[2] IPCC, 2014. Climate Change 2014: Synthesis report. Contribution of working groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Summary for policymakers. Geneva, Switzerland.

[3] European Environment Agency, 2005. The European Environment, State and Outlook 2005. Copenhagen.

The algae sink to the bottom and are broken down with consumption of oxygen in the bottom layers, causing a dead environment at the bottom. The most significant sources of nutrient enrichment are the agricultural use of fertilizers, the emissions of oxides of nitrogen from energy production and wastewater from households and industry. In 1995 the Baltic Sea received 761 000 t nitrogen and 38 000 t phosphorus from land[4]. The anthropogenic part of the nitrogen was assumed to be 79%, for phosphorus no assumption could be made.

Photochemical oxidation

Potential photochemical oxidation, or summer smog, is measured in kg ethene equivalents (C_2H_4).

Increased levels of ozone at ground level, arise through the reaction of volatile organic compounds, for example ethene and solvents, with oxygen compounds or oxides of nitrogen in air and under the influence of sunlight, so called photochemical oxidation. The effects on human health are amongst others irritation of eyes and mucous membranes as well as impaired respiratory function. Ground level ozone also has severe effects on vegetation, resulting in agricultural production losses.

Europe´s emissions in 2005 corresponded to 12 kg ethene equivalents per person[5]. Burning 1000 litres of petrol in a modern car generates around 1 kg ethene equivalents as a comparison.

Human Toxicity

Potential toxic effects on humans due to cancer and non-cancer effects is measured in CTU, comparative toxic units.

The comparative toxic unit for human toxicity impacts (CTUh) expresses the estimated increase in morbidity (the number of disease cases) in the total human population per unit of mass of the chemical emitted. In practice: disease cases per kg emitted = CTUh per kg emitted. The model takes into account both toxicity related to ingestion exposure and inhalation exposure. Characterisation factors are available for carcinogenic as well as non-carcinogenic human toxicity impacts.

Freshwater ecotoxicity

The comparative toxic unit for aquatic ecotoxicity impacts (CTUe) expresses the estimated potentially affected fraction of species (PAF) integrated over time and

[4] European Environment Agency, 2010. The European Environment, State and Outlook 2010: synthesis. Copenhagen.

[5] European Environment Agency, 2005. The European environment — State and outlook 2005.
Copenhagen

the volume of the freshwater compartment, per unit of mass of the chemical emitted. In practice: PAF × m³ × day per kg emitted = CTUe per kg emitted.

The absolute amounts are not shown here, as this was based on estimations. The environmental impacts of the reusable pouch and the steel plate model are higher, and that means that the reusable pouch has to be used for at least 20 cigarettes to compensate for the higher climate impact compared to the single use pouch. For the steel plate model, the corresponding value is 32 - both comparisons are for the example of climate effects. For other categories, the values are different and can be up to 330 because of the more intense use of metals in the steel plate ashtray.

Table: Environmental impacts in selected categories with the Ciggrid pouch and single use as baseline (impact=1); considering

Impact category	Impact per Ciggrid	Impact per reusable pouch	Impact per steel-plate ashtray
Climate change	1	20	32
Human toxicity, non-cancer effects	1	52	154
Human toxicity, cancer effects	1	31	330
Photochemical ozone formation	1	24	41
Acidification	1	23	34
Freshwater eutrophication	1	36	91
Freshwater ecotoxicity	1	9	23

In summary, portable ashtrays are an important approach to reduce toxic effects of cigarette butts on wildlife and water resources. A single use model that is consistently used can be a good choice from an environmental perspective if the more elaborate models are not accepted by users due to the odour. The minimum amount of cigarette butts for the multiple use options to compensate for higher material need is around 20 for a reusable pouch and at least 32 for a steel plate option, if the climate change category is used as a basis.

Based on Initial feedback from users, which indicates that the “Ciggrid” pouch is used for up to three cigarettes before disposal, a separate calculation was added.. It shows that this can reduce the impacts related to the “Ciggrid” pouch and means that the reusable pouch and steel ashtray need to be used more often until the higher material effort is compensated. The reusable pouch has to be used for at least 60 cigarettes to compensate for the higher climate impact compared to the “Ciggrid” pouch. For the steel plate model, the corresponding value is 97 - both comparisons are for the example of climate effects. For other categories, the values are different and can be up to 990 because of the more intense use of metals in the steel plate ashtray.

Environmental impacts in selected categories with the Ciggrid pouch and use for three cigarette filters as baseline (impact=1); considering

Impact category	Impact per Ciggrid (3 filters)	Impact per reusable pouch	Impact per steel-plate ashtray
Climate change	1	62	97
Human toxicity, non-cancer effects	1	156	154
Human toxicity, cancer effects	1	95	991
Photochemical ozone formation	1	73	122
Acidification	1	70	101
Freshwater eutrophication	1	110	272
Freshwater ecotoxicity	1	28	70

It is clearly beneficial if the pouch is used to collect and discard more than one cigarette filter, which should be communicated to buyers to raise their awareness and encourage them to use the “Ciggrid” pouch for three filters whenever possible.

References

The majority of the references is available without a subscription or fee from scientific journals:

Dobaradaran, S., Schmidt, T.C., Nabipour, I. et al. Cigarette butts abundance and association of mercury and lead along the Persian Gulf beach: an initial investigationEnviron Sci Pollut Res (2018) 25: 5465. https://doi.org/10.1007/s11356-017-0676-9; open access via author's copy http://eprints.bpums.ac.ir/6658/1/10.1007%40s11356-017-0676-9.pdf

Green, DS., Boots, B., Da Silva Carvalho, J., Starkey, T. Cigarette butts have adverse effects on initial growth of perennial ryegrass (gramineae: Lolium perenne L.) and white clover (leguminosae: Trifolium repens L.), (2019) Ecotoxicology and Environmental Safety, Volume 182, https://doi.org/10.1016/j.ecoenv.2019.109418 (not open access).

Lozano-Rivas, WA, Bonilla, R, Salinas, A, Florez, L, Campos, M, Manrique, A, Jaimes, Á. Quantification of Cigarette Butts Littered to the Streets and Sidewalks in Dance Clubs and Pub Areas in Bogota, Colombia. International Journal of Research Studies in Science, Engineering and Technology. (2015). Open access at http://ijrsset.org/pdfs/v2-i11/12.pdf

Moerman JW, Potts GE: Analysis of metals leached from smoked cigarette litter, Tobacco Control 2011;20:i30-i35

Novotny, TE, Slaughter, E.: Tobacco product waste, an environmental approach to reduce tobacco consumption. Curr Envir Health Rpt (2014) 1: 208. https://doi.org/10.1007/s40572-014-0016-x

Novotny TE, Hardin SN, Hovda LR, et al Tobacco and cigarette butt consumption in humans and animals; Tobacco Control 2011;20:i17-i20. Open access from https://tobaccocontrol.bmj.com/content/20/Suppl_1/i17

Rath JM, Rubenstein RA, Curry LE, Shank SE, Cartwright JC. Cigarette litter: smokers' attitudes and behaviors. Int J Environ Res Public Health. 2012;9(6):2189–2203. doi:10.3390/ijerph9062189

Slaughter E, Gersberg RM, Watanabe K, et al Toxicity of cigarette butts, and their chemical components, to marine and freshwater fish; Tobacco Control 2011;20:i25-i29.

Wright, S., Rowe, D., Reid, M, Thomas, K., Galloway, T. Bioaccumulation and biological effects of cigarette litter in marine worms. Scientific reports (2015). 5. 14119. 10.1038/srep14119.