

The butt in the drain

The unwanted side-effects of a smoke-free campus



Report of an inventory of butts on and around the campus of Wageningen University and Research

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The “Preventieakkoord” and the smoke-free campus

In November 2018 the Dutch Ministry of Volksgezondheid, Welzijn en Sport (VWS) published the Nationaal Preventieakkoord (www.nationaalpreventieakkoord.nl), aimed at a healthier society through stimulation of a healthier lifestyle. The Preventieakkoord has three pillars: 1) smoking, 2) overweight and obesity, 3) problematic use of alcohol. The Preventieakkoord was developed in cooperation with a broad coalition of societal partners and business companies.

With regard to smoking the aim is to have a smoke-free generation as of 2040. To reach this goal the habit of smoking needs to be de-normalised, and more and more public places and organisations will become smoke-free.

Following the Preventieakkoord an “Algemene Maatregel van Bestuur” became effective in August 2020, prohibiting smoking in not only the buildings of educational institutions, including universities, but also the terrain belonging to the institution, such as university campuses (<https://zoek.officielebekendmakingen.nl/stb-2020-218.html#d17e201>). That means that as of 1 August 2020 smoking on Dutch university campuses is prohibited by law.

Cigarette butts and the European guideline on Single-Use Plastics

On 5 June 2019 the European Parliament and the Council agreed upon a directive (2019/904) on the reduction of the impact of certain plastic products on the environment.

The Directive covers a.o. single-use plastics that are found the most on beaches in the European Union. With respect to cigarette butts the Directive states that *“tobacco product filters containing plastic are the second most found single-use plastic items on beaches in the Union”*. These filters come mainly from terrestrial sources. The Directive also states that *“Member States should promote a wide range of measures to reduce litter from post-consumption waste of tobacco products with filters containing plastic.”*

Where the Directive discusses the extended producer responsibility schemes for single-use plastics it specifically mentions that the requirements for producers of certain single-use plastic products to cover the costs of cleaning up litter, should include coverage *“of the costs of the setting up of specific infrastructure for collection of post-consumption waste of tobacco products, such as appropriate waste receptacles in common litter hotspots.”*

The unrecognised problem of the harmful effects of cigarette butts to the environment

During all sorts of clean-up activities worldwide, cigarette butts are the litter items most abundantly found. In contrast to many other litter items there is not much public awareness of the harmfulness to the environment of cigarette butts.

Cigarette butts are a relevant source of pollution with microplastic fibres

Every year we produce more plastic, with over 368 million tonnes worldwide in 2019 (PlasticsEurope, 2019), of which 4.8 to 12.2 million tonnes are assumed to be released into the marine environment each year (Jambeck et al., 2015).

One part of this plastic waste are cigarette butts: of the 6 trillion cigarettes smoked worldwide each year, surveys show that 55 - 75% are improperly disposed of in the environment (Rath et al., 2012; Rahman et al., 2020). This accounts to 0.3 - 0.8 million tonnes of plastic being released into the environment each year from smoked cigarette filters alone (Belzagui et al., 2021; Mackay et al., 2002)(The Tobacco Atlas - Judith Mackay, Michael Eriksen, Michael P. Eriksen, World Health Organization - Google Books, n.d.).

Most cigarette butts contain filters made of the modified biopolymer-based plastic cellulose acetate (CA), which does not degrade in the environment due to additives in the plastic, the physical and chemical structure of the filters, and the environmental conditions. In the environment, the temperatures are much lower than they are in most laboratory studies and the degradation processes are influenced by temperature. Additionally, if plastics get into the water, there are areas with lower oxygen levels, which also reduces the degradation (Yadav & Hakkarainen, 2021). Initial studies showed a weight loss of cigarettes in the environment of 20-30% after two years (Bonanomi et al., 2015, 2020) and estimate that cellulose acetate filters take 7.5 to 14 years to break down in compost and on soil surfaces (Joly & Coulis, 2018). Due to the high material persistence and the constant input, cigarette butts have therefore become one of the most common waste materials in the environment (Bonanomi et al., 2020; Novotny & Slaughter, 2014; Torkashvand et al., 2020).

Cigarette butts contain many toxins

Compared to other plastic items in the environment, such as food packaging or plastic bags, cigarette butts have a crucial factor of concern: due to their use, they are contaminated with over 4000 chemicals such as nicotine and heavy metals, which are known to be carcinogenic and toxic. According to Slaughter et al. (2011), just one cigarette butt per litre of water leaches enough toxins to kill half the freshwater or saltwater fish exposed to them.

Exposure to cigarette butts hampers the germination and growth of plants (Chibuike & Obiora, 2014), and plants are found to take up pollutants and accumulate them in their biomass. No more than 1 cigarette butt per square meter is able to raise nicotine levels in crop plants such as fruits, teas, spices and medicinal plants to more than 20 times the maximum residue level of 0.01 mg nicotine per kg d.w. that was set in the EU ban on nicotine-containing insecticides in 2009 (Green et al, 2019; Selmar et al., 2018).

Additionally, the leached chemicals seem to significantly affects bacterial communities in soil (Koroleva et al., 2021).

Cigarette butts can harm the environment at locations far from where they were disposed

Cigarette butts are often disposed of in the city, in car parks or on pedestrian paths. Part of them are picked up by street cleaners and disposed of properly, but another part ends up in the environment. Depending on their place of disposal, wind and surface runoff can transport the cigarette filters either into the sewage system or into the nearest water body.

When cigarette butts wash down into the sewage system, they end up in the wastewater treatment plant, where the pollutants in the filter might have negative effects on the microorganisms (Baran et al., 2020) and thus affect the effectiveness of the treatment plant.

In the aquatic environment, due to their porous structure and consequent low density, the filters can be transported over long distances until they become saturated with water and begin to sink (Dobaradaran et al., 2021; Engler, 2012).

Alternatively, the filters can be deposited on riverbanks and beaches during floods or storm surges.

Cigarette filters do not have an overall positive health effect

Filters were added to cigarettes in the 1950s, when it became increasingly clear that smoking causes lung cancer and other serious diseases (Novotny et al., 2009). They reduce the machine-measured tar and nicotine inhalation, which is why almost 99% of smokers use filtered cigarettes.

However, recent studies indicate that while filters reduce the amount of tar in the smoke, they also lead to compensatory smoking – deeper and more frequent inhalation – which dissolves the promised health benefits of filters. In fact, the changes in cigarette design (especially the ventilation on cigarette filters) has actually increased the rates of lung cancer since the 1950s (Song et al., 2017). The ventilation, which helps the filter to reduce the tar amount in the smoke, also leads to slower burning of the cigarette, which leads to more inhalations per cigarette and thus more inhalation of toxic chemicals (Novotny et al., 2009).

Incorrect disposal of cigarette butts is socially accepted behaviour with high economic costs

Surveys indicate that most smokers throw their cigarette butts in the environment because they are not aware of the negative consequences of their actions (Araújo & Costa, 2019; Rath et al., 2012).

Generally when people dispose of items outdoors, 17% do this improperly (by littering). For cigarette butts this is 65%. A strong predictor of littering cigarette butts is the presence and number of ash receptacles in the area, as is the distance to the nearest receptacle (Wesly Schultz et al., 2013).

The high prevalence of cigarette butt littering has huge economic consequences: the city of San Francisco has estimated that it costs between 0.5 and 6 million dollars annually to collect cigarette butts in streets and parks (Rath et al., 2012).

It would be better to start at the source, to close the plastic tap. Ideas to do so include:

- the development of biodegradable filters,
- to have monetary deposits on filters,
- to increase availability of butt receptacles and, most importantly,
- to increase public education.

While many other sources of plastic, such as abrasion from car tyres or lost shipping containers filled with plastic pellets, can hardly be avoided, behavioural change can reduce this important - and unnecessary - input of additional plastic into our environment.

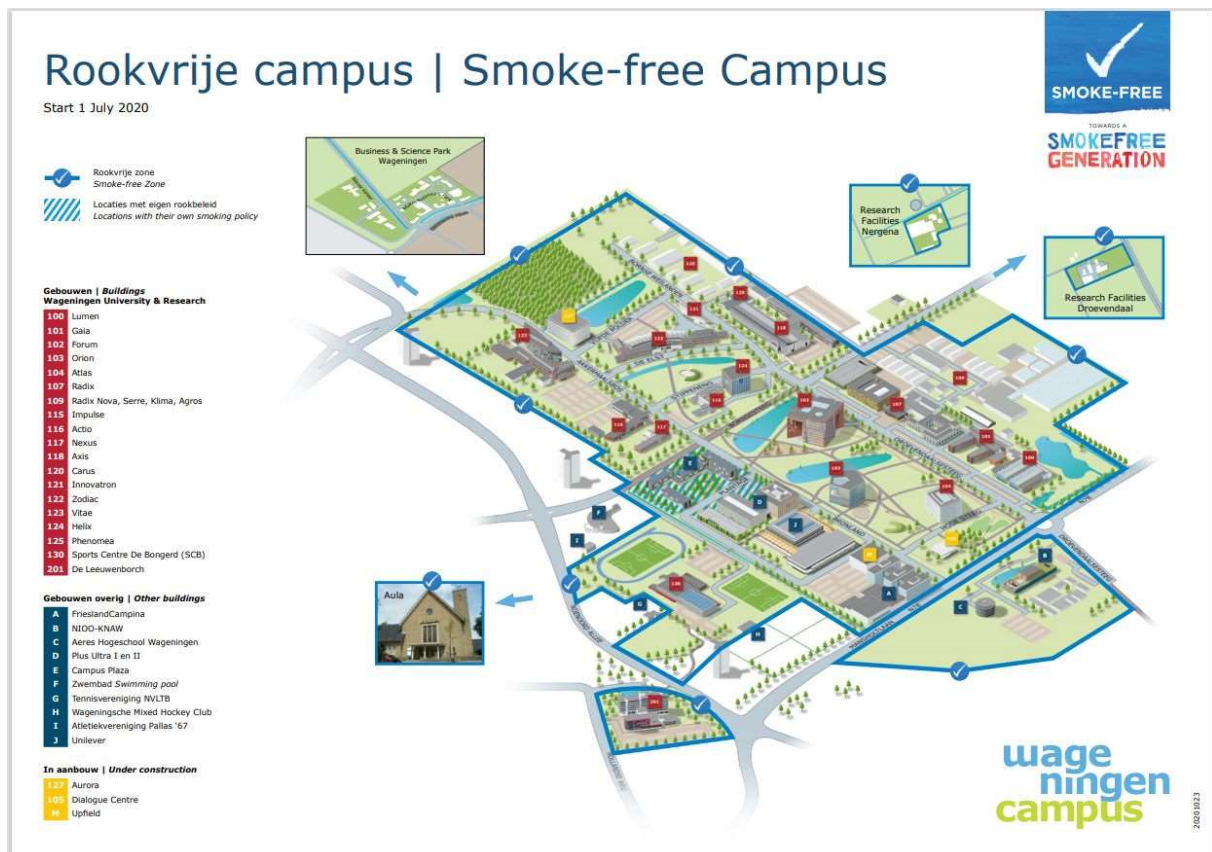
Possible measures to be taken by smokers would be:

- to carry a portable ashtray,
- to dispose of cigarette butts in the nearest waste bin, or
- to switch to unfiltered cigarettes to at least reduce the plastic input into the environment.

The situation on Wageningen campus in May 2021

Methodology

Since Wageningen campus is officially smoke-free since 1 July 2020, one would expect that the campus should be butt-free ten months after the start of the smoking ban, but it was observed that there were some spots close to the campus that were heavily littered with cigarette butts. Therefore **GREEN ESG**, the Green Impact team of ESG, initiated an inventory on the campus and on its borders.



The smoke-free area on Wageningen campus. To get the north on top, the picture should be turned about 45% counter-clockwise.

From 2-23 May cigarette butts were collected during 20 two-hour walks. The cigarette butts were photographed with the litter app Litterati. Litterati includes the location where the photo is taken, to be able to determine the distribution of the litter and to identify possible hotspots.

From 10 June – 2 July another round of butt picking was organised in the light of a national cigarette butt campaign. During this second round only cigarette butts with a plastic filter were collected. Although the butt picking was in this period not restricted to Wageningen campus, many earlier sites were visited again. The results of this second round gives an indication of the speed in which new cigarette butts accumulate on these spots. This also gives an indication of the time it took for the first round butts to accumulate and thus for the time it takes for a cigarette butt to disappear. Cigarette butts may disappear because of cleaning activities (as far as observed generally restricted to the larger roads and busy spots), washing away into the water, being covered by soil or leaves, or by disintegration into unrecognisable small parts.

At 4 July an additional butt picking walk was made on and next to the terrain of the Leeuwenborch.

Results

The results of the first round of butt collection can be found in the open data part of Litterati: <https://opendata.litterati.org/> using the selection criteria:

- **TAGS:** cigarettebutt, cigarettebutts, cigarette butt
- **COUNTRY:** Netherlands
- **ZIP CODE/CITY:** Wageningen
- **START DATE:** 2 May 2021 (first round), 10 June 2021 (second round), 4 July 2021 (Leeuwenborch)
- **END DATE:** 23 May 2021 (first round), 2 July 2021 (second round), 4 July 2021 (Leeuwenborch)

In the first round, 8591 cigarette butts were counted and collected.



Figure 1. 8591 cigarette butts collected on Wageningen campus from 2-23 May 2021







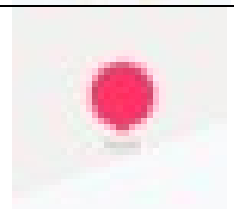
The number of cigarette butts found during the first round of cigarette butt collection, formed by the collected butts themselves.

Zooming in to some parts of the campus with Litterati

By zooming in, the distribution of the cigarette butts is visualised on different levels of detail in Litterati. A number of more detailed maps are shown on the next pages, in satellite view to make it easier to relate the spots to the real situation.

Zooming in shows that hotspots do exist, but that the littering with cigarette butts is not limited to the hotspots. Cigarette butts were found scattered all over the place.

Legenda

	Location with 1000-9999 cigarette butts found
	Location with 100-999 cigarette butts found
	Location with 10-99 cigarette butts found
	Location with 2-9 cigarette butts found
	Location with 1 single cigarette butt found

Overall view of cigarette butts on Wageningen Campus

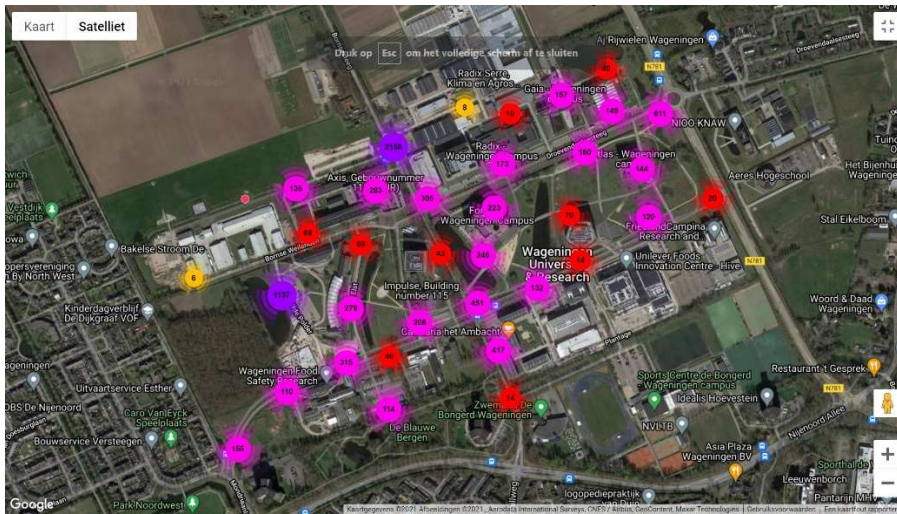


Figure 2a. Global overview of distribution of cigarette butts on Wageningen campus, first round

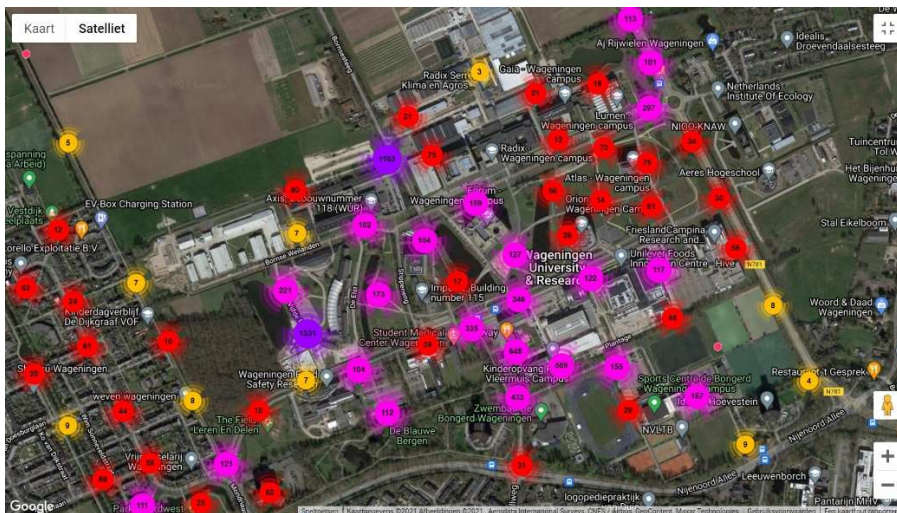


Figure 2b. Global overview of distribution of cigarette butts on Wageningen campus, second round

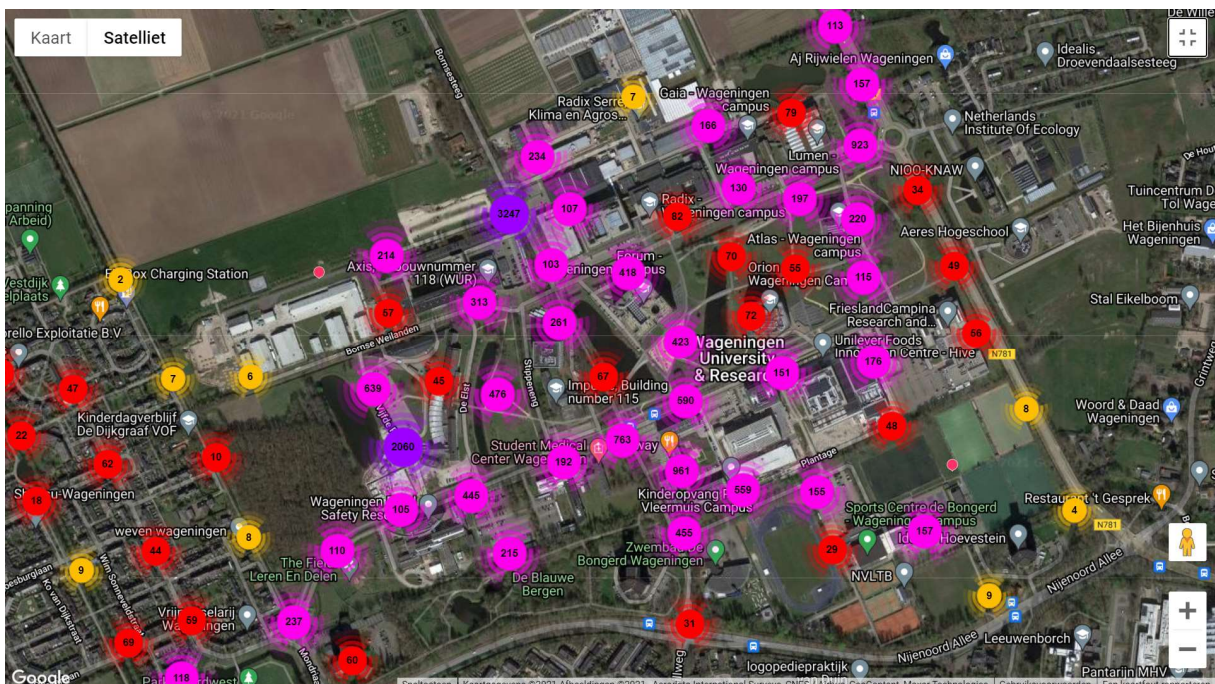


Figure 2c. Global overview of distribution of cigarette butts on Wageningen campus, accumulated

Pollution hotspots

The most important hotspot was found alongside the **Bornsesteeg**, which runs between the eastern and western part of the campus. The Bornsesteeg is not university property, but the smoking ban does also apply to this location. This fact may be unknown to many smokers who may think that it is legal for smokers to smoke here. Especially the northern part of the Bornsesteeg, between the university buildings Axis and Radix, was heavily littered.

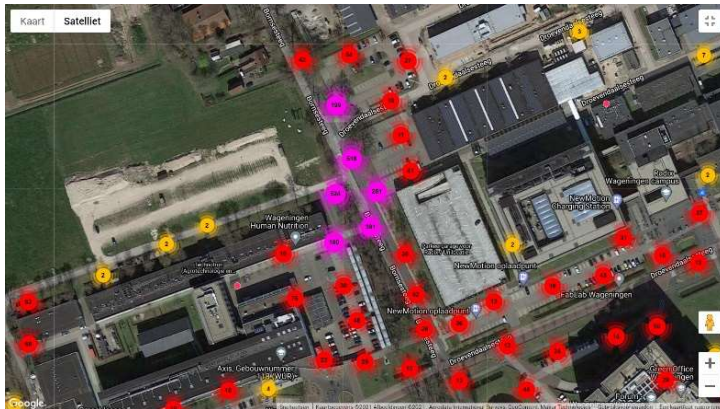


Figure 3a. Zooming in to the northern part of the Bornsesteeg bordering the campus, first round

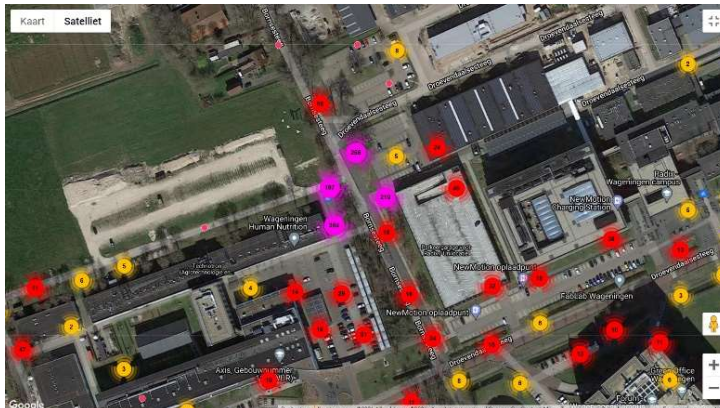


Figure 3b. Zooming in to the northern part of the Bornsesteeg bordering the campus, second round

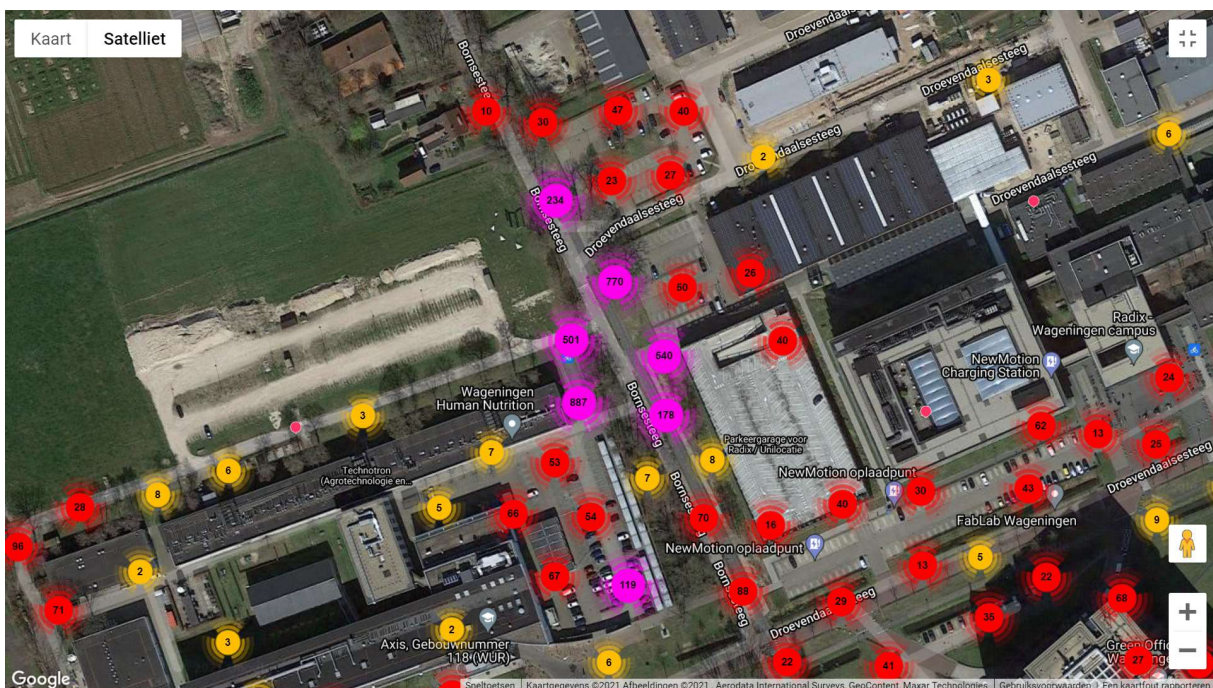


Figure 3c. Zooming in to the northern part of the Bornsesteeg bordering the campus, accumulated

A second hotspot was found on the parking lot at **Vijfde Polder**. This is most probably due to building activities in the near vicinity.

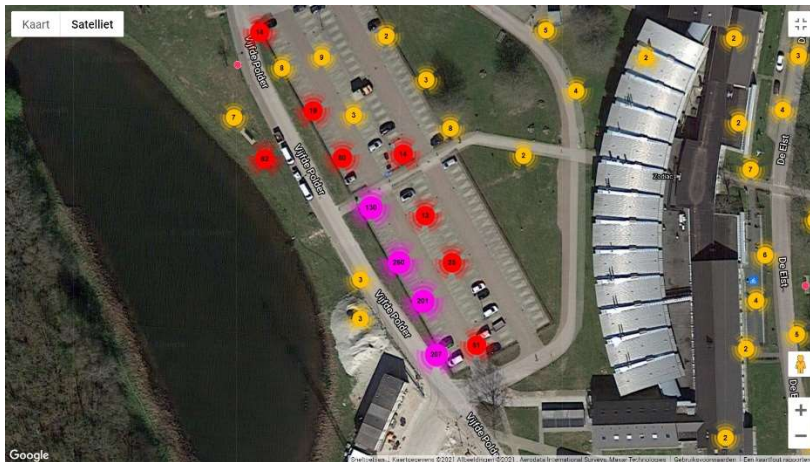


Figure 4a. Zooming in to the parking lot at Vijfde Polder, first round

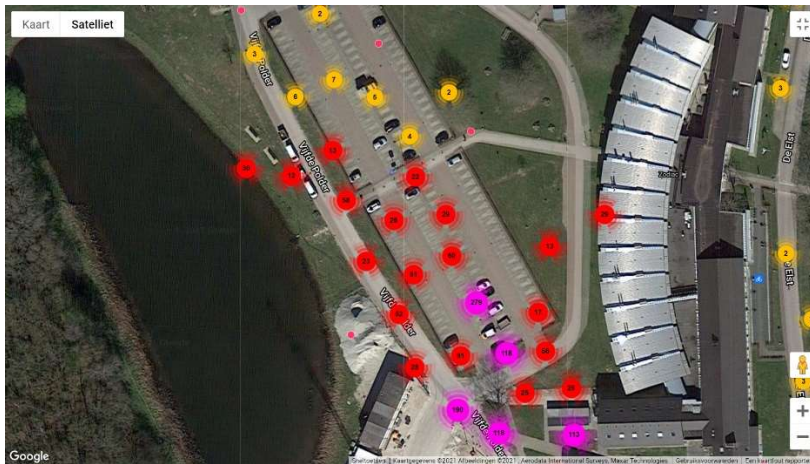


Figure 4b. Zooming in to the parking lot at Vijfde Polder, second round, including a hotspot at a bicycle shed and a small patch of grass that was overlooked during the first round. During the second round, Vijfde Polder and the parking lot was at some moment visible cleaned up by a wiping machine.

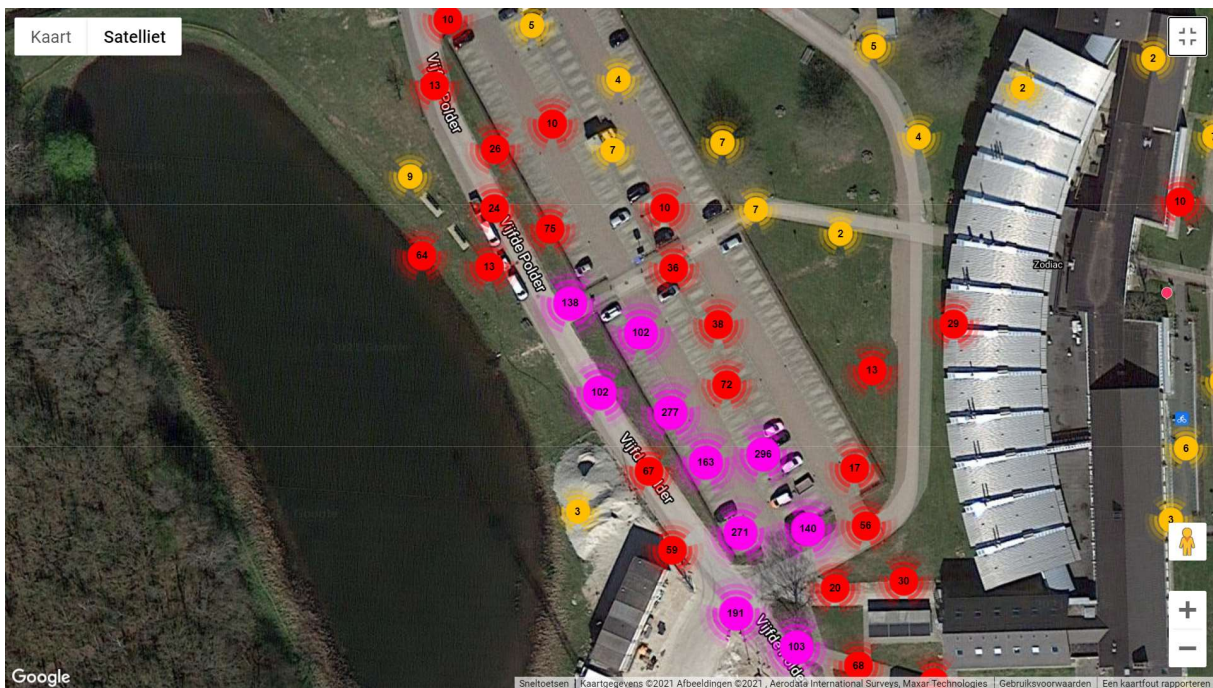


Figure 4c. Zooming in to the parking lot at Vijfde Polder, accumulated

The third hotspot was **Campus Plaza**. According to the map of the smoke-free campus, this part of the campus is a location with its own smoking policy, but there are no marks present at the location that indicate the smoking policy on the spot, or where the borders of the smoke-free campus are. At and near Campus Plaza there are shops, a bus stop, a bicycle shed and a parking lot. All these attract cigarette butts. The amount of cigarette butts in the neighbourhood of the shops was not as high as might be expected, obviously partly due to wiping of the square in front of the shops where much less cigarette butts were found than on the green parts bordering it. Another likely reason is the Covid-19 situation, that strongly limits the number of students on campus.

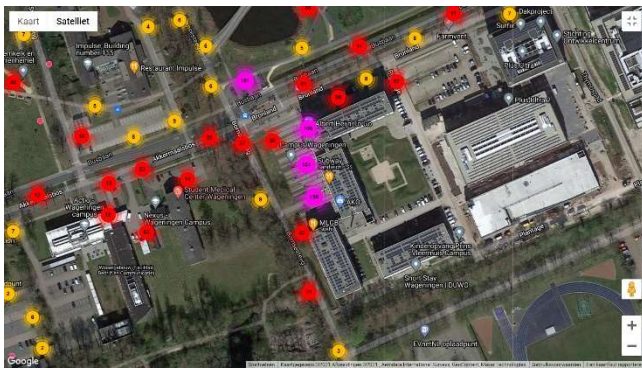


Figure 5a. Zooming in at Campus Plaza and its surroundings, first round

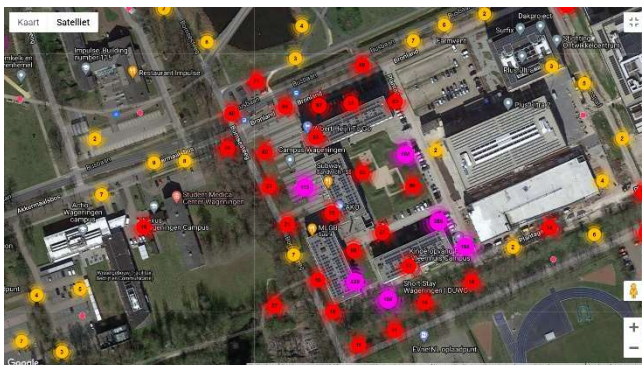


Figure 5b. Zooming in at Campus Plaza and its surroundings, second round, including the surroundings of Kinderopvang Vleermuis Campus and Short Stay Wageningen that were not included in the first round.

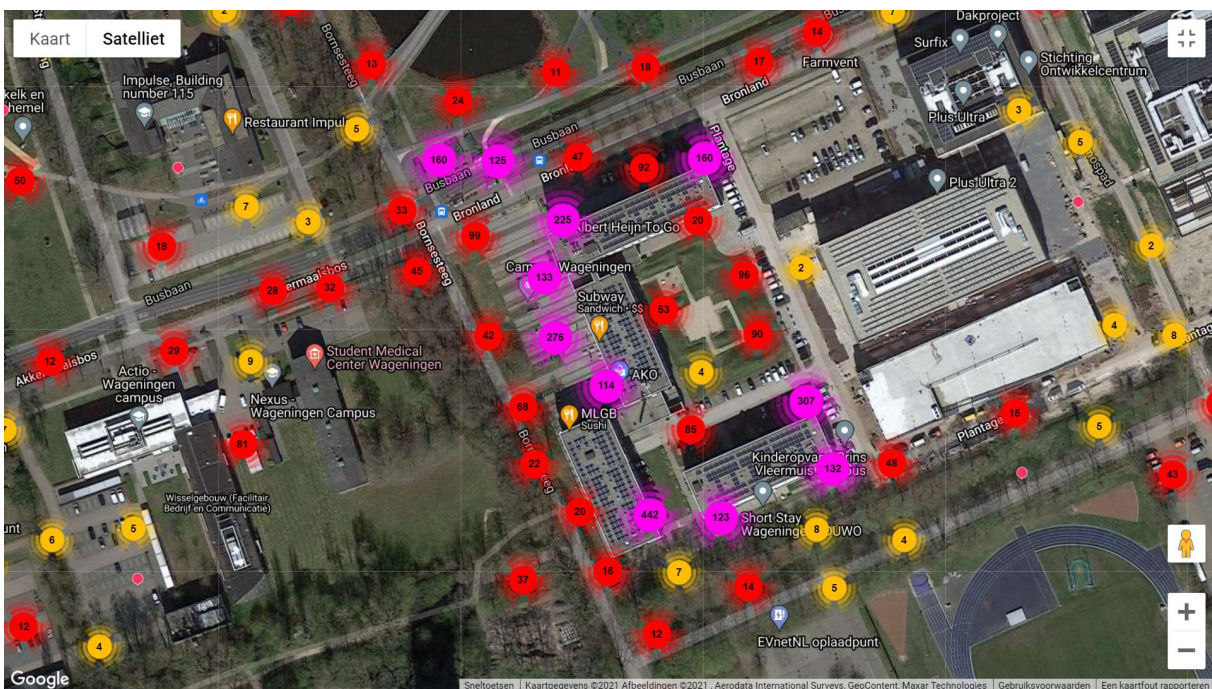


Figure 5c. Zooming in at Campus Plaza and its surroundings, accumulated

A fourth and smaller hotspot was found near the roundabout at the **Mansholtlaan**, at the borders of the campus. The unattractiveness of the location probably limits the amount of smokers here. More smokers at this location preferred the bicycle shed closer to the campus.

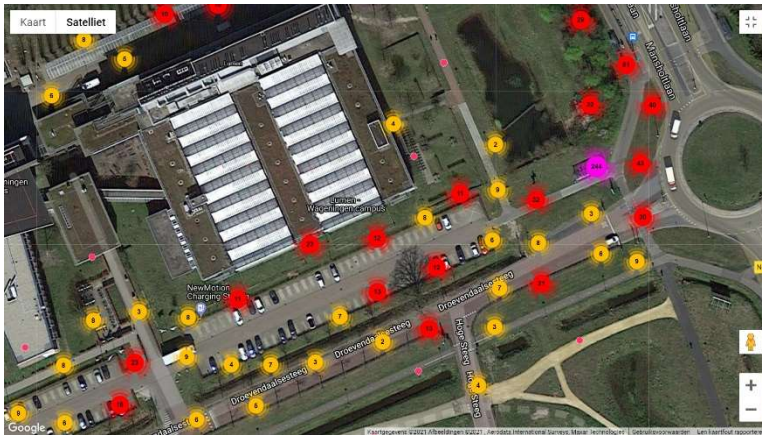


Figure 6a. Zooming in at the roundabout at the Mansholtlaan, and part of the Droevendaalsesteeg and a parking lot, first round

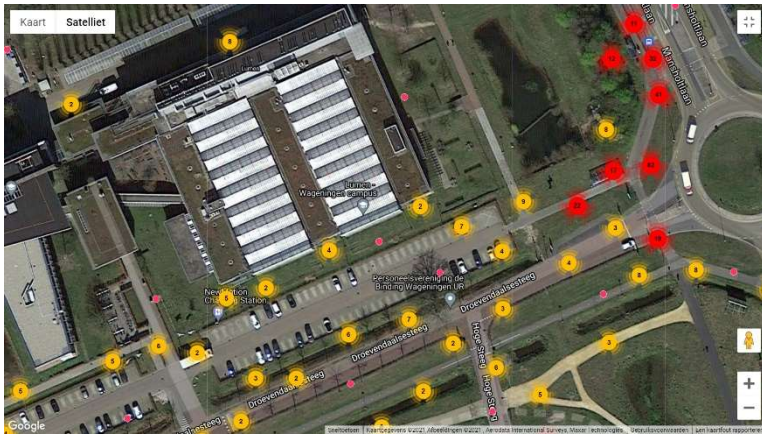


Figure 6b. Zooming in at the roundabout at the Mansholtlaan, and part of the Droevendaalsesteeg and a parking lot, second round

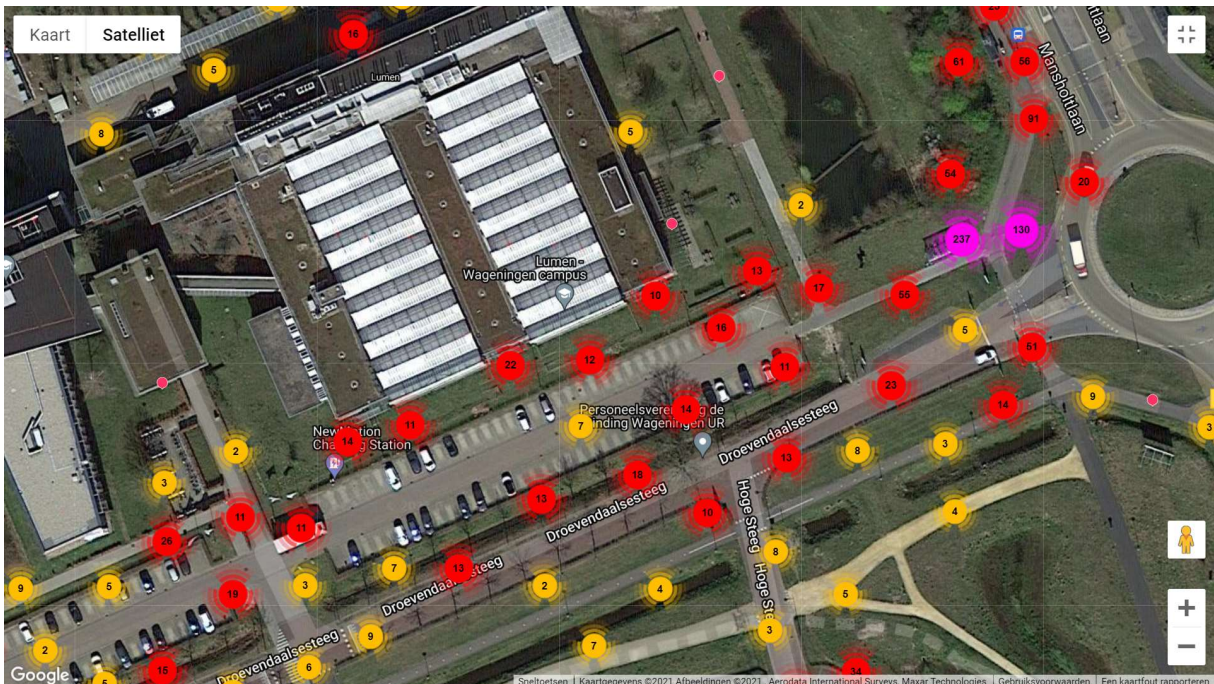
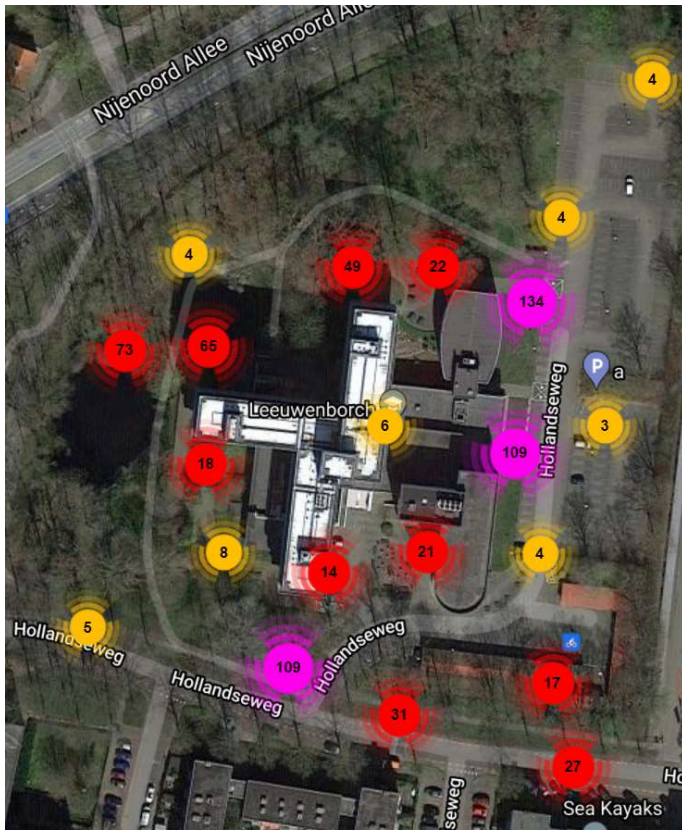


Figure 6c. Zooming in at the roundabout at the Mansholtlaan, and part of the Droevendaalsesteeg and a parking lot, accumulated



727 cigarette butts were found at the location **Leeuwenborch**, including the part of the Hollandseweg adjacent to the Leeuwenborch.

Also at this location cigarette butts were found at many places but there were a couple of hotspots especially at locations with pebbles or gravel.

Also near the entrance to the Leeuwenborch terrain there was a hotspot, where obviously part of the smokers go to smoke outside the smoke-free area.

At two locations on the eastern part of the terrain many balloons and nitrous oxide cartridges were found, indicating that youngsters use these spots for chilling outside office hours. This may also explain part of the cigarette butts found at these spots.

Figure 7. The Leeuwenborch and the part of the Hollandseweg adjacent to the Leeuwenborch terrain.



Figure 8. Part of the hotspot at the entrance of the Leeuwenborch

Next to the hotspots, many cigarette butts were found on parking lots, sometimes at bicycle sheds, and also on the roads and their verges.

The surroundings of the educational building Orion was surprisingly (though not completely) clean. This may be at least partly due to the many months of off-campus education as a result of the Covid-19 measures. Next to that it is also possible that the company DonkerGroen clears this area better than others.

A location which had far less than average cigarette butt littering was sport complex The Bongerd. This part of the campus was only visited during the second round.

“Alternative ashtrays”

Since the introduction of the smoking ban facilities for smokers to get rid of their cigarette butts correctly, such as ash receptacles, were removed from campus, in line with the government regulations and the intention of WUR to de-normalise smoking.

It was observed that part of the smokers seemed to look for alternative places to get rid of their cigarette butts neatly. During one of the campus walks a smoker (on a parking lot) literally said: “I always throw it [the cigarette butt] in the rainwater drain. Then it is gone.” She was completely unaware of the toxicity of cigarette butts and their contribution to the microplastic problem. After being informed about this, she was very much willing to look at alternatives.

Below some examples of spots that seem to function as alternative ashtrays.



Alternative ashtray 1: Cigarette butts in an abandoned pole.



Alternative ashtray 2: Cigarette butts on sheltered sandy spot right next to Axis (two weeks after first clean-up)



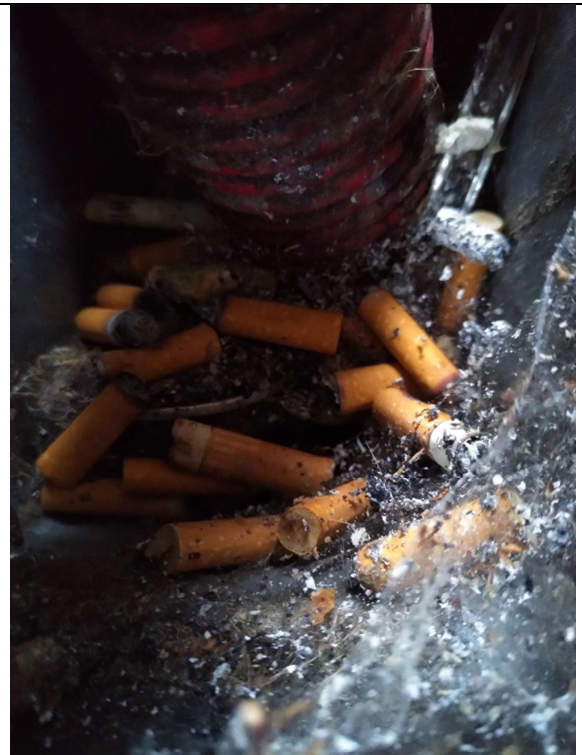
Alternative ashtray 3: cigarette butts in fire place



Alternative ashtray 4: for insiders (see 4a and 4b)



Alternative ashtray 4a: detail of inside 4



Alternative ashtray 4b: other detail of inside 4



Alternative ashtray 5a: cigarette butts on lid of rainwater drain



Alternative ashtray 5b: cigarette butts in the (same) rainwater drain

Conclusions

Despite the smoking ban on Wageningen Campus, there are still large amounts of cigarette butts to be found on the campus terrain as well as to its close surroundings, especially the Bornsesteeg and in the vicinity of on-campus building sites. This was even the case in a period in which much less employees and students were physically present on campus due to the Covid-19 situation and with less than optimal weather conditions for being out of doors (a quite rainy and cold spring).

The distribution pattern of cigarette butt litter suggests that smokers are aware of the smoking ban and go to the area bordering the campus to smoke or to hidden places on campus (most commonly parking lots).

No comparison can be made with the situation before the smoking ban, as there are no prior data known to the Green Impact team, but it is likely to assume that the on-campus smoking ban and the removal of ash receptacles leads to more littering behaviour and to littering at different locations than before the ban.

Although the second round of cigarette butt inventory did not cover the exact same locations, the rough estimation is that about 4000 cigarette butts were found on locations that were cleaned up a month earlier.

The situation per location differs a lot. This may be due to differences in butt littering behaviour, induced by for instance different weather conditions, but also to amount of cleaning up activities and the persistence of cigarette butts at the specific location. At sheltered locations, cigarette butts are likely to be visibly present for a longer period, so (incidental) butt littering at these locations may be visible for a long time. At more exposed locations cigarette butts disintegrate more rapidly, get covered or are by wind or water transported to other locations.

The added value of the second round of butt picking is therefore that it better identifies the hotspots where cigarette butts are regularly littered and in which amounts.

Health issue meets environmental issue

The issue of cigarette butt littering on campuses is a complex one, as the measures taken for health reasons (smoking ban, not facilitating smokers) counteract the measures that would be desirable in the light of the environmental issue (facilitate proper disposal of cigarette butts by smokers).

Cigarette butts are harmful to the environment. On land plants can take up toxins from the cigarette butts, even if only one cigarette butt per m^2 is present. The cigarette butts can affect the growth and vitality of the plants themselves and the plants can function as a means of transportation of the toxins to other organisms such as insects, that are for instance harmed by nicotine. Toxins from cigarette butts and the microfibres in the cigarette butts can leak into the water (drainage) system, where they can have adverse effects on water life. Part of the microfibers in cigarette butts is likely to end up in seas and oceans and significantly contribute to the worldwide plastic soup problem.

The EU Directive on single-use plastics demands that Member States should promote measures to prevent littering of single-use plastics into the environment. The Directive mentions a specific infrastructure for the collection cigarette butts, such as appropriate waste (ash) receptacles in common litter hotspots.

One can argue that there may be a tension between the Preventieakkoord and the EU Directive, as the removal of ash receptacles and the lack of alternatives offered to smokers to get rid of their cigarette butts may lead to more littering as long as the smoke-free generation is not a fact.

The existence of litter hotspot of cigarette butts on and close to campus was proved by the inventory described in this report.

The Algemene Maatregel van Bestuur (amvb) on smoke-free educational terrains explicitly states that the smoking ban is only applicable to buildings or institutes that are being used for educational purposes. This implies that it deals with locations where education is given and with locations offering facilities to be able to give education. These are terrains around class rooms, canteens where pupils or students come, buildings where administrative services for students are located, auditoria, laboratories with educational purposes, university libraries, examination locations, buildings where study advisors, student deans or student psychologists are located or sport facilities for pupils or students that can be used for educational purposes. In short, it concerns terrains belonging to buildings where pupils or students come because they serve education or offer facilities to facilitate education.

The challenge for university campuses is to find a way to comply to the intention of the Preventieakkoord (working towards an ideal health situation) while also taking measures to diminish the pressure on the environment by cigarette butt littering and thus also comply to the intention of the EU Directive on single-use plastics (working from today's reality).

Recommendations

The harmful effects of cigarette butts are largely unknown to the public, including employees and students of Wageningen University and Research.

To diminish the problem of cigarette butt littering it is necessary to raise awareness among smokers about this problem, and to offer them the opportunity to change their behaviour and get rid of their cigarette butts correctly.

Considering the scattered distribution of cigarette butts on and around the campus, it seems not feasible or highly expensive to have the cigarette butts removed by for instance DonkerGroen. Roughly estimated it might cost about €0,05 per cigarette butt to have it removed.

Apart from that an awareness campaign has the advantage of impact to society, as smokers take this knowledge and altered habits with them into their off-campus life.

The Green Impact team advises WUR to:

- Look at best practices at other Dutch universities:
 - The Erasmus University Rotterdam has marked the borders of the campus with blue lines on the ground next to the “Smoke free campus” sign. To prevent littering with cigarette butts off-campus EUR has placed ash receptacles outside the blue lines. See also <https://www.eur.nl/rookvrije-campus>.
 - Twente University carried out an inquiry about the support among smokers for a smoke-free campus and gave some recommendations, such as attention for the fact that smokers need longer breaks if they have to smoke further away from their work place, (routes to) alternative locations to smoke, the suggestion to consider a few on-campus smoking places. See also <https://www.utwente.nl/campus/gebouwen-huisregels/rookbeleid/resultaten-rookvrije-campus-onderzoeken-november-2019.pdf>, pages 9-11
- Create a project team with employees and students, including smokers, to deal with the issues that arise in the light of the smoke-free campus.
- Mark the borders of the smoke-free campus more clearly than is now the case, for instance by blue lines on the road, including the borders with the area with its own smoking policy: Campus Plaza. Make clear what the smoking policy on Campus Plaza is.
- Start an awareness campaign about the harmful effects of cigarette butts on the environment.
- Draw attention to the facts that there are portable ashtrays, and sell them on campus (see for instance <https://www.coastbusters.nl/product/peukenpocket/>).
- Place (temporary) ash receptacles at locations with building activities, discuss the smoking issue with the builders and pay extra attention to maintaining the prevention of littering at these locations.
- Consider the option to place some smoke shelters with benches and ash receptacles on spots that are at a distance from educational building or services and from the locations where students have their breaks.
- For questions and support, contact the Trimbos Institute, <https://www.rookvrijeschoolterrein.nl/contact-en-ondersteuning>

References:

- Araújo, M. C. B., & Costa, M. F. (2019). A critical review of the issue of cigarette butt pollution in coastal environments. In *Environmental Research* (Vol. 172, pp. 137–149). Academic Press Inc. <https://doi.org/10.1016/j.envres.2019.02.005>
- Baran, W., Madej-Knysak, D., Sobczak, A., & Adamek, E. (2020). The influence of waste from electronic cigarettes, conventional cigarettes and heat-not-burn tobacco products on microorganisms. *Journal of Hazardous Materials*, 385, 121591. <https://doi.org/10.1016/j.jhazmat.2019.121591>
- Belzagui, F., Buscio, V., Gutiérrez-Bouzán, C., & Vilaseca, M. (2021). Cigarette butts as a microfiber source with a microplastic level of concern. *Science of the Total Environment*, 762, 144165. <https://doi.org/10.1016/j.scitotenv.2020.144165>
- Bonanomi, G., Incerti, G., Cesarano, G., Gaglione, S. A., & Lanzotti, V. (2015). Cigarette Butt Decomposition and Associated Chemical Changes Assessed by ¹³C CP/MAS NMR. *PLOS ONE*, 10(1), e0117393. <https://doi.org/10.1371/journal.pone.0117393>
- Bonanomi, G., Maisto, G., De Marco, A., Cesarano, G., Zotti, M., Mazzei, P., Libralato, G., Staropoli, A., Siciliano, A., De Filippis, F., La Stora, A., Piccolo, A., Vinale, F., Crasto, A., Guida, M., Ercolini, D., & Incerti, G. (2020). The fate of cigarette butts in different environments: Decay rate, chemical changes and ecotoxicity revealed by a 5-years decomposition experiment. *Environmental Pollution*, 261, 114108. <https://doi.org/10.1016/j.envpol.2020.114108>
- Chibuikwe, G. U., & Obiora, S. C. (2014). Heavy metal polluted soils: Effect on plants and bioremediation methods. In *Applied and Environmental Soil Science* (Vol. 2014). Hindawi Publishing Corporation. <https://doi.org/10.1155/2014/752708>
- Dobaradaran, S., Soleimani, F., Akhbarizadeh, R., Schmidt, T. C., Marzban, M., & BasirianJahromi, R. (2021). Environmental fate of cigarette butts and their toxicity in aquatic organisms: A comprehensive systematic review. In *Environmental Research* (Vol. 195, p. 110881). Academic Press Inc. <https://doi.org/10.1016/j.envres.2021.110881>
- Engler, R. E. (2012). The complex interaction between marine debris and toxic chemicals in the ocean. In *Environmental Science and Technology* (Vol. 46, Issue 22, pp. 12302–12315). American Chemical Society. <https://doi.org/10.1021/es3027105>
- Green, D.S., Boots, B. & Da Silva Carvalho, J. & Starkey, T. (2019). Cigarette butts have adverse effects on initial growth of perennial ryegrass (gramineae: *Lolium perenne* L.) and white clover (leguminosae: *Trifolium repens* L.). *Ecotoxicology and Environmental Safety* 182. <http://dx.doi.org/10.1016/j.ecoenv.2019.109418>
- Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., Narayan, R., & Law, K. L. (2015). Marine pollution. Plastic waste inputs from land into the ocean. *Science* (New York, N.Y.), 347(6223), 768–771. <https://doi.org/10.1126/science.1260352>
- Joly, F. X., & Coulis, M. (2018). Comparison of cellulose vs. plastic cigarette filter decomposition under distinct disposal environments. *Waste Management*, 72, 349–353. <https://doi.org/10.1016/j.wasman.2017.11.023>
- Koroleva, E., Mqulwa, A. Z., Norris-Jones, S., Reed, S., Tambe, Z., Visagie, A., & Jacobs, K. (2021). Impact of cigarette butts on bacterial community structure in soil. *Environmental Science and Pollution Research*. <https://doi.org/10.1007/s11356-021-13152-w>
- Novotny, T. E., Lum, K., Smith, E., Wang, V., & Barnes, R. (2009). Cigarettes butts and the case for an environmental policy on hazardous cigarette waste. *International Journal of Environmental Research and Public Health*, 6(5), 1691–1705. <https://doi.org/10.3390/ijerph6051691>

- Novotny, T. E., & Slaughter, E. (2014). Tobacco Product Waste: An Environmental Approach to Reduce Tobacco Consumption. *Current Environmental Health Reports*, 1, 208–216. <https://doi.org/10.1007/s40572-014-0016-x>
- PlasticsEurope. (2019). *Plastics - the Facts 2019: An analysis of European plastics production, demand and waste data*. https://www.plasticseurope.org/application/files/1115/7236/4388/FINAL_web_version_Plastics_the_facts2019_14102019.pdf
- Rahman, M. T., Mohajerani, A., & Giustozzi, F. (2020). Possible recycling of cigarette butts as fiber modifier in bitumen for asphalt concrete. *Materials*, 13(3), 734.
- Rath, J. M., Rubenstein, R. A., Curry, L. E., Shank, S. E., & Cartwright, J. C. (2012). Cigarette Litter: Smokers' Attitudes and Behaviors. *International Journal of Environmental Research and Public Health*, 9(6), 2189–2203. <https://doi.org/10.3390/ijerph9062189>
- Selmar, D., Radwan, A., Abdalla, N., Hussein, T., Wittke, C., El-Henawy, A., Alshaal, T., Amer, M., Kleinwächter, M., Nowak, M. & El-Ramady, H. (2018). Uptake of nicotine from discarded cigarette butts – A so far unconsidered path of contamination of plant-derived commodities. *Environmental Pollution* (Vol. 238, 972-976). <https://doi.org/10.1016/j.envpol.2018.01.113>
- Song, M. A., Benowitz, N. L., Berman, M., Brasky, T. M., Cummings, K. M., Hatsukami, D. K., Marian, C., O'Connor, R., Rees, V. W., Woroszylo, C., & Shields, P. G. (2017). Cigarette Filter Ventilation and its Relationship to Increasing Rates of Lung Adenocarcinoma. In *Journal of the National Cancer Institute* (Vol. 109, Issue 12). Oxford University Press. <https://doi.org/10.1093/jnci/djx075>
- The Tobacco Atlas - Judith Mackay, Michael Eriksen, Michael P. Eriksen, World Health Organization - Google Books. (n.d.). Retrieved June 17, 2021, from https://books.google.nl/books?hl=de&lr=&id=BqNlWtkoYOoC&oi=fnd&pg=PA9&ots=T3VZAr_srkR&sig=RnRg4EFmZ25bPfmM84SdixCuV5w&redir_esc=y#v=onepage&q&f=false
- Torkashvand, J., Farzadkia, M., Sobhi, H. R., & Esrafil, A. (2020). Littered cigarette butt as a well-known hazardous waste: A comprehensive systematic review. In *Journal of Hazardous Materials* (Vol. 383, p. 121242). Elsevier B.V. <https://doi.org/10.1016/j.jhazmat.2019.121242>
- Wesley Schultz, P., Bator, R.J., Brown Large, L., Bruni, C.M., Tabanico, J.J. (2013) Littering in Context: Personal and Environmental Predictors of Littering Behavior. In *Environment and Behavior* (Vol. 45(I)p. 35-59). <https://doi.org/10.1177/0013916511412179>
- Yadav, N., & Hakkarainen, M. (2021). Degradable or not? Cellulose acetate as a model for complicated interplay between structure, environment and degradation. In *Chemosphere* (Vol. 265, p. 128731). Elsevier Ltd. <https://doi.org/10.1016/j.chemosphere.2020.128731>