Mapping of cigarette butts clean-up in Norway

Development of a method to quantify a baseline

Philip Morris International and Tobakkindustriens Felleskontor

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NORWASTE

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The tobacco industry in Norway has engaged Norwaste to quantify the amount of cigarette butt litter (CBL) cleaned up at national level in Norway. The purpose of the project is to establish a baseline for the number of CBL that is cleaned up annually by public authorities. To map the total picture of litter being cleaned up, the preferred method has been to identify the major clean-up fluxes/CBL fluxes that take place by or on behalf of the authorities. Examples of CBL fluxes are urban street sweeping waste, manually cleaned municipal litter, and grit litter from wastewater systems. The CBL fluxes mapped in the project are assumed to be the seven most significant clean-up fluxes. The fluxes and estimates based on mapping and projected national figures, are the following in number and wet weight:

1. Urban street sweeping waste, 40 mill. CBL/year, corresponding to 56,000 kg.
2. Manually cleaned municipal litter, 2.1 mill. CBL/year, corresponding to 1,100 kg.
3. Manual clean-up litter from municipal roads, 2.0 mill. CBL/year, corresponding to 100 kg.
4. Street sweeping gravel from municipal roads, 6.6 mill. CBL/year, corresponding to 5,900 kg.
5. Snow removal from municipal roads, 62,000 CBL/year, corresponding to 60 kg.
6. Stormwater litter collected from urban rivers, 5,000 CBL/year, corresponding to 5 kg.
7. Grit litter from wastewater systems, 45.8 mill. CBL/year, corresponding to 41,200 kg.

The total estimate of removed cigarette butts is in the level of 100 million CBL per year, corresponding to a wet weight of 100 tonnes and 20 dry tonnes. The presented methods are with some modifications shown to be feasible to make predictions about cigarette butts litter removed from the environment by or on behalf of public authorities. The national estimates are based on mapping of a few areas in Norway. The infrastructure, equipment and routines for litter clean-up vary and extrapolation to national level increases the margin of error. Although it is considered in the estimates this may lead to wrong conclusions. The project is a first of its kind, and despite uncertainties regarding estimates and margin of error, it has provided a good basis for knowledge about the amounts of CBL cleaned up and methods for mapping this.

Keywords:	Cigarette butts, CBL, litter, waste	**Geography:**	Norway
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1. Introduction

The tobacco industry in Norway, represented by Philip Morris International and Tobakkindustriens felleskontor, has engaged Norwaste to quantify the amount of cigarette butt litter (CBL) cleaned up at national level in Norway. The purpose of the project is to establish a baseline for the amount of CBL that is cleaned up annually by public authorities. Traditional litter studies often aim at quantifying the amount or level of litter within certain areas and timeframes. This may give a relevant picture of the level of litter but gives little relevant answer about the amount or level of litter nor the amount of litter being cleaned up.

To map the total picture of litter being cleaned up, the preferred method has been to identify the major clean-up fluxes that take place by or on behalf of the authorities. Examples of clean-up fluxes are urban street sweeping waste, manually cleaned municipal litter and litter from wastewater systems. This approach has not been conducted in Norway before and no references have been found in the literature. Therefore, the methodology was developed as part of the project and it was identified that the project should include a first step validation of the used methodology.

1.1. Background and statistics

- According to import figures from Statistics Norway[1] 1,581,319 kg cigarettes were imported to Norway in 2019 and 2,151,707 kg in 2020.
- One cigarette weighs approximately 1 gram, and packaging is not included in the import figures.
- This corresponds to a consumption of 1,581 million cigarettes in 2019 and 2,152 million cigarettes in 2020.
- Of Norwegians' total consumption of cigarettes, figures from the National Institute of Public Health indicate that about 40 % come from unregistered sources[2].

The results from a survey done by the tobacco industry shows that the percentage of non-domestic cigarettes decreased significantly from 38,6 % to 23 % in 2020, due to travel restrictions with Covid-19[3]. The reduction in non-domestic cigarettes is in line with the increase in import in 2020.

The total number of cigarettes, including non-domestics based on the percentage of the study, will correspond to a total of, se also table 1:

- 2,875 million cigarettes in 2019
- 2,794 million cigarettes in 2020

In most littering studies, the number of littering is normally used as a unit, while weight is used in waste statistics. In this study the littering is presented in both number and weight.

[1] https://www.ssb.no/statbank/table/08801
[2] https://www.regjeringen.no/no/dokumenter/prop.-1-ls-20212022/id2875345/?q=uregistrerte&ch=2#match_0
[3] https://braekhus.no/app/uploads/2021/11/EPS-Norway-2020-Q3-Final-Report1.pdf

Table 1: Summary of sold cigarettes in Norway (based on import figures) and estimates of the number of cigarettes in circulation including purchase from non-domestic.

	2019		2020	
	Import	**incl. non-domestic**	**Import**	**incl. non-domestic**
Weight (kg)	1,581,319	2,875,125	2,151,707	2,794,425
Number of cigarettes in millions	1,581	2,875	2,152	2,794

Cigarette filters are made of cellulose acetate, a bioplastic, introduced in the 1950s to decrease the toxic chemicals inhaled by smokers. According to UN Environment Programme filters take between 1 month and 15 years to biodegrade depending on the receiving environment[4].

1.2. Single-use plastic directive (SUP-directive)

The European Union (EU) directive on the reduction of the impact of certain plastic products on the environment, commonly referred to as single-use plastic directive, aims to prevent and reduce the impact of certain plastic products on the environment, in particular the aquatic environment, and on human health[5]. Furthermore, the objective of the directive is to promote the transition towards a circular economy, sustainable business models, products and materials.

The SUP-directive applies to several single-use items most commonly found on beaches in the Union, including tobacco products with filters, as well as fishing gear containing plastic and products made from oxo-degradable plastic.

Article 8 states that Member States shall ensure that extended producer responsibility (EPR) schemes for certain single-use plastic products are established. For cigarette filters, this means that producers must:

- cover waste collection costs for the products disposed of in public collection systems, including infrastructure and operations, and subsequent transportation and treatment of the waste; and
- the cost of cleaning up litter as a result of these products and the subsequent transport and treatment of the waste.

The costs may include the setting up of specific infrastructure for the waste collection for those products, such as appropriate waste receptacles in common litter hotspots. Furthermore, the directive states that:

"The costs to be covered (...) shall not exceed the costs that are necessary to provide the services referred to therein in a cost-efficient way and shall be established in a transparent way between the actors concerned. The costs of cleaning up litter shall be limited to activities undertaken by public authorities or on their behalf.

[4] -Valuing plastic: the business case for measuring, managing and disclosing plastic use in the consumer goods industry-2014Valuing plasticsF.pdf (unep.org)
[5] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32019L0904&from=EN#d1e1311-1-1

The calculation methodology shall be developed in a way that allows for the costs of cleaning up litter to be established in a proportionate way."

The regulations from the SUP-directive were adopted by the EEA Committee September 2021[6].

1.3. Regulation on littering in Norway

Littering is waste going astray and can be both detrimental to the environment and a source of pollution. The Pollution Control Act in Norway stipulates the polluter pays principle. Furthermore, it states that littering is prohibited, and that the polluter must ensure the necessary clean-up[7]. The municipality is the pollution authority for littering according to the Pollution Control Act.

To prevent littering, various stakeholders are responsible for setting up and emptying waste containers. Paragraph 35 in the Pollution Control Act states that the municipality shall ensure the installation and emptying of waste containers at exit points and other heavily visited public places where it must be assumed that waste will be misplaced. In connection with emptying, a reasonable clean-up must be carried out in the area.

Paragraph 36 states that the public roads authorities shall ensure that waste containers are set up and emptied along public roads outside densely populated areas where, from experience, road users leave waste behind. In connection with emptying, the road authority shall carry out the necessary clean-up within the road's property.

1.4. Mapping of CBL-fluxes

Most methods for mapping litter are based on mapping of what is found in limited urban environments or natural areas. This gives a snapshot of the litter but does not say anything about the amount of litter over a period or a larger area, nor on the amount of litter being cleaned up.

In the literature some other approaches used to quantify litter of specific products have been identified. One approach is to make qualified estimates of shares that end up as litter and multiply with the number of items put on market. Another approach used for CBL has been to survey the consumption and littering habits in selected areas by observational studies. These studies are based on a top-down structure and can be somewhat theoretical. In this project, the approach has been a bottom-up structure based on waste that has been cleaned up, i.e., a post-cleanup analysis. According to the SUP directive the mapping is limited to the fluxes that are cleaned up by or on behalf of the public sector.

An essential part of establishing the CBL baseline has been to identify and map litter fluxes of CBL. To identify litter fluxes most likely to contain CBL, mapping and analyses have been carried out in various areas. There has also been an assessment of the measure points of litter fluxes, the methodology of mapping, and how the results can be extrapolated up to a national level. The identified litter fluxes are listed up in table 2. The table also shows which authorities are responsible for clean-up.

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[6] https://www.europalov.no/rettsakt/reduksjon-av-plast-i-miljoet/id-25789#Behandlendeorgan
[7] https://lovdata.no/dokument/NL/lov/1981-03-13-6

Table 2: Overview of examples regarding different litter fluxes and different factors to describe the methodology, and methodology to extrapolate data.

Litter fluxes	Responsibility of cleaning*	Measure points of litter flux	Methodology for mapping and basis of data	Methodology for extrapolating data
Litter in cities and places (urban areas)				
In parks, shopping streets, hubs, recreation areas, streets	PA	• Clean-up services (collected waste) • Street waste (from sweepers) • Clean-up under municipal auspices (collected waste / rubbish) • Litter around waste containers (collected during emptying) • Own surveys	Representative sampling for identification and counting	Related to activity / inhabitants / infrastructure, area / time period
Bus/tram/metro stop	PA (CO)			
Private land (apartment building owners, shops, festivals etc.)	LO/CO			
Recreation areas / place of departure	PA	• Clean-up services • Clean-up under municipal auspices • Litter around waste containers • Cleaning team - collected rubbish • Own surveys		
Litter along traffic venues (roads etc.)				
Along municipal roads	PA	• Clean-up team • Sweeping masses • Stormwater system • Snow	Waste characterisation of litter/separated in plant and counted	Relate to the number of inhabitants and area / road load
Ditches along county-, national and European roads	PA	• Clean-up team • Own surveys • Stormwater system (litter in urban surface waters/urban stormwater)	Waste characterisation of clean-up litter. Separated in wastewater plants or rivers and analyses	Related to traffic traveling in km on roads / or part of a road
Along train lines	LO/CO	• Own surveys		
Tourist destinations	PA	• Clean-up team • Own surveys		Related to activity / visitors / area
Other point sources for litter				
Industry	LO/CO	• Own surveys	Sampling and waste characterisation analysis	Related to type / size / activity
Agriculture	LO			
Construction	LO/CO			
Municipal wastewater system	PA	• The wastewater system • Grit removal	Analysis of grab samples from wastewater plant / grit removal	Related to population equivalent used in the wastewater sector

*)PA = public authority, LO = land owner, CO = company

Based on a geographically limited area, the aim is to describe the number of CBL littered and cleaned up per inhabitant, or other appropriate references to the quantities for the various littered fluxes. Subsequently, the calculated data for cleaned up CBL per reference are extrapolated to national figures.

The different litter fluxes require different methods for quantification. Based on the table 2 above, the most significant fluxes of CBL that have been selected are presented in table 3.

The main method is based on merging the litter fluxes to form the national baseline of CBL.

Table 3: Litter fluxes mapped in the project, areas cleaned and method of cleaning.

Flux no.	Litter flux name	Area where litter is cleaned up	Method of cleaning
1	Urban street sweeping waste	Urban areas	Mechanically
2	Manually cleaned up municipal litter		Manually
2a	General clean-up litter in urban areas / parks / recreation areas		
2b	Clean-up litter from bus stops		
2c	Clean-up litter around public waste containers		
3	Manual clean-up litter from municipal roads	Traffic venues / roads	
4	Street sweeping gravel from municipal roads		Mechanically
5	Snow removal from municipal roads		
6	Stormwater litter collected from urban rivers		
7	Grit litter from wastewater systems	Other	

It is to expect that the different litter fluxes and the clean-up varies over the seasons. Predictions of the quantity from the various litter fluxes should therefore consider seasonal variations in a year. In order to relate the littering to a specific period of time, some fluxes require several surveys over time.

The CBL fluxes identified and quantified in the project are presented in chapters with a general description of the litter flux, method, execution, and results. Additionally, the methodology of mapping CBL flux and projecting national figures are discussed for each flux. Some of the litter fluxes may overlap, attempts have been made to identify this and adjust so that the estimates are not duplicated.

A general variation in smoking habits is likely to influence the littering and thereby also the amount of cleaned and removed CBL. National data on the variation of smoking habits is available from Statistics Norway.

Similarly, the littering in areas may not be corresponding to the number of inhabitants due to travelling like commuting activities, tourism, and recreational activities. Other factors that can affect the littering of cigarettes are the availability of ashtrays, this is not considered in this project.

Within the framework of this project, surveys have been carried out in limited geographical areas. In the estimation of the representativity of the local results to the national level, several uncertainty factors apply. In this study we have decided not to correlate the local results for smoking or travel habits. This is a choice that can be discussed. We believe this correction can be done when more data is available in different regions. Ideally, there should be more measurements from several geographical areas and seasons, but the estimates from this project will be a good start to be able to assess the amounts of CBL that are cleaned up.

2. Experimental - mapping of CBL

The mapping of the different litter fluxes of cigarette butts are presented in this chapter. Each CBL flux is presented with methodology and results of the mapping, and the chapter ends with a summary of the estimate with a national presentation of the CBL baseline. Litter along county roads, national and European roads are owned by counties and national road authorities. Clean-up of these roads is normally part of the contracts for road maintenance. However, several stakeholders (Mesta, Innlandet Fylkeskommune) have stated that small litter objects such as CBL are not cleaned up in practice. This litter flux is therefore not included in this survey.

Statistics and parameters used in the calculations

The following figures have been used for calculation of CBL fluxes and for conversion factors from number of cigarettes to weight.

Number of inhabitants:

- Norway: 5,370,000
- Kristiansand: 111,634
- Bærum:128,833
- Oslo: 697,010

Weight of CBL:

- Dry weight: 0.2 g (Labstad)
- Wet weight: 0.9 g (calculated)[8]
- Wet weight in sweeping waste: 1.4 g (measured average in field studies)
- Wet weight in waste container: 0.8 g (measured average in field studies)
- Wet weight in sweep gravel: 0.9 g (measured average in field studies)
- Wet weight in waste picking: 0.5 g (calculated based on average between dry weight and wet weight in waste container)

2.1. Urban street sweeping waste

Urban areas in cities are cleaned mechanically by sweeping cars. The municipalities clean urban areas for leaves and twigs, road dust and other litter, including CBL, see figure 1 (1-2). It is common to do this early in the morning all year round if there is no snow on the ground, and more frequently during the summer.

[8] The weight of a dry cigarette butts is 0.2 grams. The volume of a CBL that has been used is 7 mm in diameter and 18 mm long. This will give a volume of 0.7 cm^2 which corresponds to 0.7 g of water. One wet CBL will then have a weight of 0.9 grams (0.7 g + 0.2 g).

Figure 1: 1) Sweeping car emptying sweeping waste after cleaning in Lillestrøm. 2) Sweeping masses.

2.1.1. Method

The methodology of evaluating CBL flux from urban areas is partly based on analyses of sweeping waste from sweeping cars. The waste is usually unloaded in an intermediate storage where the waste is weighed and sent for further treatment. The routines and operational information of sweeping in three different municipalities have been examined. In addition, a survey has been conducted of the content of CBL in the waste in the municipality Kristiansand and Lillestrøm.

In Kristiansand municipality, the sweeping car cleans the main pedestrian street, squares, and urban central areas, typically 3-4 hours in the morning. The sweeping is done 7 days a week from the period of May to October, and fewer days a week the rest of the year. Lillestrøm municipality sweeps the streets daily during the summer months, and about 3 times a week the rest of the year, in the central area of Lillestrøm and partly Kjeller. Sweeping of the streets is ongoing if there is no snow on the ground. Street sweeping in Asker municipality is carried out 3 times a week in the center of Asker. Asker municipality conducted analysis of the street sweepings from the center of Asker in connection with a pilot project which involved installing a "plastic collector" in the river Askerelva[9].

To quantify the amount of CBL from urban street sweeping waste, analysis has been conducted to determine a concentration of CBL per tonnage sweeping waste. With waste statistics on annual sweeping waste produced in the municipalities, this in turn can be related to the number of inhabitants in a municipality and extrapolated to get a national amount of CBL from waste swept up from urban areas by the municipalities.

[9] https://www.asker.kommune.no/vann-og-avlop/arkiv-vann-og-avlop/asker-tester-nye-plastfangere/

2.1.2. Execution

To investigate the content of CBL in urban street sweeping waste, in-depth analyses were carried out in Kristiansand and in Lillestrøm. In Kristiansand, the waste from sweeping of the main pedestrian street, Markens gate, is unloaded for intermediate storage before disposal at a landfill. During the period of June 15-29th in 2021, five analyses of the daily discharge of sweeping waste were performed at the storage site, to measure the content of CBL.

The waste was screened manually, weighed and CBL was separated and counted, see figure 2. The waste varied in quantity and composition from day to day, sometimes it was mainly sand and stone, while other times it was mostly litter.

Figure 2: 1) street sweepings from cleaning of Markens in Kristiansand and 2) counting of CBL.

The same procedure was performed in Lillestrøm, five batches of sweeping waste were analysed in October 2021, see figure 3.

Figure 3: 1) sampling of street sweeps, 2) analysing CBL and 3) CBL separated from the street sweeps.

2.1.3. Methodology discussion

The selected method of quantifying the national level of CBL cleaned up with municipal urban street sweepings is based on the prediction of a concentration of CBL in street sweepings in combination with annual waste statistics of street sweeping in the municipalities.

This methodology assumes that there is a correlation between the two factors and that both factors can be predicted. The yearly tonnage of street sweeps is one of the decisive factors used to convert this into a key figure that provides a CBL flux per capita. There is today no reliable statistics available in Norway on street sweeping waste production and its distribution in the municipalities. The cleaning

routines may vary in different municipalities, and it has not been investigated whether all municipalities use sweepers. Without these statistics the extrapolation from municipal level to national level needs to be based on considerations about the representativity of the selected municipalities. In general, more measuring points with a more geographical spread will reduce the uncertainty about the results.

The two municipalities of Lillestrøm and Kristiansand represent somewhat large municipalities. Lillestrøm is a suburban municipality with a city center and consists of many inhabitants that commute to other municipalities in the Oslo-region, whereas Kristiansand is rather a commuter destination from suburban municipalities. For the purposes of this calculation, it is assumed that the two municipalities represent a representative selection of the population that lives in densely populated areas. According to Statistics Norway 82 % of the population in Norway live in densely populated areas[10]. The results from the survey have therefore been reduced by a factor of 0.82 by extrapolating to national figures.

The yearly tonnage of street sweeps may vary from year to year, and geographical area, and there may be different concentrations of CBL in the sweep masses. The analyses from Kristiansand are from the summer and seasonal variations in connection with the number of cigarette filters on the ground have not been considered. The analyses of the sweeping waste from Lillestrøm were carried out in mid and late October and can be considered a more average period. To compare the results, the average of the results from the two cities has been used, even though the Kristiansand results represent 6 times as many inhabitants. However, there is not much difference between the result of CBL / inhabitant from the two cities, which may indicate that the results are within this order of magnitude when extrapolating to national figures.

2.1.4. Results

Main estimates of CBL flux from urban street sweeping waste

- 40.0 mill. CBL/year
- 56,000 kg CBL/year wet weight (factor 1.4 g/CBL)
- 8,000 kg CBL/year dry weight (factor 0.2 g/CBL)

The calculation of cleaned up CBL from urban street sweeping waste is based on the average concentration of CBL per sweeping waste from the survey in Kristiansand and Lillestrøm. The average concentration of the analyses was 10.9 CBL per kg waste from street sweeping, as shown in table 4.

[10] https://www.ssb.no/befolkning/folketall/statistikk/tettsteders-befolkning-og-areal

Table 4: Results from the analysis of CBL in urban street sweeping waste.

Date	Number of CBL	Total weight of sweeping waste (kg)	CBL/kg sweeping waste
15.06.21	181	27.6	6.6
18.06.21	360	16.08	22.4
22.06.21	221	11.8	18.7
25.06.21	307	37.6	8.2
29.06.21	254	21.2	12.0
12.10.21	258	53.1	4.9*
26.10.21	165	28.2	5.9
26.10.21	165	12.3	13.4
26.10.21	57	9.7	5.9
		Average	**10.9**

*) Measurement from two samples of street sweepings

Key parameters used to calculate the national litter flux of CBL from street sweepings:

Lillestrøm

- Total sweeping masses Lillestrøm: 23 tonnes
- Number of inhabitants Lillestrøm and Kjeller: 18,500 inhabitants
- Total sweeping mass analysed: 103.3 kg
- Number of CBL in sweeping masses: 645 CBL
- CBL per inhabitant in Lillestrøm: 7.8 CBL/inhabitant
- Estimated total CBL nationally: 41,863,904 CBL

Kristiansand

- Total sweeping masses: 100 tonnes
- Number of inhabitants Kristiansand: 111,634 inhabitants
- Total sweeping mass analysed: 114.3 kg
- Number of CBL in sweeping masses: 1,323 CBL
- CBL per inhabitant in Kristiansand: 10.4 CBL/inhabitant
- Estimated total CBL nationally: 55,703,997 CBL

Based on the results from this survey and with the correction factor 0.82, the national amount of CBL from street sweeping is estimated to be between 34.3 to 45.7 million CLB per year, with an average of 40.0 million CBL.

2.2. Manually cleaned municipal litter

In addition to cleaning urban areas with sweeper cars, municipalities perform manual cleaning of litter in urban areas. The clean-up is typically done when emptying waste containers and clean-up during management of public parks and recreation areas, see figure 4 (1-2). Some municipalities have

separate patrols that work with litter clean-up, often as part of a job offer for vulnerable people in society. Manually cleaned municipal litter has been investigated in Kristiansand and in a city district in Oslo.

The work with manual litter clean-up is often scaled up during the summer months. In Kristiansand, one of the actors involved in litter removal, is the "Hold Sommerbyen Ren" (Keep the summer town clean) patrol. The patrol uses trolleys and picking equipment and manually picks litter in the downtown area of Kristiansand during the summer months. They clean in the afternoon and work for a few hours a day.

Organisation and operation of litter clean-up in public areas in Oslo is complex and there are many actors involved. The city districts in Oslo have the administrative responsibility for district parks, which also involves picking litter in the parks. The district Nordre Aker, is responsible for litter cleaning in 14 parks / recreation areas and has an in-house weekly routine of manually picking litter with litter stick pinches.

Figure 4: 1) Weekly routine of clearing litter from parks / recreation areas in the district of Nordre Aker in Oslo. 2) CBL typically accumulates around benches.

2.2.1. Method

The methodology of evaluating the number of CBL of the ones manually removed from urban areas, is based on analyses of waste collected from municipalities. Since there are no statistics on annual amounts of manually collected litter, the method is based on the number of CBL cleaned up in a specific period. This was done by mapping of the litter clean-up routines in Kristiansand and Nordre Aker, and analysis based on the amount of CBL cleaned up over a specific period. The results from the analysis are connected to the number of inhabitants in the different areas, and national figures are projected based on this.

Additionally, a study of the amount of CBL litter on street level in Kristiansand (not necessarily cleaned) was performed around eight central areas. Because of the uncertainties of the proportion that is cleaned up, the results from the study are not used as results in the project but used as a reference.

2.2.2. Execution

In this project the level of manually cleaned up CBL was studied in Kristiansand and the Oslo district Nordre Aker.

The sampling in Kristiansand was performed during the period of 23rd of June to 27th of July. The litter picked up from the patrol was collected in garbage bags in a separate container. The total weight of the waste collected on the relevant day was registered and counting and registration of CBL was performed on a random selection of bags. The results were used to stipulate the number of CBL in the rest of the bags of litter collected on the specific day.

During the counting and registration, the waste was spread out on a garbage bag to get an overview of the contents and to make it easier to separate the CBL. The contents of the bags varied, there were often more CBL in the bags containing sand and leaves and other small litter, than in the bags of larger litter items. From seven days, a total of 19 garbage bags were analysed, where the weight of the bags and the number of CBL was registered, see figure 5 (1-2).

Figure 5: 1) Collected litter from "Hold Sommerbyen Ren". 2) Counting the number of CBL from manually cleared CBL from urban areas.

In Nordre Aker, the number of CBL that were cleaned up together with the waste collection in the parks, was counted and registered over a period of five weeks, from 20th of October to 24th of November 2021. Norwaste monitored the operation of the 14 parks at Nordre Aker together with the operating personnel for a day in October, and the personnel reported the number of CBL cleaned for six consecutive weeks.

Additionally, Norwaste investigated eight locations where CBL at street level in Kristiansand was registered, shown in figure 6. The areas around waste containers (figure 7) and bus stops and CBL around bus stops (figure 8) have been measured because they are identified as litter hotspots in urban areas. This study was carried out in collaboration with Kristiansand municipality as part of another project to map litter.

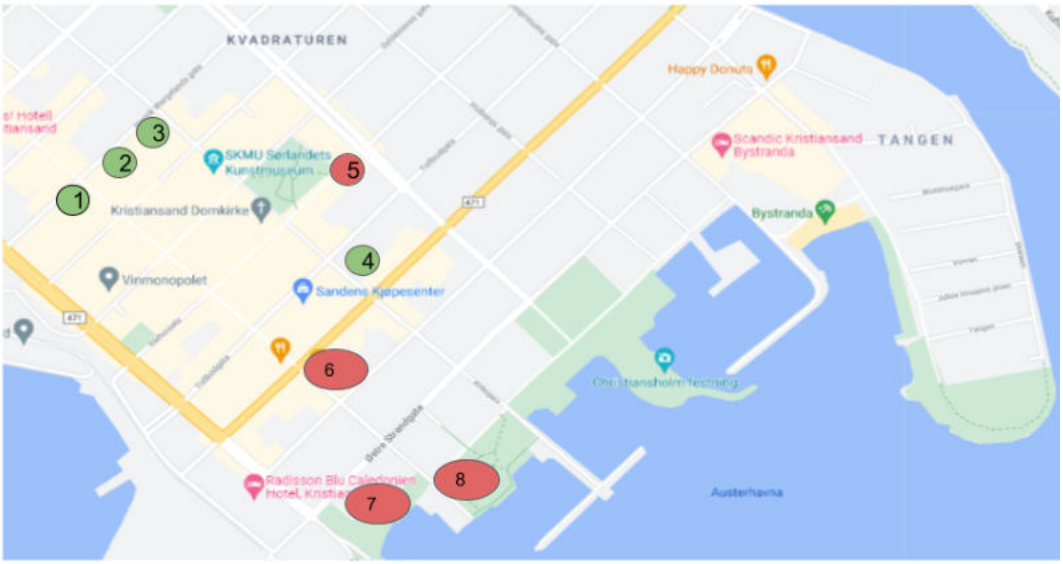

Figure 6: Areas measured by Norwaste for CBL in Kristiansand. Number 1-4 are bus stops, and 5-8 are waste containers.

To study the amount of CBL, the selected areas have been measured over a period of 4 weeks in June to July 2021 in Kristiansand. The municipality of Kristiansand has the responsibility of maintenance and clean up in the urban areas.

The amount of CBL was registered manually at 13 intervals in the 8 areas. The registration areas were limited around the waste containers and bus stops, as shown in figure 7 and figure 8.

Figure 7: Selected areas for CBL registration around waste containers in Kristiansand: 1) Øvre torg, 2) Markens gate, 3) Nupenparken 1, and 4) Nupenparken 2.

Figure 8: Selected areas for CBL registration at bus stops in Kristiansand: 1) Wergelands gate C, 2) Wergelands gate, 3) Wergelands gate E, and 4) Tollbugata N.

2.2.3. Methodology discussion

The methodology of quantifying the national level of manually cleaned up CBL from urban areas is based on establishing key factors of cleaned up CBL per inhabitant from different municipalities activities. In this project, manually cleaned urban areas in Kristiansand have been selected together with parks and recreation areas in a district in Oslo to obtain reference values.

Both the littering as well as the manual clean-up of litter in urban areas varies between Norwegian municipalities. There are no reliable waste statistics from manually cleaned up litter nationally nor for different municipalities. Without these statistics the extrapolation from municipal level to national level needs to be based on considerations about the representativity of the selected municipalities.

An unquantified sub-flux of the manually cleaned up CBL, is from litter that is collected together with waste collection of public waste bins. A study from three different cities in Norway confirms that public waste bins represent litter hot spots[11]. Information and field observations from Oslo, Viken (Lillestrøm) and Agder (Kristiansand) indicate that CBL is partly cleaned up during this waste collection. However, it was not possible to quantify the clean up activity in this survey. The reference study from Kristiansand gives some indication about the level of this unquantified clean up activity.

In addition, there may be other manual clean-up activities that take place by and on behalf of the municipalities. Clean up activities on pavements etc. by private house owners are not included in this flux.

Regarding the representativity of the selected fluxes, more measuring points with a more geographical spread would reduce the uncertainty about the result.

The results from "Hold Sommerbyen Rent" only represent the cleaning routines in Kristiansand, in the same way the results from Nordre Aker represent their routines. When extrapolated to national level, the level of litter and clean-up routines are assumed to be representative for Norwegian municipalities. Kristiansand is in Norwegian context a medium-large city and thus, manually clean-up activity may be slightly higher here than the average in Norwegian municipalities. Little is known about the seasonality of littering in urban public spaces, but the seasonality of the clean-up in Kristiansand is considered in the calculations.

The city district Nordre Aker is situated outside the most central districts in Oslo. In a simplified assumption it is assumed that the manually cleaned-up waste from the selected parks and recreational areas is representative for the population living in densely populated areas (82 %).

In addition, studies have been carried out of litter of CBL that occurs at street level around two identified hot spots: waste containers and at bus stops. These results are not necessarily quantities of CBL that are cleaned up but give an indication of how much CBL occurs in the various areas.

In total the level of manually cleaned CBL is not easy to quantify. Simplified assumptions have been made to obtain figures on a national level. To improve these estimates more data should be gathered

[11] Norwaste-rapport 6-2020: Redusert forsøpling gjennom bedre oppsamlingsløsninger

both in terms of distribution between municipalities and seasonal variations. The substreams of CBL cleaned up together with the collection of waste from public bins and around bus stops should also be assessed.

2.2.4. Results

Main estimates of CBL flux from manually cleaned municipal litter

- 2.1 mill. CBL/year
- 1,058 kg CBL/year wet weight (factor 0.5 g/CBL)
- 423 kg CBL/year dry weight (factor 0.2 g/CBL)
- Reference estimates from central bus stops and waste containers 5 mill. CBL/year

The calculation of CBL from manually cleared CBL from urban areas is done by an estimate of CBL over a period, and by extrapolating the figures to national numbers by the corresponding number of inhabitants from the area. Results from measurements conducted in Kristiansand are given in table 5.

The projected total shows an average clean-up of 1,251 CBL per day. If the patrol cleans every weekday for two months in the summer, this will correspond to cleaning up approx. 50,000 CBL through the summer season in Kristiansand. By calculating the number of CBL/inhabitant, this corresponds to the clean-up of approximately 2.4 million CBL nationally.

Table 5: Results from picking analysis of CBL in manually cleaned litter from Kristiansand (Hold Sommerbyen Ren).

Measurement number	Date	Collected litter (kg)	Mean CBL per kg	Projected total CBL
1	23.06.2021	11.9	146	1,737
2	29.06.2021	9.1	173.4	1,578
3	01.07.2021	9.9	117.2	1,161
4	05.07.2021	11.3	115.1	1,300
5	07.07.2021	9.8	101.2	991
6	27.07.2021	10.6	107.4	1,139
7	29.07.2021	7.5	113.6	852
			Average	**1,251**

The total number of CBL from six weeks of registration in Nordre Aker was 194 CBL, which gives 4.6 CBL/day and 1,686 CBL/year. With 52,327 inhabitants in the district of Nordre Aker, this corresponds to approximately 173,000 CBL nationally.

The result from the clean-up in Kristiansand is from urban areas, while Nordre Aker is from parks and recreational areas. These results are aggregated since they are assumed not to overlap. With a correction factor of 0.82, the total result will correspond to 2.1 million CBL at a national level. Since clean-up from urban areas is assumed to be the most significant flux, and the results from this are limited to a short period, the results are assumed to be underestimated.

Reference results from own survey in Kristiansand
The measurement carried out by Norwaste was based on the number of CBL littered in the area, and not necessarily cleaned up by the municipality. Since the scope of the project is related to the number of CBL cleaned up, the results are used as a reference to the results obtained from mapping of the CBL clean-up in this chapter.

The results from the mapping in Kristiansand shows that approximately 100 CBL are littered in the defined areas for waste container and bus stops over a period of four weeks.

An estimation of national litter flux from bus stops and waste containers is made by extrapolating by the number of bus stops / waste containers in the city center and number of inhabitants in Kristiansand. Litter of CBL related to waste containers is calculated to be in the order of magnitude of 4.2 million CBL and 720,000 CBL related to bus stops nationally. Although the figures are based on littering that is on site, the figures are only based on eight delimited areas, and it is assumed to only be a proportion of the total picture.

2.3. Manual clean-up litter from municipal roads

Several municipalities organise voluntary clean-up actions to clean up litter on the grid of municipal roads. The systematics of this varies, but some municipalities have annual actions, typically in the spring and / or autumn.

Bærum municipality[12] organises a clean-up operation on all municipal road ditches and similar twice a year, in the spring and autumn. The municipality also facilitates the clean-up of litter along rivers and streams, along walkways in populated areas, and at parking lots in recreational areas in the municipality. The work is contracted to various local associations, who are assigned separate routes. The teams get a description of cleaning routines prescribing that also CBL is cleaned up. The work is typically organised within the club and divided into mini routes that are distributed to families within the sports club or association. The families do the work on a voluntary basis, and the income is used to support the activity in the association. A precondition for getting paid for the work is that the collected waste is delivered to the recycling station Isi in Bærum. When the waste is delivered to the recycling station, it is weighed in and registered on a separate item code.

2.3.1. Methodology

The methodology of quantifying the manually cleaned CBL from municipal roads is based on waste characterisation of the collected litter and the waste statistics registered for this specific flux in the municipality of Bærum. To estimate the national CBL cleaned up manually from municipal roads the numbers from Bærum are extrapolated based on population data. To extrapolate from municipal level to national level it is assumed that the main factor for littering among municipal roads is the population. This means that the total grid of municipal roads receives an amount of CBL and other litter that is proportional with the inhabitants in the municipality.

[12] Department of Nature, Road and Environmental Management

The methodology is based on analysis from the spring-cleaning campaign in the municipality of Bærum. The coverage of the campaign in Bærum is comprehensive, and all municipal roads seem to be covered. In addition, walking ways and recreational parking areas are covered. The data from Bærum theoretically represents a good picture of manually clean-up in municipalities.

From the practice Norwaste has experienced that not all voluntary parties (families) deliver the collected litter to the organiser within the club, and thus the waste delivered at the Isi recycling station may be less than what was actually collected. Furthermore, the reported waste statistic indicates that not all contracted associations have reported waste. This leads to a likely underestimation for the manually collected CBL in Bærum.

The grid of municipal roads in Bærum is predominantly within a densely populated area (suburb). Translating the amount of manually cleaned up CBL on municipal road infrastructure in Bærum to a number of CBL per capita enables an estimate of the CBL collected at national level. The municipal road structure is very different from municipality to municipality. With the assumption that the littering is proportional to the inhabitants the difference in municipal road grid is of minor importance. The key condition for the extrapolation is that similar clean-up activities take place on municipal roads throughout the country. To correct for the likelihood that this predominantly takes place in densely populated areas, a factor of 0.82 is used representing the share of Norwegians living in densely populated areas. To improve the estimates more data from Bærum and similar municipalities should be collected.

2.3.2. Execution

The waste from road ditch clean-up activities was collected in separate containers at Isi during the spring campaign. A representative amount of waste bags was selected from one of the containers on the 26th of May 2021 for waste characterisation. Large objects were removed, and 11 waste bags were randomly selected from a total of 31 waste bags. The contents of the bags were spread on a table, where the waste was carefully reviewed and the CBL was separated and counted, see figure 9 (1-2).

Figure 9: Picking analysis of litter collected at the clean-up action in Bærum, spring 2021.

2.3.3. Results

Main estimates of CBL fluxes of manual clean-up litter from municipal roads

- 2 mill. CBL/year
- 1,000 kg CBL/year wet weight (factor 0.5 g/CBL)
- 400 kg CBL/year dry weight (factor 0.2 g/CBL)

The calculation of CBL from municipal clean-up actions is based on the average concentration of CBL in waste from the clean-up action in Bærum. The average concentration was 8.8 CBL/kg collected waste, see table 6.

Table 6: Results from analysis of manual clean-up litter from municipal roads in Bærum.

Sample number	Weight of waste bag (kg)	CBL in bags
1	5.90	9
2	2.36	2
3	3.47	0
4	10.90	0
5	5.00	0
6	6.62	233
7	0.58	1
8	1.16	0
9	11.70	56
10	1.58	0
11	6.80	193
Total	**56.07**	**494**

To extrapolate to national figures, the key parameters from table 7 are used. As shown in the table, the estimated number of CBL from clean-up actions nationally, is approximately 2 million in a year. The estimate is corrected with a factor of 0.82.

Table 7: Parameters to calculate the CBL flux from manual clean-up litter from municipal roads.

Analysis of CBL from clean-up actions	
Total collected waste spring 2019 (kg)	3,597
Total collected waste autumn 2019 (kg)	2,858
Total collected waste spring 2021 (kg)	3,402
Estimated waste collected in a year (kg)	6,571
Total CBL	57,892
Inhabitants Bærum	127,731
CBL per inhabitant Bærum	0.45
CBL per year Norway	**1,995,759**

2.4. Street sweeping gravel from municipal roads

Gravel that is spread on Norwegian municipal roads through the winter to maintain traffic safety is cleaned up with sweeper cars in the spring. The swept gravel contains contaminants such as small rubbish, including CBL. The swept gravel is either reused, disposed of, or delivered to treatment plants. Such a treatment plant is located in Esvald environmental park in Nes municipality, Viken county, where the masses are mechanically treated through several wet cleaning steps, see figure 10 (1-2) and figure 11 (1-3).

Figure 10: 1) The treatment plant at Nes separates the gravel according to size. 2) The flotation unit separates the organics.

2.4.1. Method

The methodology of evaluating CBL flux from municipal roads is based on analyses of street sweeping gravel. A share of gravel street sweepings is delivered to the cleaning facility in Nes, which enables an analysis of the concentration of CBL per kg gravel swept from municipal roads. Together with waste statistics on annual amounts of gravel swept in a municipality, this in turn can be related to the number of inhabitants in a municipality and extrapolated to get a national amount of CBL from gravel swept by the municipalities.

2.4.2. Execution

To investigate the content of CBL in street sweeping gravel, an experiment was carried out at the treatment plant in Nes, in November 2021. Approximately 300 tonnes of gravel from street sweepings were received at Nes transported from the intermediate storage facility at ROAF. The gravel originated from the area of Nedre Romerike; the exact tonnage and the origin municipalities of the masses are not available. A representative volume of in total 152 tonnes of the gravel was processed through the plant within 1-2 hours. The processing was adjusted to the aim of the project.

In the treatment plant the material is fed into the facility and the first cleaning step is washing via nozzles with high-pressure rinsing of water. The organic fraction is then separated in a tank with a flotation step, where the organic material floats up, and is separated from the inorganic, and then transported on conveyor belts in a separate container. This organic material consists of twigs and leaves, as well as small articles of litter, such as CBL.

Figure 11: 1) Untreated street sweeping fed into the plant. 2) Cleaning step with high pressure rinsing with water. 3) Container of organic material.

The amount of organic matter from the batch of gravel was 900 kg. To determine the amount of CBL in the organic fraction, the material was distributed to an area where samples were taken for manual analysis where CBL was identified, counted, and weighed, see figure 12 (1-4).

Figure 12: 1) Process of sample division and sampling of organic matter from street sweepings. 2) Sampling of organic matter for further review. 3) Organic material. 4) Separated CBL from the organic material.

2.4.3. Methodology discussion

The extrapolation of CBL from gravel street sweeping to a national level, is based on the concentration of CBL per tonnage of gravel street sweep, as well as waste statistics of annual amounts of street sweeps for an area, and the corresponding population in that area.

The street sweeping gravel studied in this experiment was a mixture of masses originating from several areas in Nedre Romerike / Oslo, of unknown municipal origins. Originally, the intention was to isolate and track a volume of gravel from a specific area to be able to relate the results of the experiments to this area and its population. For practical reasons, with intermediate storage, trans-shipment, transport, and many actors involved, this tracking was not feasible. On the other hand, the sample from the experiment is a mixture from several areas, and it is assumed that the materials are well mixed with several reloading steps, which can give a more representative sample for a CBL flux-concentration to be used nationally than just by examining one municipality. In addition, the use of a large-scale treatment plant for sampling of material has made it possible to analyse a large amount of gravel.

The tonnage of gravel that is spread on the Norwegian roads varies from year to year and from area to area depending on road maintenance strategy, snowfall, and temperature during the winter. The variation of spent gravel limits the validity of extrapolating a measured concentration of CBL per tonnage of gravel to national figures. To predict an average volume of swept gravel waste statistics from three municipalities / areas has been collected, representing approximately 9 % of the population in Norway.

To improve the calculations and extrapolation, better data on (spent or) swept gravel in the municipalities is needed in order to establish correlation factors and geographical as well as annual variations.

During the experiment, cigarette butts were manually sorted out. It became evident that some of the butts had been damaged through the treatment and cleaning process. It is possible that some of the butts have disintegrated and became unidentifiable.

2.4.4. Results

Main estimates of CBL flux from street sweeping gravel from municipal roads

- 6.6 million CBL/year
- 5,900 kg CBL/year wet weight (factor 0.9 g/CBL)
- 1,320 kg CBL/year dry weight (factor 0.2 g/CBL)

The calculation of litter of CBL from gravel street sweepings from municipal roads is based on the average concentration of CBL per gravel masses from the survey of the plant. The average concentration of three analyses was 6.45 CBL / organic matter, which corresponds to a total of 5,807 CBL for the entire organic sample mass. This in turn gives a concentration of 0.04 CBL per kg gravel street sweeps, as shown in table 8.

Table 8: Results from the experiment to map CBL in street sweeping gravel.

Analysis of CBL in street sweeps from Nes	
Total sample mass of street sweeps (kg)	152,000
Total organic content (kg)	900
Sample mass organic (kg)	90.2
Number of CBL in organic sample mass	582
CBL per kg organic sample mass	6.45
Estimated total CBL in sample	5,807
CBL per kg street sweeps	**0.04**

To extrapolate the results to national figures, tonnage of gravel has been obtained from selected municipalities / areas that are related to the number of inhabitants from the given area, shown in table 9.

Table 9: Basis of data to calculate the CBL flux from street sweeping gravel from municipal roads.

Areas	**Gravel street sweeps (kg)**	**Inhabitants**	**Gravel per inhabitant (kg/inhab.)**
Trondheim 2020	4,000,000	207,415	19.3
Trondheim 2021	5,500,000	207,415	26.5
Bærum 2020	5,000,000	128,833	38.8
Oslo Nord 2020	6,300,000	144,246	43.7
		Average	**32.1**

Given the average of 32.8 kg gravel per inhabitant, this will correspond to a flux of 6.6 million CBL/year from street sweeping gravel on a national level, varying from 4.1 to 9.4 million CBL depending on the waste statistics.

2.5. Snow removal from municipal roads

The handling of snow from Norwegian roads is a crucial part of road, city, and property maintenance during the winter season in Norway. Snow is handled locally by moving it into ditches or empty spaces where available, but in densely populated areas, the snow may need to be removed and placed in snowfills.

In Oslo, NCC operates a one-of-a-kind floating snow treatment facility *S/S Terje,* which melts and filters the snow using seawater. Solid particles such as grass and branches are filtered out using a grit early in the treatment process and extracted as grated waste, see figure 13 (1-2).

Figure 13: 1) Snow handling in Oslo and 2) treatment in S/S Terje.

2.5.1. Method and execution

Norwaste performed an analysis of grit, separated out at S/S Terje to estimate how much cigarette litter is extracted from Oslo through snow handling activities following periods of heavy snowfall in the winter and spring of 2021, see figure 14.

Analysis was performed on February 25 (week 8) and March 17 (week 11) 2021 and represents the collected and treated snow from days with snowfall in February and March respectively.

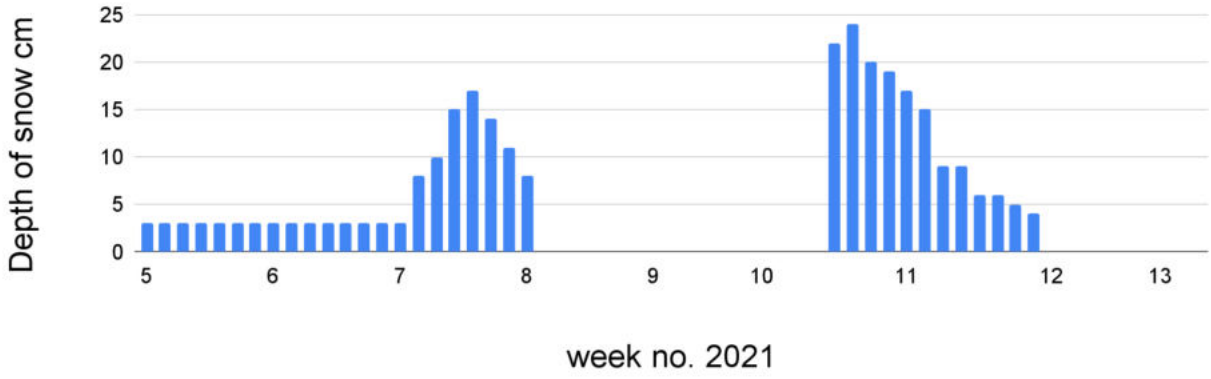

Figure 14: The snow depth i Oslo due to precipitation as snow in February and March 2021, (www.yr.no)

Most of the snow removed from Oslo in February and March was handled in S/S Terje. As shown in table 10, the sorting analysis included all the snow sent to the treatment plant S/S Terje.

The grit removal process removes organics and litter including CBL from the snow. All the grit was set aside for sampling representing 17,845 m^3 of snow. Totally 11 samples were analysed, five samples in February and six in March. The sample size was between 6.1 to 16.6 kg and was selected as combined samples taken randomly from the heap of the grit.

Table 10: Snow (m^3) treated in S/S Terje during winter and spring of 2021.

Area	February	March	Total snow (m^3)
Oslo City Centre	275	2,001	2,276
Oslo East and south	1,569	1,279	2,848
Oslo West	3,555	2,455	6,010
Oslo North	-	-	-
Oslo Harbor	2,155	3,578	5,733
Others	753	225	978
Sum	**8,307**	**9,538**	**17,845**

The amount of grit removed from S/S Terje in 2021 is not known, because the operator combined different waste categories before weighing. From previous years, in the annual report of 2018[13] from S/S Terje, the total grit removal was 18,4 tons from 497,351 m^3 snow. This represents 3.7 kg grit/m^3 snow. Using this factor for the total amount of grit for the winter season 2021 gives a total volume of 660 kg grit.

The treated snow represents close to the total snow removal in Oslo in 2021. The population in Oslo may be used as a factor to estimate the CBL flux from snow handling in snow removed from municipal roads. As stated above the solution in Oslo is one-of-a-kind in Norway. Other densely populated cities and municipalities have other solutions, varying from local dedicated landfills (snowfills) to spreading on farm fields or directly into rivers, lakes, and the ocean.

To estimate the national level of CBL removed from municipal roads a correction factor of 0.82 is used representing the population living in densely populated areas. This probably represents an overestimation.

2.5.2. Results

Main estimates of CBL flux from snow removal from municipal roads

- 62,000 CBL per year
- 56 kg of CBL/year wet weight (factor 0.9 g/CBL)
- 12 kg CBL/year dry weight (factor 0.2 g/CBL)

Results from the analysis are shown in table 11 and correspond to 17,845 m^3 snow that was treated in S/S Terje. The estimated total amount of grit for 2020 is 660 kg and are based on reports for 2018.

13 https://www.statsforvalteren.no/contentassets/495db9b1911a4fcbb7e2d98e7d40babb/snosmelteanlegget-terje-arsrapport-2018.pdf

We have analysed 105.6 kg grit and found 1,497 CBL. By assuming the total amount of grit for 2020 is 660 kg it is 9,357 CBL in the total amount of snow treated in 2020. This gives 0.5 CBL/m^3 snow.

The results from snow treatment in Oslo in 2021 are related to the population in Oslo (2021: 697,010) and are used to extrapolate the CBL flux for Norway.

The total amount of 61,894 CBL (corrected by 0.82 factor) from snow treatment in Norway refers to calculation of treated snow in Oslo winter 2021. This year had relatively little snow compared to 2019 when S/S Terje treated 497,351 m^3 and the potential of litter of CBL may be higher with years with more snow if more snow has been removed from the streets.

Table 11: Results from picking analyses in February and March representing 8,307 and 9,538 m^3 treated snow respectively.

	Batch weight (kg)	No cig. butts	No. butt/kg grit
25.02.2021			
Sample 1	16.6	186	11.2
Sample 2	10.1	74	7.3
Sample 3	12.3	30	2.4
Sample 4	9.1	53	5.8
Sample 5	8	119	14.9
Sum analysed February	**56,1**	**462**	**8.3**
17.03.2021			
Sample 1	10.6	163	15.4
Sample 2	8.2	223	27.2
Sample 3	7.1	322	45.4
Sample 4	6.9	157	22.8
Sample 5	6.1	146	23.9
Sample 6	11.7	187	16.0
Sum analysed March	**49.5**	**1,035**	**27.0**
Total	**105.6**	**1,497**	**17.6**

2.6. Stormwater litter collected from urban rivers

In 2020, a litter collection system was tested in the river outlet of Akerselva in Oslo, called TrashTrawl, see figure 15. The reported amount of CBL from this study (Jacob et.al., 2021)[14] is used to estimate the amount of CBL released to the environment by surface water through urban river systems. Another survey was performed in Asker municipality to collect litter from surface water. The system was called 'PlastfanNGeren', (de Jong, 2021)[15].

[14] Jacob, M., Moe, N, Falk- Andersson, J. (2020): Søppelanalyse Akerselva (TrashTrawl), SALT rapport nr. 1056.
[15] De Jong, C.K. (2021): Pilotprosjekt plastfaNGeren i Askerelva, rapportering til Miljødirektoratet 25.06.2021.

Figure 15: The TrashTrawl with lenses and collection net in Akerselva, Oslo (foto: SpillTech).

2.6.1. Method

ThrashThrawl

The principle of the collection system is that all floating litter in the river is collected in a net. The net was in use for around 30 days in six short periods from April to August 2020. The water flow in the period varied from 1.5 m^3/s to 10 m^3/s during the sampling, and the estimated amount of water in the river during the sampling periods was 13.4 mill m^3 water, see table 12. The riverbank was flushed when the river changed from low to high flow, which caused more litter into the river in these periods.

Table 12: Sampling periods and water flow in Akerselva when using TrashTrawl.

Sampling periods	Days	Water flow m^3/s	Water m^3
1. April - ~10. April	~10	2	1,728,000
29. May - 8. June	10	1,5	1,296,000
31. July - 3. August	3	15	3,888,000
3. August - 5. August	2	12.5	2,160,000
5. August - 7. August	2	10	1,728,000
7. August - 10. August	3	10	2,592,000
Sum	**30**	**-**	**13,392,000**

The litter was counted and sorted into categories of which CBL was one of the categories. Totally 3,030 items were collected in a period of 30 days and 457 of them were CBL.

PlastfanNGeren

In Asker municipality they installed two nets, PlastfanNGeren, to catch litter in surface water. One net on the main stormwater pipes form Asker city center, and the other one on the river outlet of Drengrudbekken before entering Askerelva. The nets were at least sampling for more than two weeks

before analysis. The samling period was from August 7th 2020 to April 6 2021. Because the nets collected mostly organic debris, identification of litter origin and especially CBL was hard to find.

The litter of cigarette butts in the two river systems is a combination of litter transported by stormwater to the river and littering of the river itself.

2.6.2. Evaluation

The study was performed in a period of shutdown due to Covid-19 and has not been a normal situation regarding nightlife and events which are more common along the river in Oslo. To use these results to calculate a baseline for CBL in stormwater and river systems is difficult. The TrashTrawl did not cover the whole river cross section, and was only catching floating litter, not the litter on the bottom of the river. 'PlastfanNGeren' was collecting litter from stormwater discharges to Asker river, however the identification of CBL was not possible in the debris.

As part of the survey in Asker, street sweep waste was analysed in the same area to see if there was any connection with the results of litter in the river and what was found in the streets. In the street sweep waste from three days the frequency of CBL was the highest of the litter fractions, counting 135 CBL from Asker city center, corresponding to 45 CBL per day.

2.6.3. Results

Main estimates of CBL flux from stormwater litter collected from urban rivers[16]

- 5,484 CBL per year
- 4.9 kg of CBL wet weight (factor 0.9 g/CBL)
- 1 kg CBL/year dry weight (factor 0.2 g/CBL)

In Akerselva in Oslo, 457 cigarette butts were collected in a period of 30 days. Given an estimate of 5,484 butts in a year.

Identification of litter and especially cigarette butts was hard to find in litter from the river system in Asker city center. The sweeping gives an estimate of 45 cigarette butts per day that may enter the river Askerelva if not collected. This gives an estimate of 16,425 CBL/year in Askerelva through stormwater. These results are however not used since the estimated flux of CBL is not measured in the river collection system, and thus we can not say the CBL has been cleaned up.

The result is neglectable compared to other fluxes and will not affect the baseline for estimating litter of CBL. There are no common relevant index parameters in the study as amount of rainfall, catchment area, runoff surface area, population / traffic in the catchment area to estimate a flow of CBL in urban rivers.

[16] Since cleaning of river systems only is installed in Oslo and Asker, it will not be correct to extrapolate to a national level. Only Oslo estimates are presented.

2.7. Grit litter from wastewater systems

The results from this chapter is collected from a study performed by Norwegian Waters Association and the organisation "Hold Norge Rent": Nye studier dokumenterer forsøpling i renseanlegg.

2.7.1. Method

A national study was performed by Norwegian Waters Association, the organisation "Hold Norge Rent" and Loop at six wastewater treatment plants (wwtp) to characterise the litter in the grit removal process at the plants, see table 13. The total removal of grit from these wwtp of a combined 848,000 person equivalent (pe) was 1,200 tonnes/year. This gives 1.42 kg grit per pe.

The characterisation of the litter / grit was done by taking 20 kg wastewater litter from each plant, a total 143.8 kg grit was analysed, where 589 CBL was identified in the grit.

Table 13: Capacity (pe) of the wwtp investigated in the survey and total capacity (pe) of wwtp in Norway.

Wastewater treatment plant (county)	PE capacity of plant
Nedre Romerike Avløpsanlegg (Viken)	150,000
Flateby ra. (Viken)	8,000
Bore ra. (Rogaland)	30,000
Vik ra. (Rogaland)	80,000
Holen ra. (Vestland)	110,000
Bekkelaget ra. (Oslo)	500,000
Sum wwtp (6) in the survey	848,000
Sum all Norwegian wwtp (plants >50pe)	7,900,000

2.7.2. Evaluation

The data are collected and analysed from wastewater plants with a grit removal process, usually a rake screen. Since the CBL are soaked in water and have travelled through the sewage system, probably affected by pumping in the sewage system, it is believed that many CBL are dissolved and not caught by the screen at the wastewater plant. Sewage systems with stormwater connected to the sewage (combined sewage), and old sewage pipes with heavy intrusion of groundwater, heavy rainfall will cause flooding in the sewage systems. This will cause discharge of untreated sewage in periods with heavy rain, and litter in the sewage system is released into the environment. If these episodes happen after a long dry period, sudden flooding in the sewage system may flush the pipes and release more litter into the sewage water and increase the probability of more discharges of litter into the environment. Litter and grits in sewer overflows are not treated and thereby not collected and quantified in this baseline study.

The amount of cigarette butts at the wastewater treatment plants may have originated from both stormwater from streets and parking lots, and the sewage itself from households. However, in this

study the results are compared with findings in closed sewage systems, which indicates that the wastewater originates from households. The relative proportion of litter in grit supports that the litter originates from households.

2.7.3. Results

Main estimates of CBL flux from grit litter from wastewater systems

- 45.8 million CBL
- 41.2 ton CBL/year wet weight (factor 0.9 g/CBL)
- 9,200 kg CBL/year dry weight (factor 0.2 g/CBL)

From the study it was found 589 CBL in 143.2 kg grit, which gives 4.1 CBL/kg grit. To extrapolate the data to find the total grit tonnage in Norway per year we have used existing pe capacity for all wastewater plants in Norway of 7,900,000 pe (see table 13) and the amount of grit from the studied wastewater treatment plants. The estimated national amount of grit is 1.42 kg grit/pe. This gives a total amount of 11,179 tonnes of grit on a national level. Using 4.1 CBL/kg grit gives a total of 45.8 mill. CBL removed from wastewater systems. One wet CBL weighs 0.9 grams and the estimated proportion of wet CBL will be 41.2 tons in wastewater.

2.8. Results and discussion

Adding all the CBL fluxes mapped in this study gives a total estimate of approximately 100 million CBL cleaned and removed from the environment by or on behalf of public authorities per year. This corresponds to about 100 tonnes in wet weight and 20 tonnes in dry weight. A summary of the estimates is presented in table 14.

The estimates of each CBL flux are presented in both the number of CBL as well as wet weight and dry weight. The dry weight is based on a standard weight of a used cigarette of 0.2 g. In the waste statistics, wet weight is used and it is assumed to be the most correct way to present the data. Conversion factors have been used to calculate the wet weight of the various fluxes and are presented in the beginning of chapter 2. For each flux, an assessment is made of which factor is most representative.

Table 14: Summary of estimate of CBL clean-up from all the surveys executed by Norwaste and others, projected national results.

CBL litter flux	CBL/year in millions	Wet weight (kg/year)	Dry weight (kg/year)
Urban street sweeping waste	40.0	56,004	8,001
Manually cleaned municipal litter	2.1	1,058	423
Manual clean-up litter from municipal roads	2.0	998	399
Street sweeping gravel from municipal roads	6.6	5,922	1,316
Snow removal from municipal roads	0.062	56	12
Stormwater litter collected from urban rivers (Akerselva, Oslo)	0.005	5	1
Grit litter from wastewater systems	45.8	41,211	9,158
Total estimate of cleaned and removed CBL	**96.6**	**105,253**	**19,310**

According to the table the most significant fluxes are CBL from wastewater grit removal and street sweeping waste. The litter fluxes from snow handling and stormwater are negligible compared with the other fluxes. Compared to the total amount of cigarettes put on market, legally and illegally, this represents an estimated clean up share of 3.5 %.

As discussed in the designated chapters there are considerable uncertainties for each of the identified clean-up fluxes as well as for the total estimate. Some important uncertainties that have been identified are:

- The amount of mechanically cleaned CBL for urban areas should be verified with more data from other municipalities and checked for seasonal variations.
- The amount of manually cleaned municipal CBL is probably underestimated, especially the removal of litter around public waste bins.
- The amount of manually cleaned CBL from municipal roads should be verified with data from other municipalities.
- The survey has taken place in the year two of Covid restrictions. This means that a part of the year the outdoor behavior of the population has not been the same as in a "normal" year.

Figure 16 shows the percentage distribution of the different fluxes based on the number of CBL per year, while figure 17 shows the distribution based on the estimated wet weight of CBL per year. The figures show a small variation in the distribution depending on whether they are presented in number or in weight. However, it is visible that the most significant fluxes are:

1. Urban street sweeping waste with a share of 41 % in number and 53 % in wet weight.
2. Grit litter from wastewater systems with a share of 47 % in number and 39 % in wet weight.

The third largest share is CBL from street sweeping gravel from municipal roads with a percentage of 6 % in wet weight and 7 % in number. While the other clean-up fluxes are 2 % or less of the total.

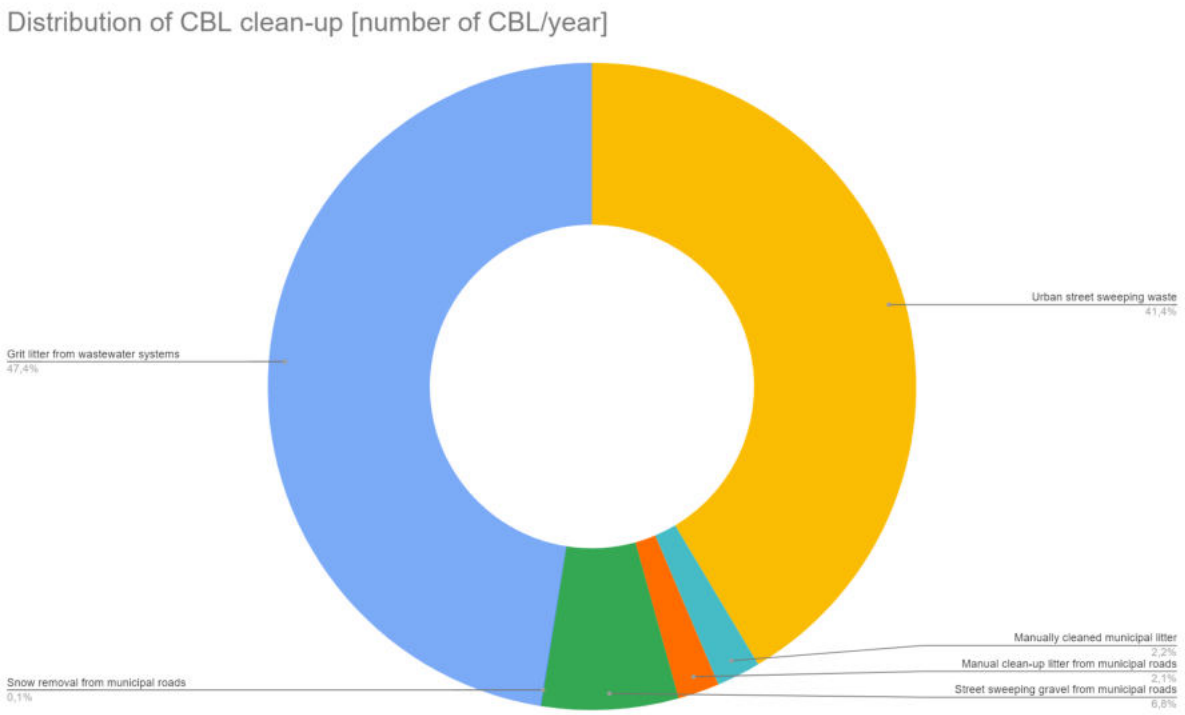

Figure 16: Estimated distribution of different fluxes of cleaned up CBL (in number of CBL).

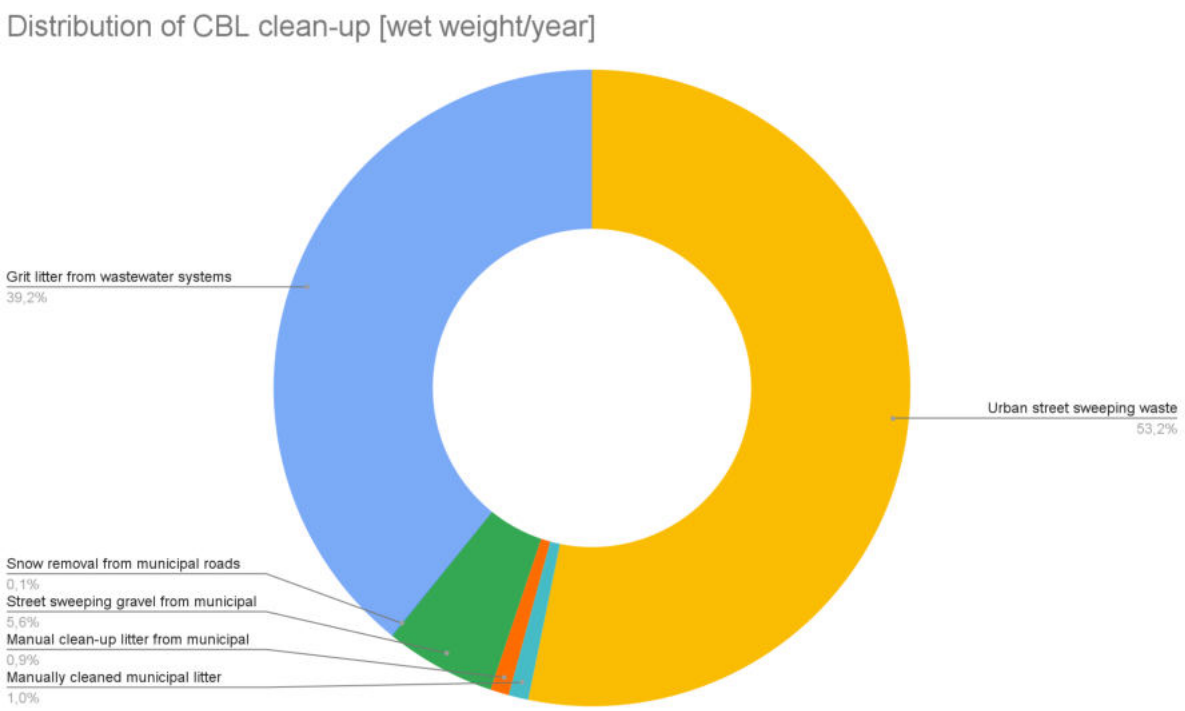

Figure 17: Estimates distribution of different fluxes of cleaned up CBL (in wet weight of CBL).

3. Conclusions and recommendations

This study has combined the identification of relevant fluxes of public litter clean-up and the development and verification of methods to estimate the level of CBL removal through the identified fluxes. The most important conclusions and recommendations from the project are:

- The total estimate of removed cigarette butts is in the level of 100 million CBL per year, corresponding to a wet weight of 100 tonnes and 20 dry tonnes.
- The presented methods are, with some modifications, shown to be feasible to make predictions about cigarette butts litter removed from the environment by or on behalf of public authorities.
- The national estimates are based on mapping of a few areas in Norway. The infrastructure, equipment and routines vary and extrapolation to a national level increases the margin of error. Although it is considered in the estimates this may lead to wrong conclusions. Most likely there are some clean-up fluxes not covered in this study, e.g., part of the stormwater system. The main clean-up fluxes are assumed to be covered in the project.
- The baseline result of this project contains several uncertainties, the main uncertainties are:
    - The amount of littering, clean-up activities and waste infrastructure in cities and other public places in Norway is subject to strong variations.
    - The amount of urban littering in a municipality is related to the weather conditions and the travel within as well as in and out of the municipality.
    - The estimates only represent the year 2021. Due to the Covid-19 situation this year was unusual with regards to outdoor and tourist activity.
    - The amount of street sweeping gravel and snow removed are closely related to conditions in the winter season, this will vary between years.
- Other comments on the estimates regarding representativity on national figures:
    - The estimates of CBL from wastewater treatment plants represent a large proportion of treatment plants in Norway and is assumed to be relatively representative.
    - The estimates of CBL from street sweeping waste represent several measurements, representing two municipalities and two seasons, summer and autumn. However, upscaling has uncertainties due to restricted information on waste statistics and variation of tonnage street sweeping waste from different areas in Norway.
    - The estimates of CBL in gravel from street sweepings represented a large volume and represented several municipalities, however upscaling has uncertainties due to restricted information on waste statistics and variation of tonnage gravel in different areas in Norway.
- To follow up this work we recommend examining the infrastructure and routines of litter clean-up in a selection of Norwegian cities.

- The study has revealed a general lack of litter statistics. To establish better statistics municipalities and other road authorities should be obliged to report specific data on litter waste.
- Ideally, an assignment that was rooted in the municipalities would make it easier to carry out experiments and obtain operational data and statistics from the municipalities, since the municipalities themself have this information at hand.
- Repetition of measurements can be done after targeted measures have been implemented in cities or municipalities to document the effect of these.
- The project is a first of its kind, and despite uncertainties regarding estimates and margin of error, it has provided a good basis for knowledge about the quantities of CBL cleaned up and methods for mapping this.