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Temporal and geographical patterns of solid waste collected at recycling centres

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Abstract

Citizens increasingly dispose their waste at household waste recycling centres (HWRC). To enhance the collection of recyclables materials, local authorities and waste management companies invest considerable resources in planning. While the planning of these centres requires a comprehensive understanding of collected solid waste, only limited studies have consistently investigated waste data from HWRC. To fill this knowledge gap, historical data for HWRC from the Greater Copenhagen, Central Zealand, Silkeborg and Djursland in Denmark were analysed with regards to temporal and geographical variation. The results showed the mass of collected waste varies seasonally; this trend was consistently seen during the period 2010 - 2016. Moreover, the data revealed that the total waste collected was principally driven by the number of visitors. The geometric bar plot and ternary plot depicted an increase in the percentage of recyclable materials, whereas the percentage of incinerated waste decreased during the period 2010-2016. The waste characterisation study indicated that about 7 % of small miscellaneous combustible waste was brought in black plastic bag, although these bags were forbidden; the results suggest that the percentage of misplaced recyclable materials could considerably decrease if citizens bring their waste in clear plastic bags.

Key words:

Household waste recycling centres;

Mean ratio

Ternary plot

clr (centered log-ratio)-biplot

Seasonality

1 Introduction

Household waste is generally collected in a full service scheme in many developed countries. In recent year, more and more citizens dispose their waste such as bulky, small miscellaneous and recyclable waste directly at household waste recycling centres (HWRC) (WRAP, 2012). For example, it was estimated that in Denmark about 25% of the total household waste was collected at HWRC in 2015 (Toft et al., 2017). Given this growing interest, various initiatives aiming to increase recycling rates at these centres were established, including competitive salaries, education and training of staffs, public information campaigns, appealing signage, effective sign posting, good site layout, and extended opening hours (Krook and Eklund, 2010; Ordoñez et al., 2014, and WRAP,2012). In Denmark, for example, an increasing number of HWRC is open during 24 hours (a day), enabling citizens to dispose of their waste at any time. Further measures towards increasing recycling focus on reducing the residual waste fraction, which in Denmark is denominated “small miscellaneous combustible”. For example, a black bag policy was enforced in Denmark in 2010, prohibiting citizens to handle solid waste in a black plastic bag at the HWRC. Instead, site users must handle their waste in clear plastic bags to enable the staff to check whether the bags contain recyclable materials that could be further sorted prior to the disposal of the bag (Danish EPA, 2018).

Although the planning and implementation of different initiatives are very costly, both monitoring of their possible effect on recycling rates as well as documentation of the lessons learnt at the local level are quite scarce. This may be explained by two factors. First, the lack of data on waste collected at HWRC, despite their important contribution to the total municipal solid waste. For example, European solid waste statistics publish only aggregated data (European Commission, 2016). While waste collected at HWRC in Norway (Avfall Norge, 2019) and Sweden (RVF, 2018) are published each year, these data are not available for

Denmark. Moreover, the existing data for these Nordic countries are solely the total mass collected. As an example, the yearly waste collected at HWRC are available for all regions and main cities from 2015 to 2018 (Avfall Norge, 2019). However, data describing seasonal patterns remain sparse despite their importance. Second, existing methods applied to waste composition datasets (in percentage) suffer from some serious shortcomings. Statistical analysis applied to compare waste fractional composition datasets (in percentage) in order to assess the effectiveness of an implemented measurement does not consider the inherent nature of compositional dataset (Katsamaki et al., 1998; Navarro-Esbrí et al., 2002). The waste fractional composition dataset is a “closed dataset” (Edjabou et al., 2017a), because the percentage of individual waste fractions must sum to 100, which is known as the “total sum constrain” problem (Aitchison, 1994; Buccianti and Pawlowsky-Glahn, 2011). Consequently, statistical analysis applied directly to a waste fractional composition dataset results in inaccurate outcome such as spurious correlation coefficients (Edjabou et al., 2017b). Moreover, although the waste composition is derived from mass, previously published studies have found no relationship between the distribution of the two datasets: (1) waste fraction composition in percentage and (2) waste fractional generation rate such kg/person/week (Edjabou et al., 2018; Edjabou et al., 2017b). As a solution, compositional data analysis technique (Aitchison, 1994; Pawlowsky-Glahn et al., 2015) was shown to be a valid method to adequately analyse waste fractional composition data (Edjabou et al., 2017b). This means that, to provide a complete interpretation of statistical analysis where total waste is included, waste data could be modelled as compositional data with total sum (Kynčlová et al., 2015).

Two issues are related to the inherent structure of waste composition. Firstly, a study of a single waste fraction may provide incomplete knowledge of the whole system, given that waste management systems are generally "closed systems" (Martinez-Sanchez et al., 2016). Secondly, the dynamic nature of waste may mislead the estimates of recycling rates. A typical example is "heavy" waste fractions such as garden waste and construction and demolition (C&D). The collected amount of these fractions is mainly subject to the vagaries of the weather (Boldrin and Christensen, 2010) and economic growth (Danish Government, 2013), respectively. These inherent dynamics characteristics of waste collected at HWRC require a critical method to reveal and document the impact of any changes in recycling rates at the HWRC.

To fill the knowledge gap aforementioned, this study aims at investigating geographical and temporal patterns in the generation and composition of solid waste from HWRC. This is done by: (i) collecting and analysing historical waste data of 36 HWRCs grouped into four study areas; (ii) statistically comparing different variables, including the number of visitors, population, generation and composition of solid waste; (iii) developing dynamic visualization tools to ease the interpretation and communication of results; (iv) assessing the effectiveness of the black bag policy at HWRCs in Greater Copenhagen, Central Zealand and Silkeborg. The findings could support local authorities in improving the management and planning of HWRCs.

2 Methods and materials

2.1 System definition

2.1.1 Waste fractions classification

Waste fractions were grouped into two compositional datasets, as presented in Table 1:

(1) eleven main waste fractions: (i) bulky, (ii) small miscellaneous combustible (SMC), (iii) construction and demolition waste (C&D), (iv) garden waste, (v) soil, (vi) fibres and other, (vii) glass, (viii) metal, (ix) plastic, (x) wood and (xi) other waste (OW). Construction and demolition (C&D) waste comprises of bricks, blocks, plaster, concrete, tiles, paving slabs, etc. The target waste fractions are included in the European Union´s circular economy package and the Danish

Resource Strategy Plan (Danish Government, 2013). They consist of (a) fibres and others (paper, board, and textile), (b) metal, (c) glass, (d) wood and (f) plastics. Due to difference in number and type of waste fractions in HWRCs, we first aggregated all fractions into detailed material fractions (Table 1). These fractions were subsequently grouped into the main fractions. For example, we grouped textile, paper and board into “fibres and other” for consistency reasons and because textile was poorly recorded before 2016.

(2) waste treatment forms consist of (i) incineration (ii) recycling, and (iii) other treatments (European Commission, 2016; Toft et al., 2017). This classification enables to assess the progress toward waste recycling targets based on collected waste from HWRCs. Recyclable are materials fractions intended for recycling such as garden waste, paper, board, glass, etc. Thus, “recycling rates” refers to the percentage of waste sorted at HWRC for recycling, whereas the potential recycling rate is the percentage of recyclable after adding misplaced materials. Other treatments involve temporary storage, landfill and special treatments (Bigum et al., 2013). Waste fractions that are neither “recyclable” nor suitable for other treatments are incinerated. Often, these waste fractions are collected as “miscellaneous combustible” and are generally subdivided into “small miscellaneous combustible (SMC)” and “bulky” waste. While small miscellaneous combustible comprises of small items, such as dirty paper and board, composite materials, etc., bulky waste is items larger than 50x50x100 cm (Nilsson and Christensen, 2010). It includes for example furniture, mattress, bric-a-brac, homewares, etc.

2.1.2 Study area and household waste recycling centres

This study involved 36 HWRCs from 13 municipalities (Figure 1), located in the areas ranging from densely (blue on the map) to sparsely populated (North Djursland municipality) municipalities.

HWRCs were grouped into Zealand consisting to Greater Copenhagen, Central Zealand, and Jutland, which comprises of Silkeborg and Djursland (Figure 1). The HWRCs from each region are managed by a waste company owned by a consortium of municipalities in this region. One of the differences between these regions is the ratio between housing types, namely single-family and multi-family houses (Table S1). Here, single-family houses have a garden, while multi-family houses are block apartments without a garden. The highest percentage of single-family houses was 97% (municipality of Lejre in Central Zealand) and the lowest was 3% (municipality of Frederiksberg in Greater Copenhagen). In the contrary, the percentage of single-family houses was 78% in the municipality of Dragoer that is also located in the capital city (Greater Copenhagen). Overall, the percentage of single-family houses ranges from 62-94% in Djursland, Silkeborg and Central Zealand (Table S1). The distribution between housing types remains stable during the period 2010-2016 (Statistics Denmark, 2017).

Although the management of HWRCs follows the national waste regulations and legislations, each municipality and/or waste management company can organise their HWRCs according to local conditions. This involves, for example, measures to increase recycling rates, such as opening hours, number of waste fractions, employees at HWRCs, signage, billing system, etc.

2.1.3 Household waste management

The waste collection system in this study consisted of (1) door-to-door waste collection for residual household waste, source-separated recyclables materials (paper, cardboard, metal and glass), bulky waste (Edjabou et al., 2015); (2) public collection points for glass and paper, and (3) HWRCs.

In single-family residential areas, households have their own waste bins; whereas in the multi-family residential areas several households shared bins (join full service collection point).

Collection frequencies for residual waste depended on housing types. It was every two weeks in single-family residential areas and every week in multi-family areas. However, source-sorted recyclable and bulky waste were collected upon request or on monthly basis.

Waste collected at HWRCs has considerably increased from 10 to about 30-54% of households waste in this study area (Danish Government, 2013).

2.2 Data collection

We used data on (1) mass of collected individual waste material fractions, (2) composition of small miscellaneous combustible, (3) number of visitors, (4) population, and (5) housing types.

2.2.1 Mass of collected waste, number of visitors, population, and housing types

Waste management companies provided monthly amount of individual waste fractions collected and the number of sites users. The waste collection rates (WCR) were then computed for each municipality as (1) per household (WCR_{house} [kg/household/year]), (2) per inhabitant ($WCR_{inhabitant}$ [kg/inhabitant/year]), and (3) per visitor ($WCR_{visitor}$ [kg/visitors/year]). This method enables to consistently compared HWRC.

We excluded data for waste directly reused at the site through “intern” flea market and “Waste exchange centres” (a visitor can leave reusable items that others can take away), because HWRCs did not consistently registered these waste flows during the period 2010-2016. Similarly, materials such as good quality furniture or items given to charity were not included in this study.

The number of site users includes all visitors entering HWRC by any means (pedestrian, bicycles, cars, van, etc…). Given the diversity of counting systems and discrepancy in their reliability (Cope et al., 1999), we excluded uncertainties associated with counting systems. Data for number of households and inhabitant were retrieved from the Danish national statistics database (Statistics Denmark, 2017).

2.2.3 Composition of small miscellaneous combustible (SMC)

Small miscellaneous combustible (SMC) from seven HWRCs (Figure 1) was characterised. In total, 22 Mg of SMC (between 1 and 5 Mg per HWRC) was collected during two weeks in June 2017 and sorted manually into (Table 1): (i) target waste fraction (plastic film, plastic packaging, glass packaging, metal packaging, polystyrene, paper and board, textile, etc.), (ii) small miscellaneous combustible, and (iii) Other (garden waste, PVC, treated wood, residual household waste). We avoided compacting and sieving in order to distinguish individual material fractions. The samples were transported to the sorting facility in closed containers (30-36 m^3) to protect waste from weather exposure and minimise any physical changes that may result in inaccurate waste composition data.

At the sorting facility, the loaded waste was first sorted according to the type of plastic bags containing the waste, which were (1) black bags, (2) clear bags, (3) other bags and (4) "loose waste" referring to waste disposed without bags. Following, the waste from each bag type was sorted separately.

2.3 Data visualisation tools and statistical analysis

2.3.1 Data visualisation tools

Various dynamic visualisation techniques were applied to explore and capture insights into waste data prior to statistical analysis. In contrast to classical visualisation plots, geometric mean bar plot (Edjabou et al., 2017a) was used to estimate ratio changes in waste composition. This graph enables to picture systematically changes in percentage of each waste fraction in a group compared to the average of all the groups, which is considered as a consistent reference. Thus, a negative value indicates that the percentage of a group has decreased compared to the average of all the groups, whereas the contrary is true for a positive value.

Ternary diagram (Hamilton, 2017; Pomberger et al., 2017; Thió-Henestrosa and Martín-Fernández, 2005) was employed to simultaneously visualise changes in waste composition for all HWRCs in the period 2010 to 2016. Finally, principal component analysis of waste composition based on a standard covariance biplot for the centered log-ratio (clr-biplot) permitted showing multivariate compositional waste data on a one plot diagram (Aitchison and Greenacre, 2002). These graphs have the advantage of illustrating clearly the variability of individual waste fractions (based on log-ratio transformation) and their relationship. Additionally, they enhance the visibility of the variability of waste fractions and their relationships between several parameters including waste fractional composition, years, HWRC, municipalities and regions (Pawlowsky-Glahn and Egozcue, 2011).

For total waste collected and number of visitors, we used the arithmetic mean ratio to quantify and visualise average monthly variation in waste collection during the study period (Cowpertwait and Metcalfe, 2009). This method compares consistently collected waste and number of visitors, regardless of their units.

2.3.2 Statistical analysis methods

The dynamic relationship among waste fractions was addressed applying time series techniques. First, time series decomposition (Ellis, 2016) was used to identify possible seasonal or cyclical patterns and trend in amount of waste collected and its composition. Second, seasonal Kendall test was applied to test for statistical significance of trend and seasonality patterns (Pohlert, 2016) Third, Pettitt´s test was applied to ascertain whether the waste collection significantly changed in the period 2010-2016 (Pohlert, 2016). Finally, autocorrelation function (acf) was used to evaluate the dynamic correlation between waste fractions (Barry, 2016).

We also analysed statistical relationship between waste and (i) visitors at the sites, (ii) inhabitants, and (iii) density. This was addressed using the classical Spearman correlation test using symmetric balances (Kynčlová et al., 2017). This latter correlation method addresses the problem of total sum constrain and the interpretation of correlation coefficients is similar to the classical correlation test.

For this study, 5% significance level was used as recommended (European Commission, 2004; Nordtest, 1995; US EPA, 2002).

2.3.3 Programming software R packages

Data analysis and statistics were carried in R (R Core Team, 2017), using *tidyverse* (Hadley, 2017) and *lubridate* (Grotemund and Wickham, 2011) for data wrangling; *ggplot* (Wickham, 2009) for graphics, *ggtern* for ternary plot (Hamilton, 2017), and *Composition* (van den Boogaart, 2008) and *robComposition* (Filzmoser and Hron, 2009; Templ et al., 2011) for compositional analysis techniques.

3 Results and discussion

3.1 Waste collected at HWRC

3. 1.1 Aggregated annual waste collected at HWRC

Total annual waste collected in 36 HWRC is shown in Table 2. Noticeably, the mass of waste was zero from 2010 to 2012 in Bispeengen, because this centre was established in 2013. The results show that the waste collection fluctuated considerably for the period 2010-2016. The highest mass was recorded in 2011 at HWRC of Hvidovre (about 41,000 Mg/year) in Greater Copenhagen, and the lowest was at HWRC of Sejeroe, which is a small island (about 260 Mg/year) in Central Zealand (Table S2).

The total mass of waste increased sharply in 2011 and declined suddenly in 2012 in most HWRCs (Figure 2). Subsequently, it increased steadily from 2014 to reach almost the same level as in 2011 in Central Zealand, and Silkeborg. Meanwhile, the mass of waste in Djursland showed a downward trend (Figure 2).

The waste collection rates computed for each municipality are shown in Table 3. Most waste collection rates decreased steadily from 2012 to 2016 (Table 3 and Figure S1). For example in 2016, waste collection rates in the municipality of Copenhagen were 127 kg/household/year, 64 kg/person/year and 93 kg/visitor/year (Table S3). On the contrary, for the same year, the waste collection rates equalled to 1481 kg/household/year, 630 kg/person/year and 68 kg/visitor/year in Dragoer (Table S3). These results are within the range of estimates in the UK. For instance, 83-292 kg/person/year and 174 kg/person/year were reported in Southampton (Woodard et al., 2004) and Altrincham (WRAP, 2012), respectively. Additionally, Norfolk County Council estimated 341- 379 kg/person/year, 753-906 kg/household/year and 744-1514 kg/visitor/year (Norfolk County Council, 2015). Consequently, a meaningful comparison among performance of HWRCs should account for the difference between units of waste collection rates.

The most striking observation to emerge from Table 3 was the number of visitors per household, which is the ratio between waste collection rates per household and per visitors (Table S2). For illustration, the number of visitors per household in Frederiksberg in 2010 was 0.43 visitor/household (Table S2 and Figure S1 and S2). The number of visitors per household was lowest in Copenhagen (1.3 visitors/household) and highest in Dragoer (23 visitors/household) in the period 2010-2016. However, the average number of person per household were 2.4 and 2.0 in Dragoer and Copenhagen respectively (Table S3). Thus, the key difference between these municipalities is the ratio between housing types (single and multi-family houses). In the municipality of Copenhagen about 92% of houses are multi-family houses where lives about 88% of the population. Conversely, the municipality of Dragoer accounts 22% of multi-family houses and where 18% of the population lives (Table S1). This finding indicates that citizen from single-family house areas may tend to visit more often HWRC than those in multi-family house areas. A possible explanation might be that garden waste occurs in single-family houses. Moreover, construction and demolition waste may also arise more often in single-family houses due to activities such as rehabilitation, new construction, etc. However, despite these explanations, care is needed in further interpretation of these results, because municipalities in the Greater Copenhagen are very close and citizens may use any HWRC regardless of the municipalities where they live (Figure 1).

3.1.2 Monthly waste collection

A decomposition plot shown in Figure 3 illustrates the monthly waste collection (Figure 3.a), the underlying trend (Figure 3.b), and the seasonal patterns (Figure 3.c). Figure 3.a shows that the total waste collected followed regular cycles, exhibiting clear seasonal patterns displayed in Figure 3.b, which reveals a modest upward trends.

The arithmetic mean ratio (in percentage) boxplots for total waste and the number of visitors from all HWRCs is shown Figure 4, displaying the dynamic relationship between the mass of collected waste and the number of visitors at HWRCs. The boxplots are based on data from individual HWRC. Dots show the ratios (mass and the number of visitors) for each month at individual HWRC.

Figure 4 illustrates also the seasonal and monhtly variation between the mass of collected waste and the number of visitors enabling to comprehend their dynamic interaction. Here, negative mean ratios indicate that the monthly value is lower than the average value for the same year, whereas positive mean ratios indicate that the monthly value is higher than the average for the same year (Table S4).

In November 2011, extremely high mass was collected from HWRC in Hvidovre, mainly due to cleaning after the storm, which occurred in 2011 and led to flooding in this area. This is illustrated in Figure 4 by a dot that is higher than 100%.

The results point out that the total mass and the number of visitors follows the same seasonal patterns. The highest number of sites users and total mass was in April and May, decreased moderately and consistently in summer and autumn months (April to October). Subsequently, the sites users and the mass of waste dropped dramatically to the lowest value in winter from November to March (Figure 4). The results also show that the average mass of waste and number of visitors (red point in each boxplot) were 35-54% lower than their respective average from December to February. On the other hand, the average mass and number of visitors were 27- 41% higher than their individual average in May and July.

The comparison between number of visitors and total mass could indicate that the average visitor brings more waste when the mean ratio of mass waste is higher than visitors. For example, a visitor at HWRC in May, August, and November, may bring more waste compared to January to April and July (Figure 4).

3.1.3 Dynamic patterns and factors affecting the mass of collected waste

Table 4 presents the results of the Kendall test. Here, DF is the degree of freedom equalled to 11 (12months minus 1). P-values measure statistical significance for trend (z (Trend)) and heterogeneity (Chi-Square (Het)) respectively. The heterogeneity measures the difference between the observed trends. The 95% confidence intervals refer to the trend values.

The results shown in Table 4 depict a decreasing trends in Djursland (-0.39 Mg/year) and Copenhagen (-0.22 Mg/year) and increasing trends in Silkeborg (1.86 Mg/year) and Central Zealand (1.60 Mg/year), over the period 2010 and 2016 (Figure 3.c). However, the seasonal Kendall test for trend presented in Table 4 (p-values > 0.05 and two-sided 95% confidence intervals contain zero value) indicated no statistically significant trend in collected waste. These results may imply that the mass of collected waste in the period 2010 – 2016 did not significantly change. On the other hand, the autocorrelation (ACF) graph (Figure S3) displays a clearly seasonal pattern in mass of collected waste, implying that a time series analysis of waste collection at HWRCs should include a seasonal component.

Figure 2 depicts a noticeable increase in total mass of waste collected in these regions in 2011. However, the test of change-point detection (Pettitt´s test) reveals that it was only in Hvidovre that the collected waste in 2011 (in November) was significantly higher during the study period, for the reason previously explained.

The spearman correlation test (Table S6-8) indicates that the number of visitors to HWRCs was highly correlated with discarded waste (r = 0.80- 0.96). However, there was a weak correlation between the mass of waste and both the number of households (r = 0.32) and the number of inhabitants (r= 0.33) for each municipality. These results suggest that the total waste collected at HWRC may be highly driven by the number of visitors. Moreover, the correlation test (Table S10) also shows that the number of visitors was principally influenced by single-family houses (r = 0.83 for number of houses and r = 0.85 for the number of persons). Owned to these findings, the disparity between waste collection rates (kg/person/year and kg/visitor/year) shown in Table 3 may be explained by the ratio between single-family and multi-family households. For example, the estimated waste collection rates per visitor were higher than per inhabitant in Copenhagen and Frederiksberg (2013-2016), where about 92 - 97% of household are multi-family houses (Table S1).

3.2 Waste composition based on main fractions

3.2 1 Aggregated yearly waste composition based on main fractions

The yearly composition of main waste categories is shown in Table 2. The waste collected at HWRC mainly consisted of construction and demolition (C&D) waste in Greater Copenhagen (24-30%), and garden waste (24-32%) in other regions (Central Zealand, Djursland and Silkeborg). A plausible explanation is that Greater Copenhagen is the capital city. It consists mainly of multi-family houses (Table S1), generating less garden waste. Additionally, there may be more building activities in the capital city generating construction and demolition waste.

The target waste fractions represented was one of the predominant waste fractions occurring in these regions. Remarkably, the percentage of target waste nearly doubled (from 13 to 22%) in Greater Copenhagen from 2010 to 2011 (Table 2). This is due to establishment of a new source segregation fraction, namely wood (untreated wood), to substitute bulky waste, which were removed from HWRCs.

Overall, small miscellaneous combustible and bulky waste accounted for more than 10% of total waste at HWRCs (Table 2). Moreover, the percentage distribution between main waste fractions vary considerably between regions. This is illustrated in Figure 5 (Clr-biplot) according to two distinct groups: (1) Djursland and (2) other areas (Central Zealand, Greater Copenhagen, and Silkeborg). Figure 5 indicates also that waste composition at HWRCs from where small miscellaneous combustible waste was sampled and characterised (Grenaa, Hvidovre, Jyllinge, Tandskov, Tietgensvej, Vermlandsgade and Viby) exhibited similar patterns as other HWRCs in their respective group. The difference between these groups is mainly due to "other waste" representing the second largest categories in Djursland (18-23 %). The underlying reason is that Djursland is located in rural area with large landfill capacity. As a result, this area receives considerable amount of landfill waste from neighbouring municipalities, which is accounted as waste from HWRC. On the contrary, "other waste" accounted less than 12% in other regions. Moreover, Figure 5 depicts that while wood was predominant main fraction in Greater Copenhagen, fibres and other (paper, board and textile), soil and construction and demolition waste were also prevalent in this region. We also notice that HWRCs in Greater Copenhagen can be further subdivided into two groups: (1) HWRCs located in areas with prevalence of single-family houses with garden (Dragoer) and (2) those located in areas with prevalence of multi-family houses such as Copenhagen, Frederiksberg and Taarnby. The difference between these two sub-groups in Greater Copenhagen was that target waste fraction (mainly wood) was predominant in the HWRCs located in the neighbourhood of multi-family houses, whereas soil and garden waste constituted the principal categories in HWRCs located close to single family houses with garden namely Taarnby (Table S11 and S12 for detail waste composition).

3.2.2 Monthly waste composition based on main fractions

Multivariate analysis show that the composition of most waste fractions exhibited a significant seasonal variation patterns (Table S9). Additionally, a generalised univariate analysis (Table S10-11) indicate a significantly seasonal patterns for most main categories and HWRCs excluding Christiania (Copenhagen), Sejeroe (Central Zealand), and Roende (Djursland). These later HWRCs recorded relatively small mass (Table 1), which fluctuates independently of monthly variation.

While the relationship between the collection of garden waste and seasonal variation is quite well documented (Boldrin and Christensen, 2010), these results suggest that the collection of most main fractions at HWRCs may be also significantly associated with seasonal variations.

3.3 Variation of waste treatments forms

A comparative composition of waste fractions based on treatment forms is illustrated in Figure 6. The percentage of waste for other treatment forms was lowest (9-14%), whereas recycling (65-75%) was the largest waste treatment forms followed by incineration (14-19%). The geometric bar plot (Figure 7) reveals an overall relative increase in the percentage of recycling and a relative decrease of incineration. Moreover, there was a relative small change in the composition of waste treatment forms in Djursland compared to other areas. Although the percentage of other treatment form was the smallest and almost constant in Figure 6, it fluctuated considerably during this period as shown in Figure 7. For example, the percentage of other treatment forms was 30% higher than the average in 2010, and 24% smaller than the average in 2016. Figure 7 shows that the percentage of recycling decreased from 22 to 4% in Greater Copenhagen in 2016. This may be explained by the new regulation banning the recycling of construction and demolition waste contaminated or suspected to be contaminated with PCB (Christensen et al., 2016). Figure 7 also highlights a drastic relative change in percentage of incinerated waste in Greater Copenhagen (74 to 4 higher than average) and “other treatment” (85 higher to 12 lower than average) in 2011. This sudden decrease was mainly due to the establishment of wood waste as a separate waste fraction in HWRCs.

To compare the performance of individual HWRCs, we used ternary plot presented in Figure 8, where three groups of HWRCs are distinguished: (1) Christiania (from Greater Copenhagen area) and Sejeroe (from Central Zealand) where the lowest mass of waste was recorded; (2) all HWRCs in Djursland, and (3) other HWRCs from Central Zealand, Greater

Copenhagen and Silkeborg. The difference between the second and the third group was the percentage of waste treated by means of other treatment forms, which was 15-25% in Djursland and less than 20% in the third group. Additionally, a moderate decrease in the percentage of incinerated waste was observed in Djursland (15 to 12%). On the other hand, there was a considerable decrease in incinerated waste in the third group (40 to 13%). Figure 8 indicates also that the performance of monitored HWRCs was comparable to other HWRCs in the distinguished groups.

3.4 Effectiveness of black plastic policy

The characterisation of 22 Mg of small miscellaneous combustible (SMC) from seven HWRC reveals that 50% (41-57%) of SMC was disposed of in HWRC without using bag. On the other hand, 23% (11-36%) and 19% (12-25%) of SMC was disposed of using clear, and mixed plastic bags, respectively. Moreover, 7% (3– 9%) waste was brought in black bags, although it was forbidden. Seemingly, the percentage of SMC brought in black bag was relatively lower compared to other bags (Figure 9). The results showed that black bags and other bags contained principally target waste fractions. This finding suggests that misplaced target waste fractions could be considerably reduced if users bring their waste mainly using clear plastic bags.

The data revealed also that overall, only 32% (19-44%) of waste was SMC, suggesting that about 68% (56-81%) of waste was misplaced materials, consisting of 49% (41-60%) target waste fractions and 18% (13-35%) hazardous and other waste. These results indicate that considerable efforts and initiative are needed to reduce significantly the percentage of misplaced waste in containers for SMC. They may also support the “believe” that citizens tend to dispose of their waste in the container for small miscellaneous combustible when they are in doubt.

Importantly, some of the clear plastic bags contained only target waste fractions. This may suggest that although some citizens may correctly sort their waste at home, they unfortunately dispose their sorted waste in the container of SMC. Therefore, an adequate assistance to users, such as the “meet-and-greet staff” strategy (WRAP, 2012), could provide help to users in disposing their waste in the appropriate waste containers.

Figure 10 show the potential recycling rates achievable if no target waste and hazardous waste are disposed in container for SMC. For most of the HWRCs, there would be an obvious increase in recycling rates, as well as other waste treatment forms. Noticeably, the percentage of incinerated waste would decrease considerably from 32 to 15 % in Viby (red arrow in Figure 10 moving from 2016 to the estimated potential recycling rates) and Jylling, whilst only a 3 % increase in the recycling rate would be observed in Hvidovre. These results highlight that the effort and benefit to reduce misplacement of target recycling waste vary according to the HWRC, because of the difference in the percentage of SMC. For example, in 2016, the small miscellaneous combustible waste amounted to 5-7% in Greater Copenhagen, Djusrland and Silkeborg, and 11% in Central Zealand.

3.5 Implications and perspectives

The waste analysis shows that the waste collection at HWRC was mainly driven by the number of visitors, which was significantly affected by the number of single-family houses. The large disparity in waste collection rates between municipalities may cause serious inconsistency in comparing the performance of HWRCs.

The findings of this study urge waste practitioners and researchers to explore new dynamic visualisation tools to enclose features contained in waste data and consistently compare waste composition data. Various data visualisation tools were used to fully understand and capture patterns in waste collection and composition data. Stacked bar plot (Figure 6) visualises the distribution between waste treatment forms in a quite intuitive manner. However, changes in "other treatment" are barely noticeable and direct comparison between areas was not striking. Fortunately, these limitations are transcended by geometric bar plot (Figure 7), which quantify relative changes regardless of the size of the fraction (percentage). Furthermore, the trend in waste treatment forms were perceptible (and the comparison between areas were directly feasible in Figure 7. Markedly, recycling has increased whereas incineration and "other treatment" have decreased. Despite these advantages, presenting a geometric bar plot of 36 HWRCs in one page may be overwhelming and technically challenging. Nevertheless, this is an area in which ternary plot excels. Figure 8 allows presenting the treatment forms of 36 HWRCs, from 2010 to 2016. This visualisation enables to monitor the past, the current and to model the future paths as shown in Figure 11. Additionally, ternary plot enables a direct comparison between many parameters by grouping the HWRC having the same patterns. However, ternary plot can be used only for illustrating three parameters at a time (here waste treatment forms). An alternative could be clr-biplot, which take into consideration the inherent nature of compositional datasets.

The results of seasonal analysis indicates the total waste collection as well as main waste fraction follow seasonal patterns. Importantly, seasonal variation significantly affected the number of visitors, which was strongly correlated with the waste collection. These results imply that a public awareness campaigns should be carried out in the period April-September in order to target a broader and larger audience.

Characterisation of SMC provided substantial information about misplacement rates. This may also suggest that characterisation of all fractions sorted at HWRC is required in in mapping impurity and misplacement rates. This information contributes to optimise waste collection and increase the purity of recyclable materials and thereby conduct a reliable material flow analysis as well as environmental impact assessment of a HWRC.

4 Conclusions

The purpose of this study was to analyse historical waste compositional data to enable an optimal planning of household waste recycling centres. This study identified that the mass of waste collected at recycling centres was significantly correlated with the number of visitors. Moreover, the number of visitors and waste collection followed a seasonal pattern. The seasonal Kendall test for trend revealed no significant trend in waste collection suggesting that it did not significantly change during the period 2010-2016. The results also showed a large discrepancy in waste collection rates (kg/visitors/year, kg/inhabitant/year, and kg/household/year), which could be explained by the ratio between number of visitors and single-family houses. However, a further historical data analysis of all household waste streams may provide a comprehensive understanding of the discrepancy between waste collection rates. This may help identifying the factors influencing waste collection and its composition.

We also observed an increase in recyclable rates and a decrease in the percentage of incinerated waste for the 36 HWRCs involved in the study period 2010-2016. This demonstrates the importance of ternary plot for comparing directly multiple parameters.

The characterisation of small miscellaneous combustible waste suggested that about 7% of small miscellaneous combustible was brought in black plastic bags. Overall, about 68% of small miscellaneous combustible was misplaced materials consisting of recyclable materials (49%) and hazardous waste and other (18%). These results suggest that a consistent material flow analysis of waste from recycling centres may require a characterising of source-segregated waste fractions in order to estimate misplacement rates.

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Temporal and geographical patterns of solid waste collected at recycling centres

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List of Tables

Table 1: List of waste fraction disposed of at HWRC grouped into Waste treatment forms, Main waste fraction, and Waste target fractions

Waste Treatments	Main fractions	List of components
Incineration	Bulky	(1) Furniture, (2) sludge and Other bulky waste
	Small miscellaneous combustibles (SMC)	(3)Residual household waste (4) Miscellaneous combustible
Recycling	Construction and demolition waste (C&D)	(5) Asphalt residues, (6) bricks, (7) mixed bricks, (8) blocs and tiles, (9) concrete, (10) Gypsum waste, (11) sanitary ware, (12) tiles, (13) waste exchange
	Garden waste	(14) Garden waste
	Soil	(15) Soil
	Fibres and other[a]	(16) Paper and board, (17) Textiles
	Glass[a]	(18) Glass packaging, (19) window glass
	Metal[a]	(20) Cables, (21) ferrous metal, (22) metal containers and cans, (23) non-ferrous metal
	Plastic[a]	(24) hard plastics, (25) plastic composite, (26) plastic film, (27) plastic garden furniture, (28) polystyrene
	Wood[a]	(29) untreated wood
Other[b]	Other waste	(30) Anti-freeze, (31) asbestos, (32) waste, (33) batteries, (34) big bags, (35) CDs and DVDs , (36) chemical fertilize, (37) clinical waste, (38) cooling and heating white goods, (39) fire extinguisher, (40) fireworks , (41) garden herbicides and pesticides, (42) gas bottles, (43) landfilled waste, (44) large household Appliances, (45) lighting equipment, mattresses, (46) mineral oil, (47) mixed waste, (48) other wood, (49) paints, (50) polyvinylchloride (PVC), (51) printer cartridges, (52) small household appliances, (53) solvent-based waste, (54) spray can, (55) thermal insulation materials, (56) treated wood, (57) tyres, untreated wood, (58) waste accumulators, (59) windows glass with PCB

[a]*Target waste fractions consisted of Fibres and textiles, Glass, Metal, Plastic and wood;* [b]*Landfill, temporarily storage and special treatments*

Table 2: Waste composition [% wet mass basis] at HWRC based on main waste categories

		Waste composition [%]						
Areas	MWC[a]	2010	2011	2012	2013	2014	2015	2016
	Fibres[c]	2.80	2.60	2.60	2.70	2.60	2.60	2.90
	Plastic	0.10	0.10	0.30	0.70	0.90	0.90	1.00
	Metal	4.70	4.40	4.20	4.10	3.80	3.90	4.20
	Wood	4.00	13.50	13.90	14.70	14.80	15.70	15.90
	Glass	1.40	1.40	1.10	1.10	1.00	1.10	1.00
Greater Copenhagen	*TWF[b]*	*13.00*	*22.00*	*22.10*	*23.30*	*23.10*	*24.20*	*25.00*
	Garden	12.30	12.90	11.90	12.60	13.00	12.60	12.90
	Soil	14.10	14.00	15.40	14.10	14.50	14.50	13.90
	C&D	24.40	31.40	32.50	32.10	32.80	32.60	30.80
	SMC	12.40	11.00	9.60	9.40	8.70	8.10	7.80
	Bulky	8.00	1.20	0.40	1.30	1.40	1.30	1.40
	OW	15.80	7.50	8.00	7.10	6.40	6.70	8.20
	Total[d]	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Mg/year wet mass[f]	Total	106156	123789	93360	90652	99548	104371	104521
	Fibres[c]	2.30	2.00	2.10	2.10	1.90	1.90	1.80
	Plastic	0.00	0.00	0.00	0.10	0.10	0.10	0.10
	Metal	4.10	4.30	4.30	3.90	4.30	4.30	4.70
	Wood	0.10	0.00	0.00	0.00	0.00	2.30	6.60
	Glass	2.20	2.30	2.70	2.30	2.30	2.40	2.00
Central Zealand	*TWF[b]*	*8.70*	*8.60*	*9.10*	*8.40*	*8.60*	*11.00*	*15.20*
	Garden	26.00	24.20	25.70	25.30	25.80	25.50	25.90
	Soil	8.60	7.80	7.90	7.30	8.20	8.10	8.10
	C&D	24.00	23.80	24.00	23.90	25.10	25.70	25.40
	SMC	12.00	18.00	12.30	12.60	13.60	14.20	11.10
	Bulky	11.70	8.40	12.90	13.10	11.90	9.50	7.90
	OW	8.90	9.20	8.00	9.50	6.80	6.00	6.30
	Total[d]	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Mg/year wet mass[f]	Total	118773	147437	126747	127689	132580	138100	140811
	Fibres[c]	1.90	1.90	1.80	1.80	1.70	1.80	2.30
	Plastic	0.70	0.90	0.90	1.00	0.90	1.00	1.00
	Metal	4.30	4.70	4.40	4.50	4.40	5.00	5.00
	Wood	7.00	7.10	7.00	7.20	7.00	7.90	8.70
	Glass	0.80	1.60	1.80	1.80	1.70	2.00	2.20
Djursland	*TWF[b]*	*14.70*	*16.20*	*15.90*	*16.30*	*15.70*	*17.70*	*19.20*
	Garden	28.50	29.60	33.10	34.40	37.50	33.30	32.30
	Soil	9.70	6.90	7.00	6.00	6.20	6.40	6.50
	C&D	14.80	16.00	15.20	14.60	14.00	14.50	13.70
	SMC	6.00	6.10	5.80	5.80	5.40	5.50	5.50
	Bulky	3.50	3.30	3.30	3.30	3.00	3.00	3.20
	OW	22.80	22.00	19.60	19.70	18.20	19.70	19.60
	Total[d]	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Mg/year wet mass[f]	Total	40320	42861	40841	39251	42921	40358	37254
	Fibres[c]	3.70	2.80	3.40	3.90	4.10	3.60	3.80
	Plastic	0.10	0.20	1.00	1.20	1.20	1.30	1.20
	Metal	4.20	4.10	3.90	3.90	3.70	3.90	4.00
	Wood	6.00	8.30	9.70	10.80	11.30	11.10	11.10
	Glass	1.70	2.00	2.50	2.50	2.50	2.40	2.40
Silkeborg	*TWF[b]*	*15.70*	*17.40*	*20.50*	*22.30*	*22.80*	*22.30*	*22.50*
	Garden	26.00	27.00	28.30	26.50	27.70	27.60	27.00
	Soil	10.30	10.50	10.80	11.30	11.70	11.60	11.10
	C&D	20.50	22.30	21.70	21.50	20.90	21.80	22.20
	SMC	10.50	10.10	8.10	8.00	6.90	6.70	6.00
	Bulky	6.70	5.00	3.40	3.00	2.80	3.10	3.40
	OW	10.30	7.80	7.20	7.40	7.20	6.90	7.00
	Total[d]	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Mg/year wet mass[f]	Total	39306	41181	38324	37554	39523	40938	41389

[a]*Main waste categories;* [b]*target waste fractions;* [c]Fibers includes paper, board and textiles. [d]Total is rounded to 100.00. Due to significant digit, the total may not always sums up to 100; [f]Mass on wet basis in Mg/year

Table 3: Aggregated yearly waste generation rates (wet mass), expressed in kg/household/year for WCR_{house}, kg/inhabitant/year for $WCR_{inhabitant}$, and kg/visitors/year for $WCR_{visitor}$

Municipalities	Parameter	Years						
		2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Greater Copenhagen	WCR_{house}	326	377	244	235	257	268	266
	$WCR_{inhabitant}$	171	195	125	120	129	133	132
	$WCR_{visitor}$	118	125	117	112	98	97	98
Central Zealand	WCR_{house}	1143	1407	1205	1206	1243	1283	1299
	$WCR_{inhabitant}$	507	627	538	541	558	576	583
	$WCR_{visitor}$	-	-	172	131	130	121	127
Djursland	WCR_{house}	1128	1193	1134	1080	1172	1095	1002
	$WCR_{inhabitant}$	512	543	518	496	543	511	469
	$WCR_{visitor}$	103	100	99	95	100	90	88
Silkeborg	WCR_{house}	1020	1066	988	963	1008	1037	1035
	$WCR_{inhabitant}$	448	467	433	424	444	458	459
	$WCR_{visitor}$	99	98	94	91	89	90	94

[a]kg/visitor/year; [b]kg/inhabitant/year; Data on population statistics and density areas, and number of visitors are provided in Table S1-3.

Table 4: Results of testing for trend in waste generation using the seasonal Kendall test for trend:

Areas	DF[a]	Test Statistics		P-values		95% Confidence Interval[i]	
		Chi-Square (Het)[b]	z (Trend)[c]	Chi-Square (Het)[d]	z (Trend)[f]	LCL[g]	UCL[h]
Greater Copenhagen	11	6.699	-0.217	0.823	0.828	-0.251	0.172
Central Zealand	11	6.940	1.604	0.804	0.109	-0.033	0.270
Djursland	11	19.030	-0.390	0.061	0.696	-0.098	0.054
Silkeborg	11	18.466	1.864	0.071	0.062	-0.003	0.055

[a]*Degree of freedom;* [b]*chi-square test for heterogeneity;*

[c]*Test statistics value for trend*

[d]*p-value for chi-square test for heterogeneity indicating if the trend is different for different seasons;*

[f]*p-value associated with seasonal Kendall test for trend (p>0.05 signifies that the trend is not statistically significant)*

[g]*Lower bound confidence interval;*

[h]*Higher bound confidence interval*

[i]*The two sided 95% confidence interval for the trend(e.g. Djursland 95% confidence interval of estimated trend was [-0.09; 0.05])*

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Figure captions

Figure 1: Map of Denmark showing the population per municipality, 36 household waste recycling centres (HWRC) involved in this study from which seven were selected to evaluate the effectiveness of the black plastic bag policy. "Sorting WS" are HWRCs where small miscellaneous combustible (SMC) was sampled and characterised.

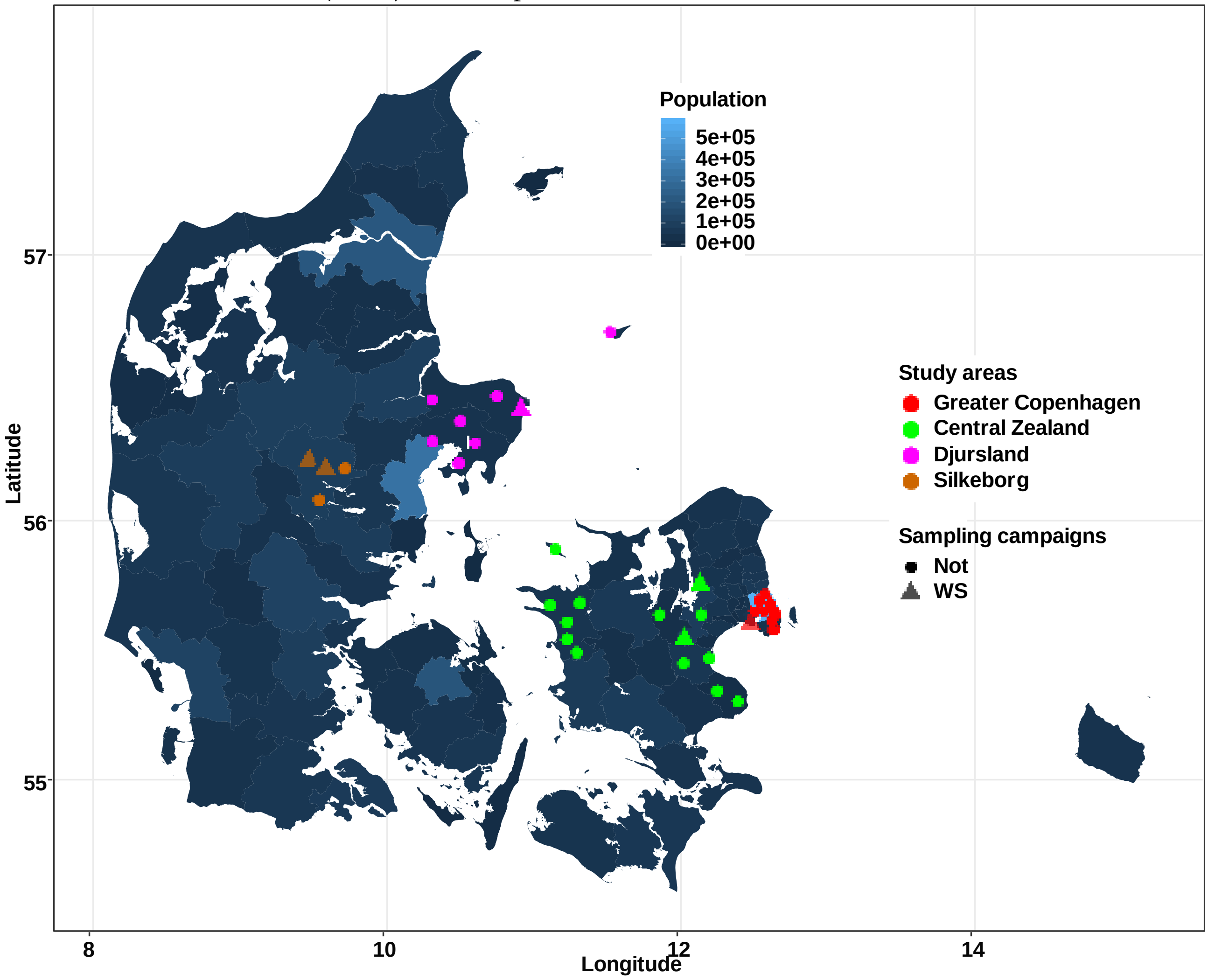


Figure 2: Total yearly waste generation [1000 Mg/year] in each study region from 2010 to 2016

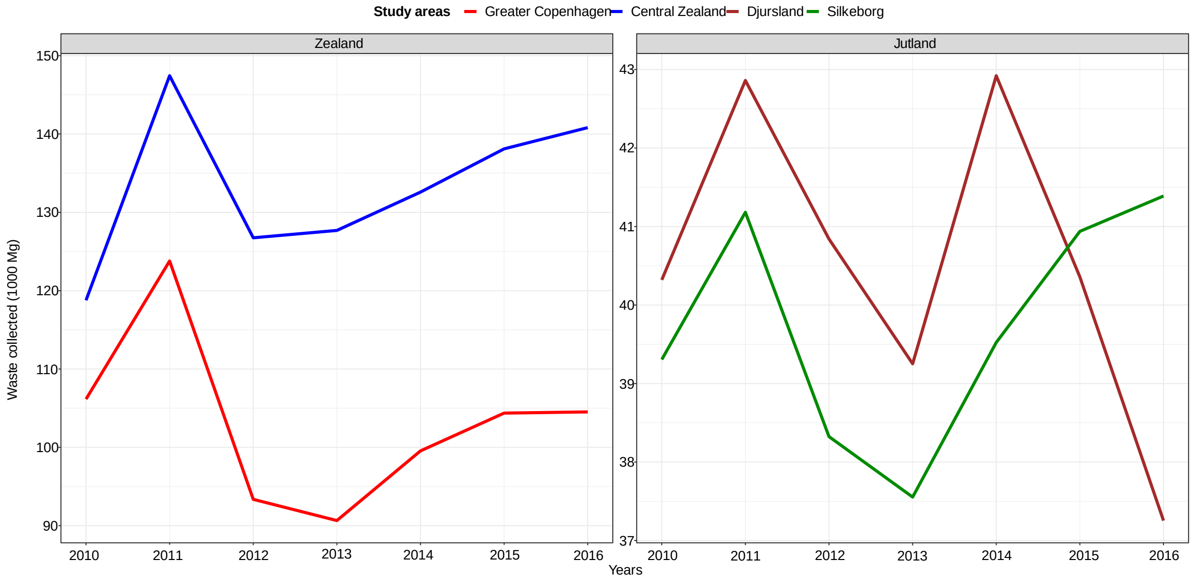


Figure 3: Decomposition of waste generation on a monthly basis in the four studies areas: Greater Copenhagen, Central Zealand, Silkeborg and Djursland.

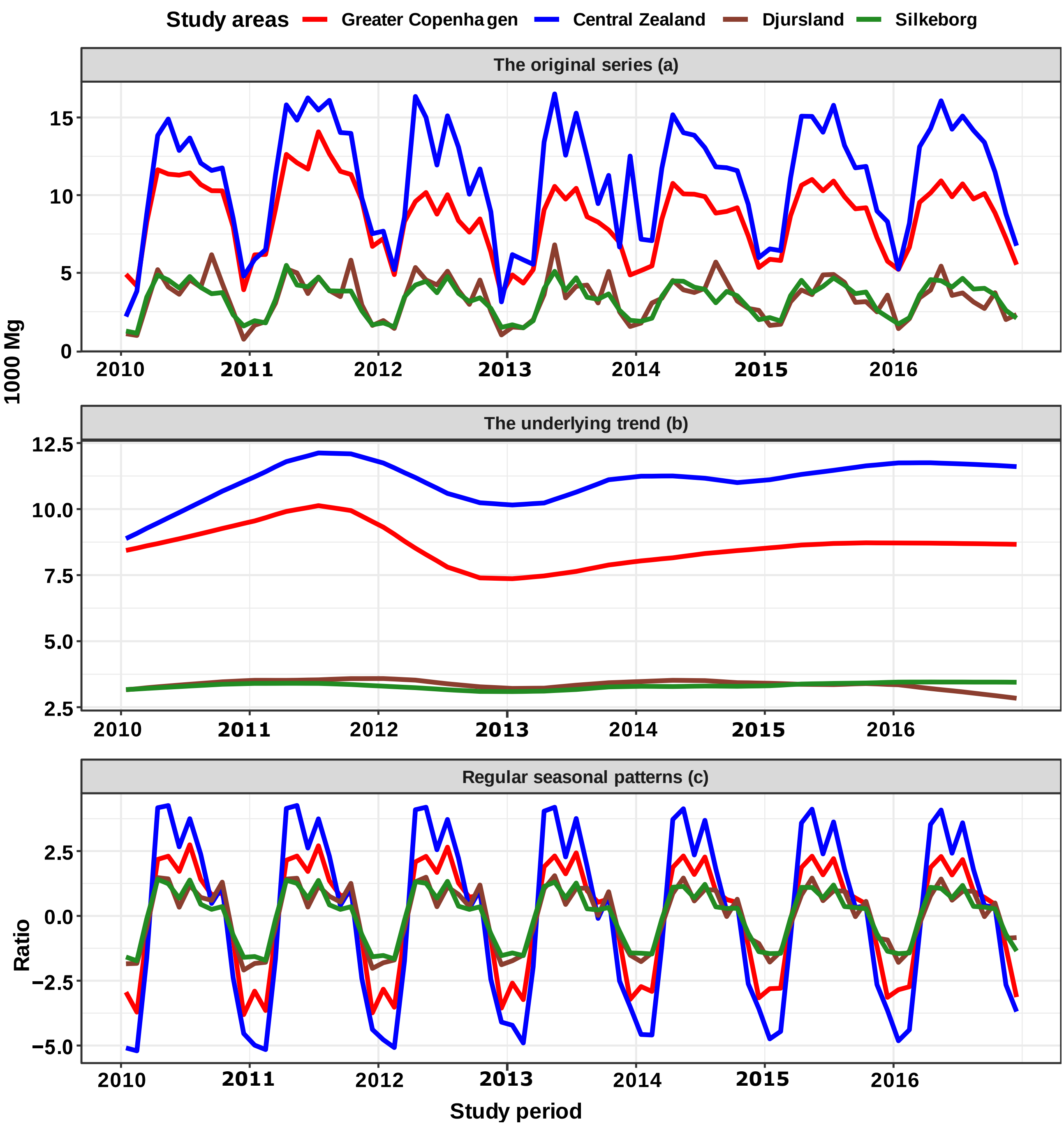


Figure 4: Boxplot showing the percentage change in mass of waste collected in and number of visitors for the period 2010-2016 (see Table S4-5 for detailed data)

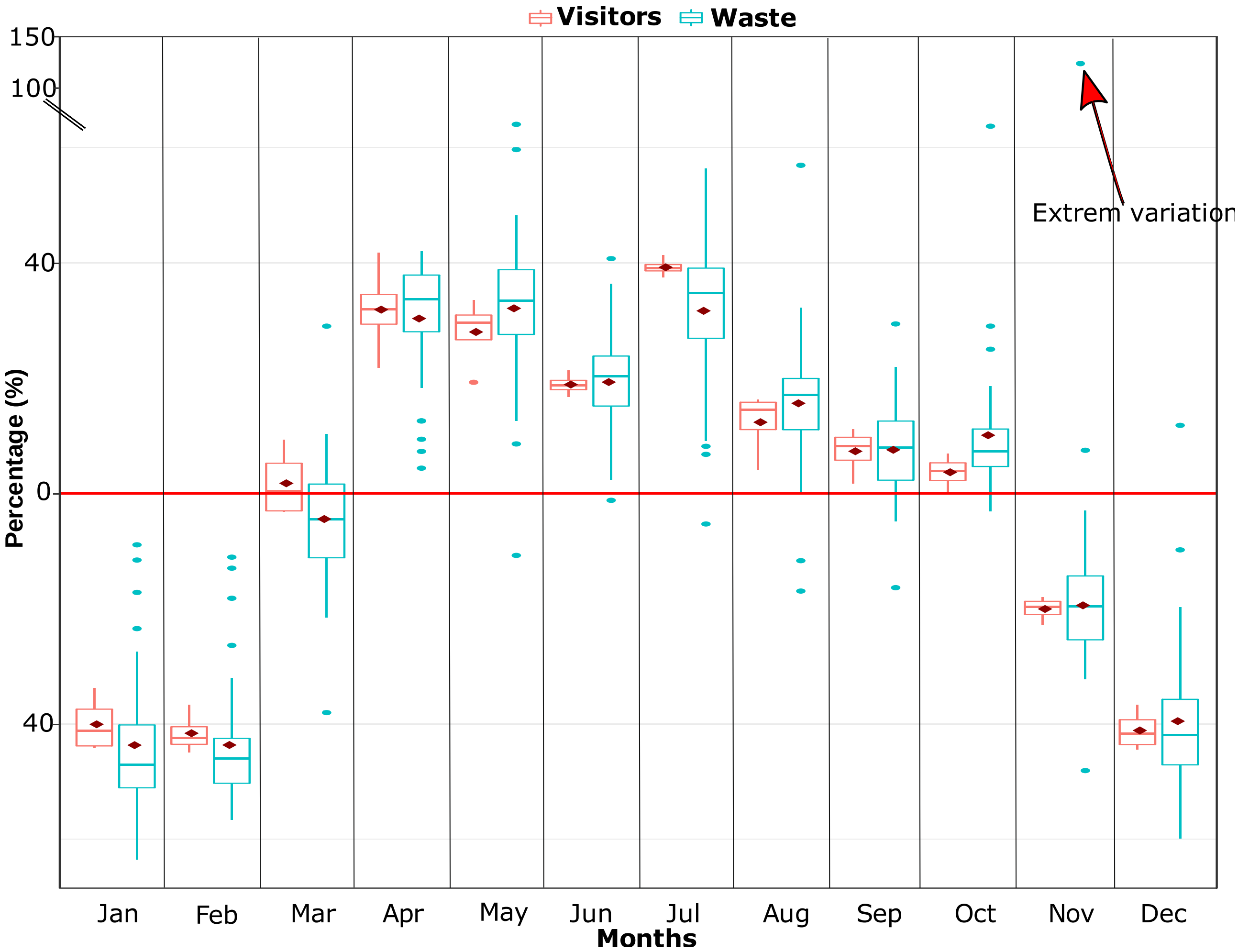


Figure 5:clr-biplot analysis of main categories and detailed target waste fractions. Dots represents the yearly waste composition. The proportion of the total variability retained by the first (1st) and second (2nd) equalled to 85%, indicating that the representation of the composition was significant.

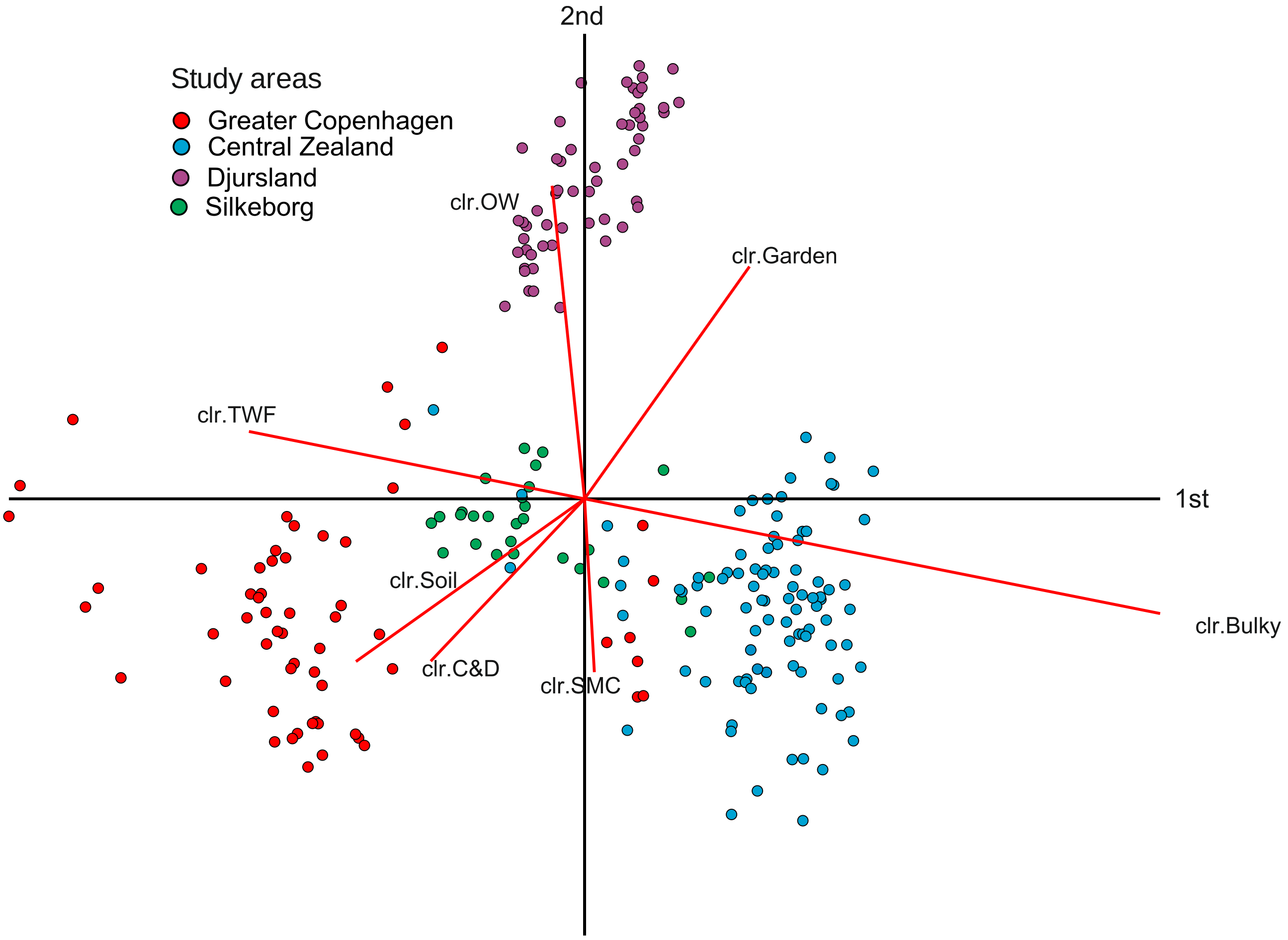


Figure 6: Bar plot showing the distribution of treatment forms of waste in Greater Copenhagen, Central Zealand, Silkeborg and Djursland from 2010 to 2016.

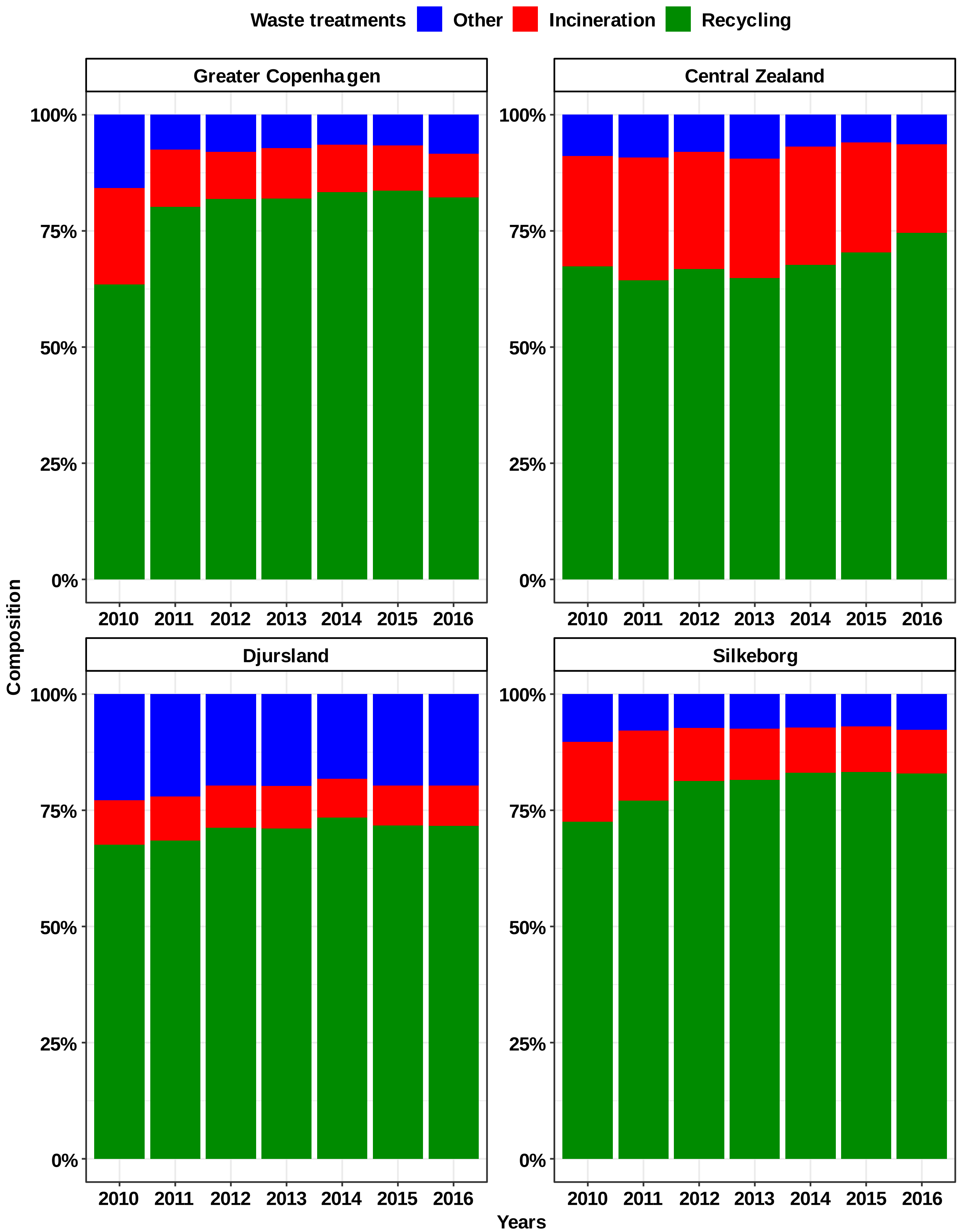


Figure 7: Geometric bar plot exploring the relative changes in treatment forms in Copenhagen, Central Zealand, Silkeborg and Djursland from 2010 to 2016

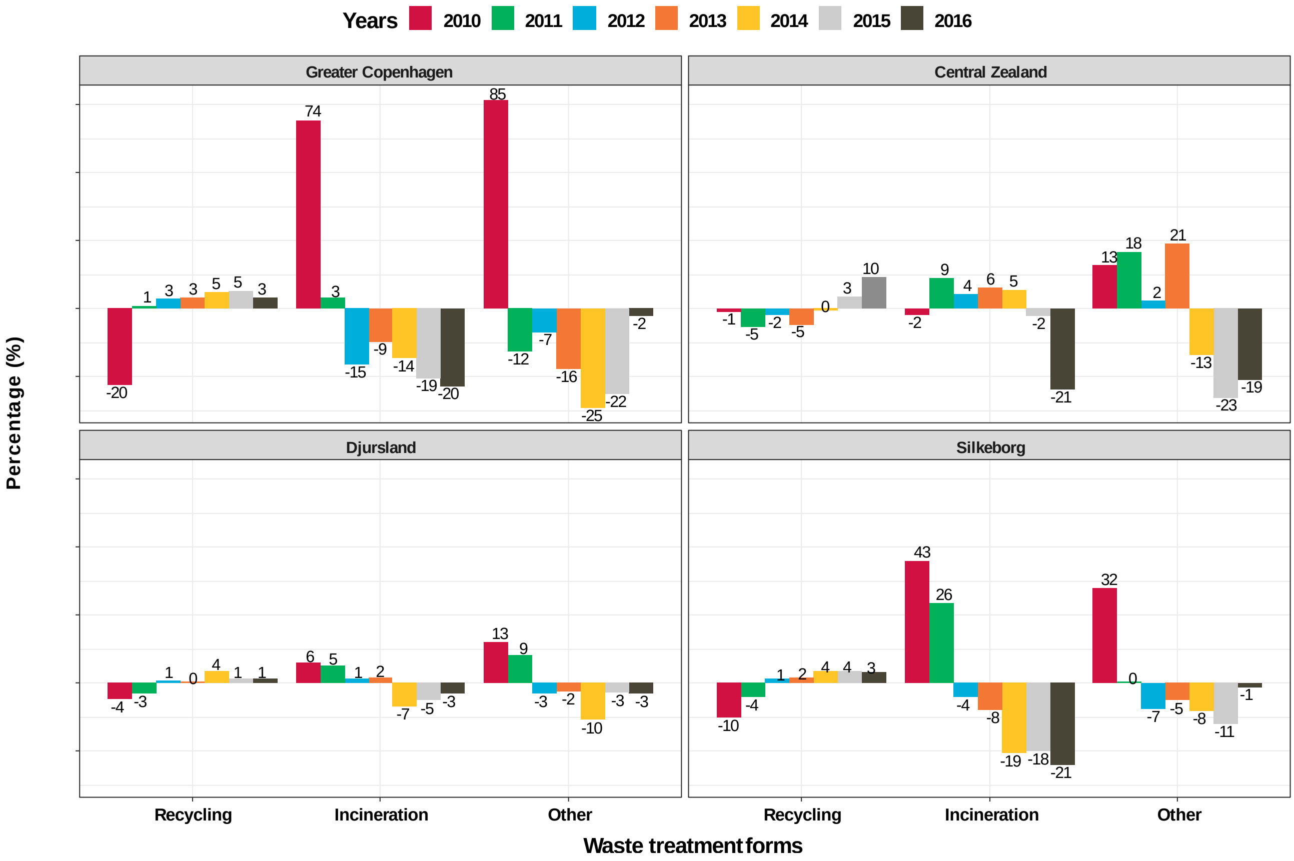


Figure 8: Ternary plot exploring the distribution between waste treatment forms. Dots present treatment forms in each HWRC from 2010 to 2016

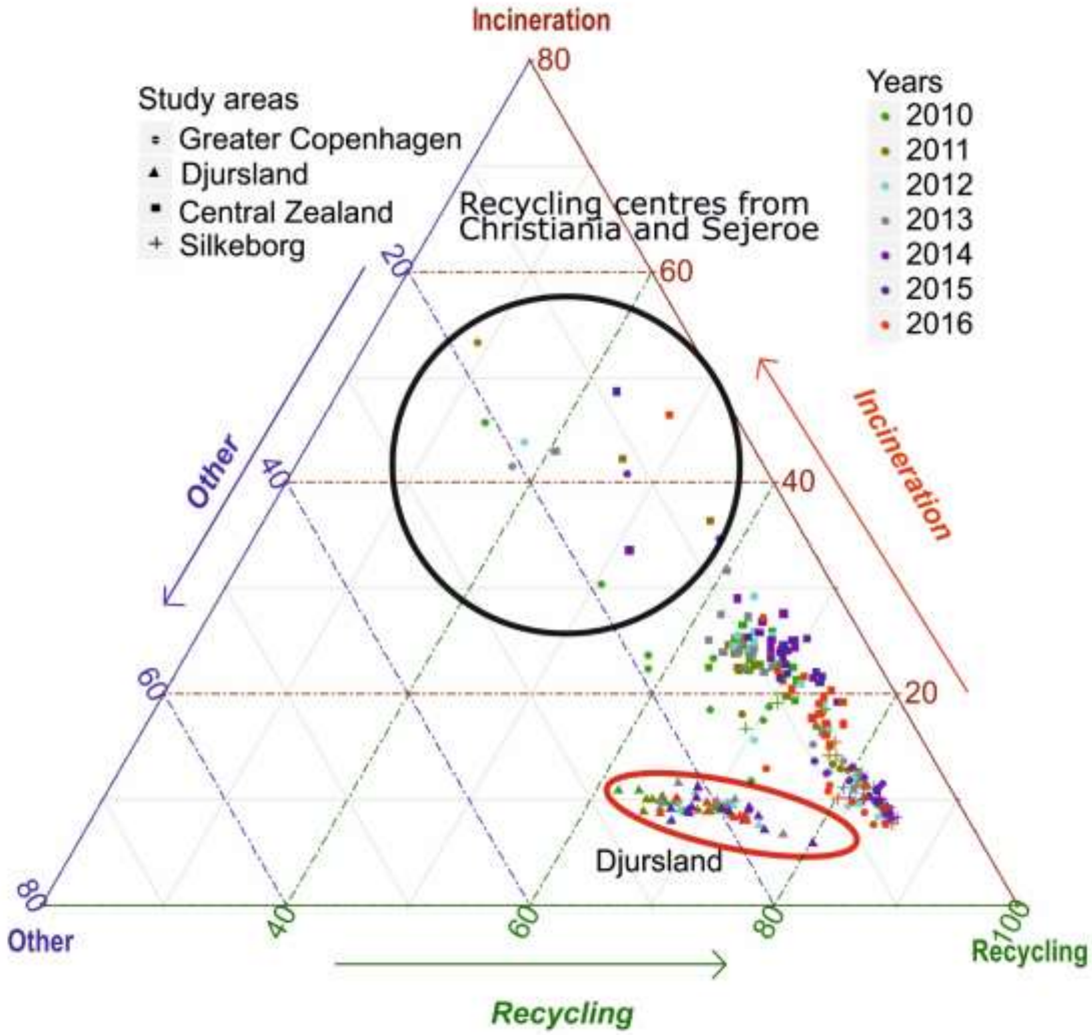


Figure 9: Composition of miscellaneous combustible from HWRC sorted according to delivery bags including mixed, clear, and black plastic bags as well as without bag. Waste sorted into target fractions, miscellaneous combustible and other (Table S14 for detailed descriptive statistics).

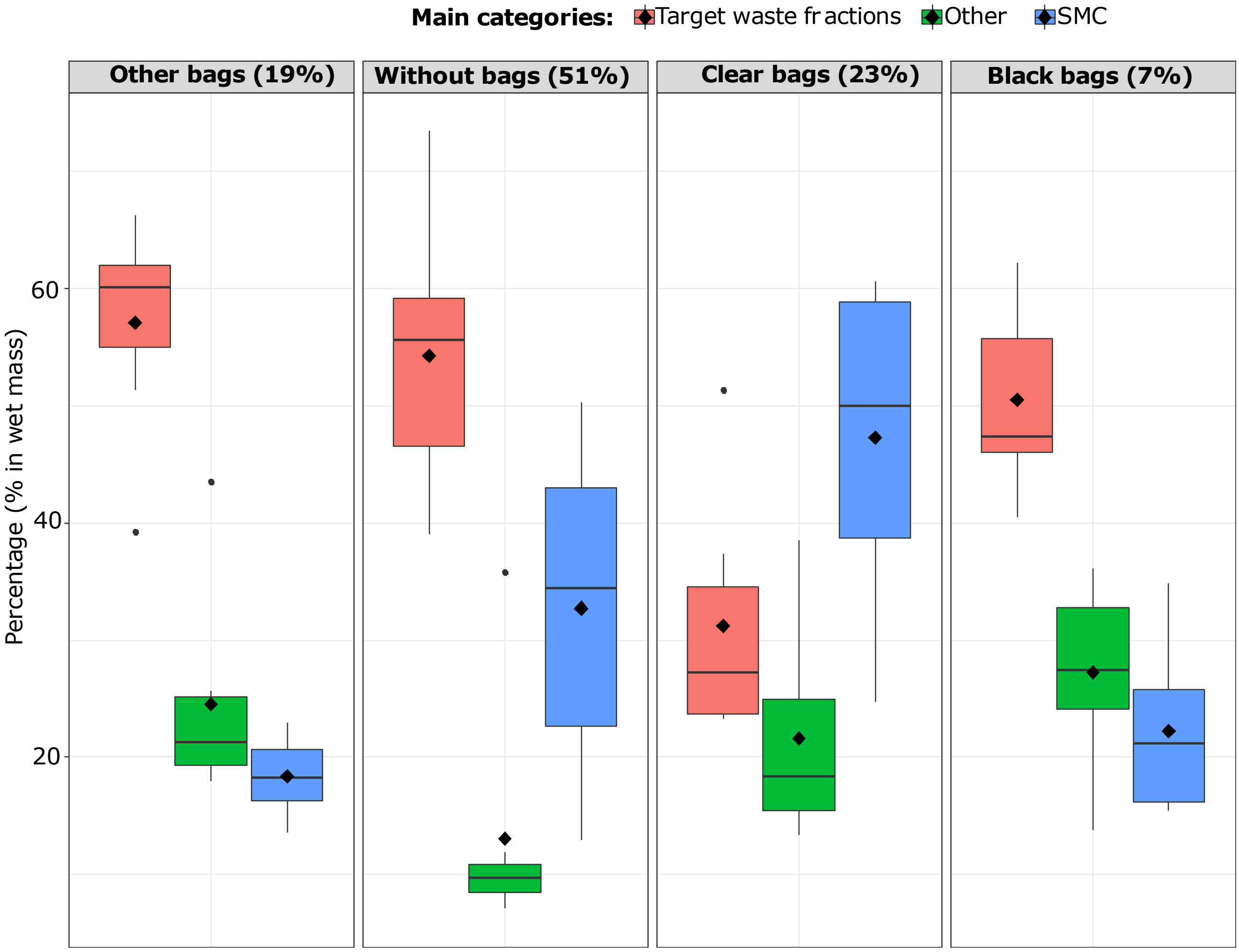
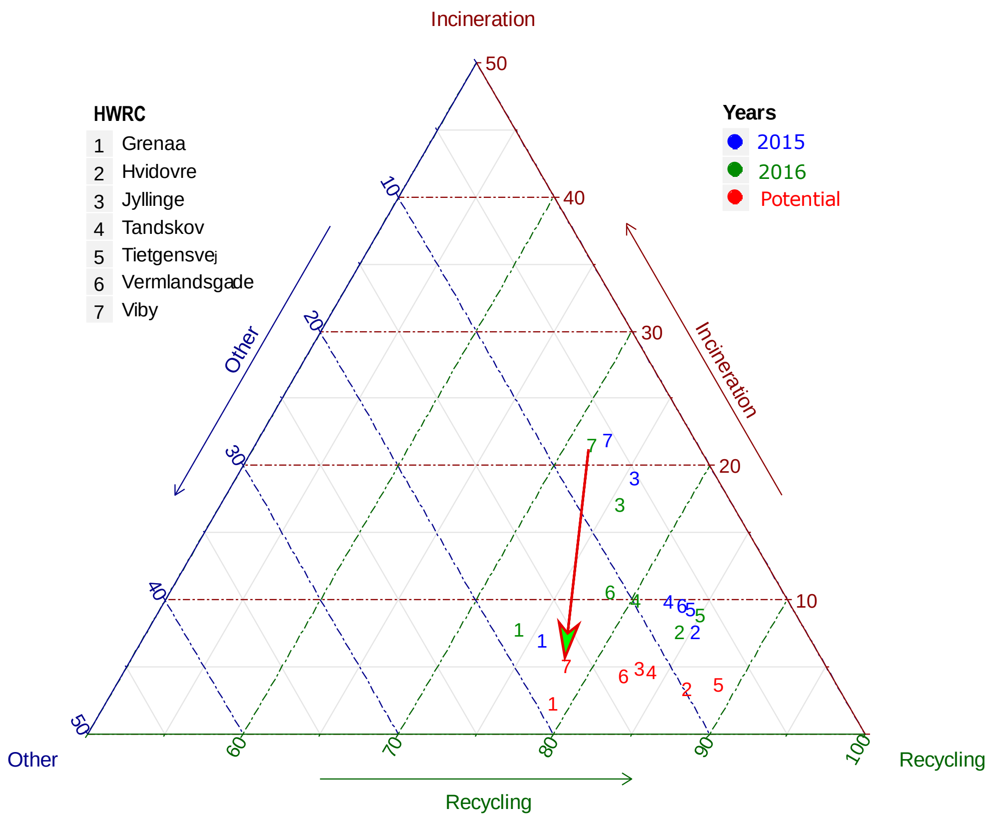


Figure 10: Ternary plot showing waste treatment forms in period 2015-2016 and expected potential if miscellaneous waste is sorted correctly at HWRCs marked as "Sorting WS" in Figure 1.



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Supplementary materials for:

Temporal and geographical patterns of solid waste collected at recycling centres

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List of Tables

Table S1: Percentage of single-family houses and people living in single-family houses

Kommune	Factor	2010	2011	2012	2013	2014	2015	2016	2017
Frederiksberg	Houses SF	97	97	97	97	97	97	97	97
Frederiksberg	Person SF	95	95	95	95	95	95	95	95
Dragoer	Houses SF	22	22	23	22	22	22	22	22
Dragoer	Person SF	16	16	16	15	15	15	15	15
Hvidovre	Houses SF	57	57	57	57	57	57	57	57
Hvidovre	Person SF	46	46	46	46	47	46	46	46
Koebenhavn	Houses SF	92	92	92	92	92	92	92	92
Koebenhavn	Person SF	88	88	88	88	88	88	88	88
Taarnby	Houses SF	53	53	53	53	53	53	53	53
Taarnby	Person SF	43	43	43	43	43	43	43	43
Koege	Houses SF	30	30	30	31	31	31	31	31
Koege	Person SF	24	24	24	24	24	25	25	25
Kalundborg	Houses SF	17	17	18	17	18	18	18	18
Kalundborg	Person SF	13	13	13	13	13	13	13	14
Lejre	Houses SF	3	3	3	3	3	3	3	4
Lejre	Person SF	2	2	2	2	3	3	3	3
Stevns	Houses SF	6	6	6	7	7	7	7	8
Stevns	Person SF	5	5	5	5	5	5	6	6
Roskilde	Houses SF	38	38	38	38	38	38	38	38
Roskilde	Person SF	28	29	29	29	29	29	29	28
Syddjurs	Houses SF	11	12	12	12	12	12	12	12
Syddjurs	Person SF	7	8	8	8	8	8	8	8
Norddjurs	Houses SF	17	18	18	18	18	19	19	19
Norddjurs	Person SF	12	12	12	13	13	13	13	14
Silkeborg	Houses SF	26	26	26	26	27	27	27	27
Silkeborg	Person SF	17	17	18	18	18	18	19	19

Table S2: Estimated number of visitors per household and population for all municipalities

Regions	Municipalities	Number of visitors per	2010	2011	2012	2013	2014	2015	2016
Greater Copenhagen	Frederiksberg	Household	-	-	0.43	1.59	3.1	3.54	3.42
	Frederiksberg	Population	-	-	0.23	0.83	1.6	1.82	1.74
	Dragoer	Household	21.58	23.10	21.93	21.56	23.25	21.44	21.68
	Dragoer	Population	9.25	9.86	9.38	9.15	9.9	9.18	9.22
	Hvidovre	Household	4.64	5.22	3.79	3.63	4	3.98	3.96
	Hvidovre	Population	2.20	2.46	1.78	1.7	1.85	1.83	1.81
	Koebenhavn	Household	1.52	1.65	1.18	1.04	1.31	1.41	1.37
	Koebenhavn	Population	0.81	0.87	0.61	0.54	0.66	0.71	0.69
	Taarnby	Household	13.27	14.52	12.17	11.72	13.19	13.97	14.05
	Taarnby	Population	6.13	6.67	5.56	5.32	5.94	6.25	6.25
Central Zealand	Koege	Household	-	-	6.2	8	8.36	8.22	7.31
	Koege	Population	-	-	2.7	3.5	3.66	3.61	3.19
	Kalundborg	Household	-	-	9.11	13.09	14.04	15.1	13.65
	Kalundborg	Population	-	-	4.26	6.16	6.62	7.15	6.47
	Lejre	Household	-	-	5.76	8.69	9.08	10.37	11
	Lejre	Population	-	-	2.33	3.52	3.69	4.21	4.47
	Stevns	Household	-	-	5.45	6.3	7.62	9.67	9.59
	Stevns	Population	-	-	2.4	2.8	3.41	4.33	4.3
	Roskilde	Household	-	-	6.97	8.52	8.38	9.87	10.1
	Roskilde	Population	-	-	3.19	3.9	3.84	4.51	4.6
Djursland	Syddjurs	Household	11.23	12.26	12.04	12.08	12.33	12.81	13.35
	Syddjurs	Population	4.98	5.42	5.33	5.38	5.54	5.8	6.04
	Norddjurs	Household	10.63	11.66	10.95	10.67	11.04	11.4	9.49
	Norddjurs	Population	4.95	5.46	5.16	5.06	5.28	5.5	4.61
Silkeborg	Silkeborg	Household	10.29	10.91	10.55	10.6	11.31	11.55	11.03
	Silkeborg	Population	4.52	4.79	4.62	4.66	4.99	5.1	4.89

Table S3: Aggregated yearly waste generation rates (wet mass), expressed in kg/household/year for WCR_{house}, kg/inhabitant/year for $WCR_{inhabitant}$, and kg/visitors/year for $WCR_{visitor}$

Regions	Municipalities	Parameter	Years						
			2010	2011	2012	2013	2014	2015	2016
Greater Copenhagen	Frederiksberg	WCR_{house}			44	178	273	283	291
		$WCR_{inhabitant}$			23	93	141	146	148
		$WCR_{visitor}$			101	112	88	80	85
	Dragoer	WCR_{house}	1586	1681	1374	1392	1611	1548	1481
		$WCR_{inhabitant}$	680	717	587	591	686	663	630
		$WCR_{visitor}$	73	73	63	65	69	72	68
	Hvidovre	WCR_{house}	805	883	608	547	593	612	615
		$WCR_{inhabitant}$	382	416	285	255	275	282	281
		$WCR_{visitor}$	174	169	161	151	148	154	155
	Copenahgen	WCR_{house}	175	214	150	122	124	129	127
		$WCR_{inhabitant}$	93	113	78	63	63	65	64
		$WCR_{visitor}$	115	130	128	117	95	92	93
	Taarnby	WCR_{house}	1602	1793	1425	1371	1400	1517	1522
		$WCR_{inhabitant}$	740	823	651	622	631	679	677
		$WCR_{visitor}$	121	124	117	117	106	109	108
Central Zealand	Koege	WCR_{house}	963	1259	1096	1106	1154	1156	1251
		$WCR_{inhabitant}$	418	547	477	484	506	508	546
		$WCR_{visitor}$			177	138	138	141	171
	Kalundborg	WCR_{house}	1576	1681	1477	1403	1559	1563	1454
		$WCR_{inhabitant}$	727	778	690	660	735	740	689
		$WCR_{visitor}$			162	107	111	104	106
	Lejre	WCR_{house}	1079	1294	1144	1268	1135	1148	1207
		$WCR_{inhabitant}$	430	520	462	514	461	466	491
		$WCR_{visitor}$			198	146	125	111	110
	Stevns	WCR_{house}	1203	1461	1220	1243	965	963	1038
		$WCR_{inhabitant}$	523	641	537	553	431	431	466
		$WCR_{visitor}$			224	197	127	100	108
	Roskilde	WCR_{house}	1002	1357	1128	1128	1215	1320	1332
		$WCR_{inhabitant}$	458	622	517	517	557	603	607
		$WCR_{visitor}$			162	132	145	134	132
Djursland	Syddjurs	WCR_{house}	1054	1109	998	965	1039	1005	1063
		$WCR_{inhabitant}$	468	491	442	430	467	455	481
		$WCR_{visitor}$	94	91	83	80	84	78	80
	Norddjurs	WCR_{house}	1204	1280	1275	1199	1310	1188	941
		$WCR_{inhabitant}$	560	600	602	569	627	573	456
		$WCR_{visitor}$	113	110	117	112	119	104	99
Silkeborg	Silkeborg	WCR_{house}	1020	1066	988	963	1008	1037	1035
		$WCR_{inhabitant}$	448	467	433	424	444	458	459
		$WCR_{visitor}$	99	98	94	91	89	90	94

[a]kg/visitor/year; [b]kg/inhabitant/year; Data on population statistics and density areas, and number of visitors are provided in Table S1-3

Table S4: Mass of waste annually collected [Mg/year wet mass] at individual HWRCs

Areas	Municipalities		HWRC	Mass of waste collected [Mg/year]						
				2010	2011	2012	2013	2014	2015	2016
Greater Copenhagen	Frederiksberg	1	Bispeengen	0	0	2277	9334	14344	14897	15339
	Dragoer	2	Dragoer	9136	9757	7993	8177	9522	9200	8808
	Hvidovre	3	Hvidovre	18864	20647	14317	13008	14141	14621	14720
	Copenhagen	4	Borgervaenget	1749	5097	6197	5886	5701	6249	6613
		5	Chrisiania	519	543	589	764	706	998	998
		6	Kulbanevej	21995	25474	17691	13148	12106	12782	13670
		7	Vasbygade	3977	4285	2391	2152	2558	2437	2375
		8	Vermlandsgade	20347	24756	15500	12684	14439	14784	13494
	Taarnby	9	Kirstinehoej	28585	32307	25599	24578	25099	27398	27549
		10	Vaegtergangen	984	923	806	921	932	1005	955
Central Zealand	Kalundborg	11	Bregninge	5585	6438	6312	6536	7448	7065	6831
		12	Goerlev	6772	7413	6655	6799	6961	6487	6408
		13	Hoeng	3908	4114	3321	3454	4030	4330	4194
		14	Kalundborg	16280	17116	14339	12624	14074	15110	13491
		15	Sejeroe	472	339	619	264	285	288	291
		16	Ubby	2513	2578	2132	2055	2582	2411	2162
	Koege	17	Bjaeverskov	4364	5414	4248	4720	4457	5068	6784
		18	Koege	19145	25514	22669	22848	24670	24647	25443
	Lejre	19	Torkilstrup	11330	13743	12250	13655	12300	12496	13209
	Roskilde	20	Jyllinge	7036	7575	7628	7599	8731	10371	9926
		21	Roskilde	23430	35210	27502	27287	28697	30077	30769
		22	Viby	6672	8215	7544	7945	9023	10362	11065
	Stevns	23	Haarlev	5303	6572	6281	6811	4032	3869	4651
		24	Store Hedding	5961	7196	5245	5092	5288	5519	5588
Djursland	Norddjurs	25	Glesborg	4126	4491	4141	3967	4063	4097	4185
		26	Grenaa	9107	9869	10765	10468	12139	9854	9232
		27	Roende	5084	5132	4797	4294	4673	4796	2361
		28	Tirstrup	2842	3075	2836	2677	2695	2810	1483
	Syddjurs	29	Ebeltoft	6255	6618	5994	5816	6365	6206	6556
		30	Hornslet	5187	5441	4979	4819	5372	5157	5760
		31	Knebel	3503	3706	3212	3169	3296	3219	3285
		32	Ryomgaard	4216	4529	4118	4042	4318	4220	4393
Silkeborg	Silkeborg	33	Gjern	3838	4247	4048	4027	4306	4346	4580
		34	Tandskov	16114	17615	16438	15660	16169	17028	16805
		35	Them	4303	4489	4187	4044	4859	4913	5375
		36	Tietgensvej	15052	14831	13651	13823	14188	14651	14629

Table S5: Number of person per household; number of household for single and multi-family houses

Municipalities	Number of person in	2010	2011	2012	2013	2014	2015	2016	2017
Frederiksberg	Household	1.86	1.88	1.9	1.92	1.94	1.95	1.97	1.98
Frederiksberg	MF household	1.82	1.85	1.86	1.89	1.91	1.92	1.93	1.94
Frederiksberg	SF household	3.07	3.09	3.07	3.1	3.13	3.15	3.16	3.17
Dragoer	Household	2.33	2.35	2.34	2.37	2.36	2.35	2.36	2.38
Dragoer	MF household	1.64	1.64	1.61	1.63	1.64	1.6	1.61	1.63
Dragoer	SF household	2.53	2.55	2.55	2.58	2.57	2.57	2.58	2.59
Hvidovre	Household	2.13	2.15	2.16	2.17	2.19	2.2	2.22	2.23
Hvidovre	MF household	1.73	1.74	1.74	1.76	1.78	1.79	1.79	1.8
Hvidovre	SF household	2.67	2.69	2.71	2.72	2.73	2.76	2.79	2.81
Copenhagen	Household	1.88	1.91	1.94	1.96	1.98	2	2.02	2.03
Copenhagen	MF household	1.81	1.83	1.86	1.88	1.9	1.92	1.94	1.95
Copenhagen	SF household	2.78	2.8	2.82	2.85	2.89	2.91	2.94	2.96
Taarnby	Household	2.17	2.18	2.19	2.2	2.22	2.24	2.25	2.26
Taarnby	MF household	1.75	1.76	1.77	1.78	1.79	1.79	1.8	1.81
Taarnby	SF household	2.64	2.65	2.67	2.7	2.72	2.75	2.76	2.78
Koege	Household	2.3	2.3	2.3	2.29	2.28	2.28	2.29	2.29
Koege	MF household	1.8	1.8	1.8	1.79	1.79	1.8	1.82	1.83
Koege	SF household	2.52	2.52	2.52	2.5	2.5	2.49	2.5	2.5
Kalundborg	Household	2.19	2.19	2.16	2.17	2.16	2.15	2.15	2.14
Kalundborg	MF household	1.58	1.59	1.57	1.57	1.58	1.59	1.61	1.64
Kalundborg	SF household	2.32	2.31	2.29	2.29	2.28	2.27	2.26	2.25
Lejre	Household	2.55	2.53	2.53	2.51	2.51	2.51	2.51	2.5
Lejre	MF household	1.84	1.86	1.84	1.84	1.89	1.86	1.86	1.84
Lejre	SF household	2.57	2.55	2.55	2.54	2.53	2.53	2.53	2.52
Stevns	Household	2.33	2.3	2.3	2.27	2.26	2.26	2.25	2.25
Stevns	MF household	1.76	1.75	1.71	1.66	1.69	1.72	1.75	1.84
Stevns	SF household	2.36	2.34	2.33	2.32	2.31	2.3	2.29	2.29
Roskilde	Household	2.23	2.22	2.23	2.22	2.22	2.23	2.24	2.25
Roskilde	MF household	1.67	1.67	1.68	1.68	1.67	1.68	1.68	1.69
Roskilde	SF household	2.56	2.56	2.56	2.56	2.56	2.57	2.58	2.59
Syddjurs	Household	2.28	2.29	2.29	2.28	2.26	2.25	2.24	2.23
Syddjurs	MF household	1.47	1.49	1.51	1.5	1.51	1.5	1.51	1.53
Syddjurs	SF household	2.39	2.4	2.39	2.38	2.36	2.34	2.34	2.32
Norddjurs	Household	2.15	2.14	2.13	2.12	2.1	2.09	2.08	2.07
Norddjurs	MF household	1.49	1.47	1.49	1.48	1.49	1.51	1.5	1.52
Norddjurs	SF household	2.3	2.28	2.27	2.26	2.24	2.22	2.21	2.2
Silkeborg	Household	2.28	2.29	2.29	2.28	2.27	2.27	2.26	2.25
Silkeborg	MF household	1.53	1.53	1.55	1.55	1.56	1.57	1.57	1.58
Silkeborg	SF household	2.55	2.55	2.55	2.54	2.53	2.52	2.51	2.5

Table S6: Ratio to determine the difference in monthly waste generation in the four areas

Month	Greater Copenhagen			Roskilde			Djursland			Silkeborg		
	Tonnes/year	Month/Mean[b]	Ratio[c]	Tonnes/year	Month/Mean[b]	Ratio[c]	Tonnes/year	Month/Mean[b]	Ratio[c]	Tonnes/year	Month/Mean[b]	Ratio[c]
Jan	6411.00	0.65	-35.33	5834.44	0.53	-47.42	1560.80	0.46	-53.80	1758.47	0.53	-46.91
Feb	6085.71	0.61	-38.61	6149.45	0.55	-44.58	1786.45	0.53	-47.13	1707.45	0.52	-48.45
Mar	9431.14	0.95	-4.86	10018.52	0.90	-9.72	3036.11	0.90	-10.14	3240.12	0.98	-2.17
Apr	12350.71	1.25	24.59	14850.91	1.34	33.83	4526.92	1.34	33.99	4582.81	1.38	38.37
May	12614.86	1.27	27.25	15197.23	1.37	36.95	4765.23	1.41	41.04	4424.31	1.34	33.58
June	11886.57	1.20	19.91	13682.08	1.23	23.30	3861.84	1.14	14.30	4000.57	1.21	20.79
July	12752.14	1.29	28.64	14778.88	1.33	33.18	4445.21	1.32	31.57	4594.03	1.39	38.71
Aug	11423.86	1.15	15.24	13269.57	1.20	19.58	4173.94	1.24	23.54	3748.28	1.13	13.17
Sep	10886.57	1.10	9.82	11718.40	1.06	5.60	3696.43	1.09	9.41	3627.29	1.10	9.52
Oct	10690.57	1.08	7.84	11942.28	1.08	7.62	4258.83	1.26	26.05	3636.94	1.10	9.81
Nov	8631.00	0.87	-12.93	8725.73	0.79	-21.37	2524.75	0.75	-25.27	2583.61	0.78	-21.99
Dec	5795.14	0.58	-41.54	6994.87	0.63	-36.97	1907.27	0.56	-43.55	1841.03	0.56	-44.41
Mean[a]	9913.00	-	-	11097.00	-	-	3379.00	-	-	3312.00	-	-

[a] *monthly mean or mean of waste from the 12 months (Mean).*

[b] *monthly mean divided by the monthly waste generation. Example: Jan for Greater Copenhagen: 6411/9913=0.65*

[c] *calculated based on the value of month/mean. If month/mean is higher than 1 (e.g. April Greater Copenhagen, 1.25), then Ratio is (1.27-1)*100=27.25%. However, if month/mean is lower than 1, (e.g. January Roskilde, 0.53), then Ratio is -(1-0.53)*100=-47.42*

Table S7: Ratio to determine the difference in monthly waste generation in the four areas

HWRC	Months											
	Jan	Feb	Mar	Apr	Maj	Jun	Jul	Aug	Sep	Okt	Nov	Dec
Tandskov	-44.2	-44.5	5.2	42.0	34.6	20.4	35.8	6.8	4.9	6.0	-19.6	-47.4
Tietgensvej	-49.4	-51.9	-12.2	35.3	34.4	22.6	40.4	19.2	14.4	14.4	-25.6	-41.7
Bispeengen	-23.5	-18.2	0.8	18.2	21.6	23.6	22.1	-11.7	-4.6	6.2	-8.6	-25.9
Bjaeverskov	-54.7	-55.0	-14.7	39.8	42.8	23.4	56.3	18.7	10.0	9.2	-32.2	-43.6
Borgervaenget	-11.6	-13.0	0.4	7.3	8.6	-1.2	8.1	0.0	4.1	9.7	7.5	-19.8
Bregninge	-52.8	-52.9	0.2	40.9	31.7	22.8	42.7	32.1	1.6	2.5	-25.4	-43.5
Chrisiania	-31.3	-42.5	29.0	12.6	12.6	26.6	9.0	5.5	19.1	12.6	-17.7	-35.5
Dragoer	-49.1	-53.5	-11.1	38.5	44.6	23.8	34.6	17.1	21.9	6.0	-19.6	-53.3
Ebeltoft	-55.0	-47.5	6.1	38.8	33.0	15.8	34.8	11.9	10.4	16.7	-14.4	-50.5
Gjern	-49.8	-48.4	6.3	34.0	34.0	15.2	42.3	11.0	10.1	8.2	-22.3	-40.6
Glesborg	-56.0	-48.4	0.8	34.8	33.6	15.5	55.2	22.6	2.7	10.0	-19.6	-51.2
Goerlev	-51.3	-43.1	-4.9	37.0	32.5	21.5	46.0	17.6	13.0	3.7	-26.6	-45.4
Grenaa	-63.6	-43.3	-38.0	31.0	64.0	2.3	6.7	56.9	-4.9	63.7	-48.1	-26.7
Hoeng	-44.2	-43.2	10.2	28.2	48.2	24.0	31.5	13.9	-2.3	-3.1	-25.9	-37.3
Hornslet	-51.0	-53.5	-10.1	26.4	35.7	19.7	38.6	10.9	29.4	18.6	-17.2	-47.5
Hvidovre	-40.0	-43.8	-7.5	30.8	31.9	25.0	27.9	21.5	12.4	6.3	-17.4	-47.0
Haarlev	-43.8	-56.0	-21.5	36.0	45.2	8.0	17.5	25.5	1.8	9.1	-11.9	-9.8
Jyllinge	-52.1	-51.6	-7.5	30.7	38.7	36.4	36.5	15.3	8.1	7.1	-25.6	-35.8
Kalundborg	-42.0	-40.0	1.6	31.3	39.0	19.9	29.7	15.6	10.1	1.4	-26.2	-40.5
Kirstinehoej	-48.6	-48.7	-6.2	37.3	41.9	29.5	41.9	19.6	0.7	4.8	-20.3	-51.9
Knebel	-48.3	-46.6	-4.7	30.5	27.7	10.9	45.2	16.3	13.9	14.1	-16.8	-42.1
Koege	-53.5	-44.6	-15.9	38.2	41.2	19.6	37.2	18.2	6.7	9.4	-23.2	-33.4
Kulbanevej	-27.4	-32.0	1.8	18.8	16.8	15.6	30.8	12.0	10.8	6.5	-14.7	-38.8
Roende	-46.7	-48.9	-4.2	33.2	32.9	26.3	31.6	0.6	15.7	29.0	-12.0	-57.4
Roskilde	-39.8	-39.9	-15.5	27.3	32.5	23.5	23.9	18.8	2.4	17.3	-12.6	-37.8
Ryomgaard	-46.3	-48.7	-2.2	36.0	28.6	15.0	37.9	17.1	13.9	6.0	-12.6	-44.8
Sejeroe	-47.4	-49.8	-14.5	4.4	-10.8	8.7	-5.3	-17.0	-16.4	3.0	133.3	11.8
Store_Hedding	-45.8	-42.4	-3.8	29.1	34.8	29.9	35.5	26.0	4.8	-0.5	-22.3	-45.4
Them	-46.3	-51.9	-5.2	38.8	27.2	21.5	40.5	19.2	10.4	10.7	-19.1	-45.7
Tirstrup	-50.7	-45.8	4.0	38.5	33.2	16.8	30.0	14.9	0.6	25.0	-14.3	-52.2
Torkilstrup	-51.0	-46.1	-6.5	37.7	36.2	20.1	35.1	21.9	7.7	3.0	-25.4	-32.6
Ubby	-37.1	-37.1	6.1	37.0	21.6	12.2	33.1	30.8	-3.0	-0.7	-24.3	-38.5
Vaegtergangen	-40.2	-56.6	-11.6	30.0	59.6	27.4	35.9	21.0	17.1	4.3	-27.0	-59.9
Vasbygade	-8.9	-11.1	2.9	12.5	13.3	4.6	19.4	2.2	7.4	7.5	-13.5	-36.2
Vermlandsgade	-17.1	-26.3	-0.5	9.5	13.8	6.7	17.5	10.5	12.2	8.8	-3.0	-32.2
Viby	-51.8	-44.5	-17.7	38.5	37.7	40.7	33.1	19.0	4.5	6.0	-23.0	-42.5
Mean	-43.7	-43.7	-4.5	30.3	32.1	19.3	31.6	15.6	7.5	10.1	-15.2	-39.5
Standard deviation	12.5	11.2	11.1	10.3	14.1	8.3	13.3	12.6	8.7	11.5	27.4	13.6

Table S8: Spearman correlation analysis to determine factors influencing the total waste generation and the number of visitors at household recycling centres. Correlation analysis was based on data collected from 2010 to 2016. .

Municipalities	Correlation between total mass and:			Correlation between number and visitors and:	
	Visitors	Inhabitants	Density (inhabitant/km2)	Inhabitants	Density (inhabitant/km2)
Dragør	0.50	**-0.04**	**0.46**	**-0.07**	**0.32**
Frederiksberg	0.96	0.99	0.95	0.99	0.95
Hvidovre	0.75	**-0.36**	**-0.43**	**-0.39**	**-0.46**
Copenhagen	0.79	-0.64	**-0.32**	-0.64	**-0.32**
Taarnby	0.71	**-0.36**	**0.25**	**-0.39**	**0.14**
Norddjurs	0.86	-0.75	-0.68	**-0.07**	**0.00**
Syddjurs	0.71	-0.64	**-0.21**	**-0.36**	**0.14**

[a] *The number of recycling centres per municipalities and number of visitors are shown in Table 1*

[b]*:kg wet mass waste per working day for the office area investigated.*

[c]*: Number employees per working days.*

[d]*:Employees at work.*

Table S9: Spearman correlation analysis to determine factors influencing the total waste generation and the number of visitors at household recycling centres. Correlation analysis was computed per year based on the data from municipalities (Table 1) Dargør, Frederiksberg, Hvidovre, Copenhagen, Taarnby, Norddjurs and Syddjurs.

Municipalities	Correlation between total mass and:			Correlation between number and visitors and:	
	Visitors	Inhabitants	Density (inhabitant/km2)	Inhabitants	Density (inhabitant/km2)
2010	0.82	**0.18**	-0.21	**0.07**	-0.32
2011	0.93	**0.14**	-0.32	**0.07**	-0.32
2012	0.93	**0.14**	-0.32	**0.07**	-0.32
2013	0.79	**0.32**	-0.21	**0.11**	-0.36
2014	0.93	**0.36**	-0.14	**0.29**	-0.14
2015	0.93	**0.43**	-0.14	**0.32**	-0.14
2016	0.96	0.77	0.70	0.63	0.67

[a] *Wet mass*

[b]*:kg wet mass waste per working day for the office area investigated.*

[c]*: Number employees per working days.*

Table S10: Correlation between number of visitors and household size

	Visitors	area_km2	Household	Person	MF_Household	MF_Person	SF_Household	SF_Person
Visitors	1							
area_km2	0.41	1						
Household	0.5	-0.22	1					
Person	0.51	-0.21	1	1				
MF_Household	0.43	-0.29	0.99	0.99	1			
MF_Person	0.42	-0.29	0.99	0.99	1	1		
SF_Household	0.84	0.58	0.38	0.4	0.28	0.28	1	
SF_Person	0.85	0.47	0.48	0.5	0.39	0.39	0.99	1

Table S11: Results of the test Ljunk-Box

Areas	X-squared	Df	p-value
Greater Copenhagen	47.19	1	6.44E-12***

Roskilde	35.766	1	2.23E-09***
Djursland	19.783	1	8.68E-06***
Silkeborg	37.346	1	9.89E-10***

*p-values<0.05: significant autocorrelation; ***Highly significant autocorrelation*

Table S12: Univariate Box-Pierce test

Areas	Municipalities	Recyling centers	statistic	p.value	parameter	method	Answer
Djursland	Norddjurs	Glesborg	26.71535	0.00000	1	Box-Pierce test	significant
	Norddjurs	Grenaa	0.00005	0.99442	1	Box-Pierce test	No-sign
	Norddjurs	Roende	24.64980	0.00000	1	Box-Pierce test	significant
	Norddjurs	Tirstrup	24.68332	0.00000	1	Box-Pierce test	significant
	Syddjurs	Ebeltoft	27.15883	0.00000	1	Box-Pierce test	significant
	Syddjurs	Hornslet	21.93223	0.00000	1	Box-Pierce test	significant
	Syddjurs	Knebel	27.57318	0.00000	1	Box-Pierce test	significant
	Syddjurs	Ryomgaard	26.50164	0.00000	1	Box-Pierce test	significant
Silkeborg	Silkeborg	Tandskov	30.44238	0.00000	1	Box-Pierce test	significant
	Silkeborg	Tietgensvej	36.15314	0.00000	1	Box-Pierce test	significant
	Silkeborg	Gjern	24.43454	0.00000	1	Box-Pierce test	significant
	Silkeborg	Them	28.12465	0.00000	1	Box-Pierce test	significant
Greater Copenhagen	Dragoer	Dragoer	32.61141	0.00000	1	Box-Pierce test	significant
	Frederiksberg	Bispeengen	31.58424	0.00000	1	Box-Pierce test	significant
	Hvidovre	Hvidovre	48.81693	0.00000	1	Box-Pierce test	significant
	Copenhagen	Borgervaenget	32.19019	0.00000	1	Box-Pierce test	significant
	Copenhagen	Chrisiania	10.69465	0.00107	1	Box-Pierce test	significant
	Copenhagen	Kulbanevej	58.15301	0.00000	1	Box-Pierce test	significant
	Copenhagen	Vasbygade	41.82745	0.00000	1	Box-Pierce test	significant
	Copenhagen	Vermlandsgade	56.07806	0.00000	1	Box-Pierce test	significant
	Taarnby	Kirstinehoej	43.03532	0.00000	1	Box-Pierce test	significant
	Taarnby	Vaegtergangen	28.24106	0.00000	1	Box-Pierce test	significant
Central Zealand	Kalundborg	Bregninge	32.21069	0.00000	1	Box-Pierce test	significant
	Kalundborg	Goerlev	32.43045	0.00000	1	Box-Pierce test	significant
	Kalundborg	Hoeng	21.67075	0.00000	1	Box-Pierce test	significant
	Kalundborg	Kalundborg	30.62308	0.00000	1	Box-Pierce test	significant
	Kalundborg	Sejeroe	0.61653	0.43234	1	Box-Pierce test	No-sign
	Kalundborg	Ubby	20.75011	0.00001	1	Box-Pierce test	significant
	Koege	Bjaeverskov	31.99063	0.00000	1	Box-Pierce test	significant
	Koege	Koege	27.30350	0.00000	1	Box-Pierce test	significant
	Lejre	Torkilstrup	22.92409	0.00000	1	Box-Pierce test	significant
	Roskilde	Jyllinge	35.42817	0.00000	1	Box-Pierce test	significant
	Roskilde	Roskilde	25.64590	0.00000	1	Box-Pierce test	significant
	Roskilde	Viby	31.65126	0.00000	1	Box-Pierce test	significant
	Stevns	Haarlev	8.77963	0.00305	1	Box-Pierce test	significant
	Stevns	Store Hedding	32.82482	0.00000	1	Box-Pierce test	significant

Table S13: Univariate test of autoregression based on on aggregrade

Areas	Statistic	p-value	Parameter	Method	Answer
Djursland	19.09252	1.25E-05	1	Box-Pierce test	significant
Greater Copenhagen	45.54366	1.49E-11	1	Box-Pierce test	significant
Central Zealand	34.51795	4.22E-09	1	Box-Pierce test	significant
Silkeborg	36.04304	1.93E-09	1	Box-Pierce test	significan

Table S14: Detail composition based on main fractions for each household recycling centers from 2010 to 2016 (wet mass percentage)

Regions	Municipaliteis	HWRC	FraktionTWF2	2010	2011	2012	2013	2014	2015	2016
Greater Copenhagen	Frederiksberg	Bispeengen	Fibres			2.77	3.1	3.06	3.4	3.87
Greater Copenhagen	Frederiksberg	Bispeengen	Plastic			0.75	0.78	0.77	0.87	1
Greater Copenhagen	Frederiksberg	Bispeengen	Metal			4.61	4.69	4.11	4.33	4.8
Greater Copenhagen	Frederiksberg	Bispeengen	Wood			20.11	19.54	18.72	19.73	20.13
Greater Copenhagen	Frederiksberg	Bispeengen	Glass			1.71	1.21	1.22	1.05	1.04
Greater Copenhagen	Frederiksberg	Bispeengen	Garden			2.2	5.09	6.39	7.34	7.72
Greater Copenhagen	Frederiksberg	Bispeengen	Soil			9.53	8.64	9.99	8.96	8.12
Greater Copenhagen	Frederiksberg	Bispeengen	C&D			39.53	37.78	38.91	36.78	34.62
Greater Copenhagen	Frederiksberg	Bispeengen	SMC			9.44	9.35	8.3	8.65	8.03
Greater Copenhagen	Frederiksberg	Bispeengen	Bulky				1.86	1.78	1.81	1.86
Greater Copenhagen	Frederiksberg	Bispeengen	OW			9.35	7.96	6.76	7.08	8.79
Greater Copenhagen	Dragoer	Dragoer	Fibres	2.78	2.62	2.7	3.18	2.7	2.93	3.11
Greater Copenhagen	Dragoer	Dragoer	Plastic	0	0	0.46	0.64	0.7	0.65	0.82
Greater Copenhagen	Dragoer	Dragoer	Metal	3.62	3.49	3.92	3.72	3.59	3.78	3.81
Greater Copenhagen	Dragoer	Dragoer	Wood	2.07	7.94	9.77	10.11	10.04	10.62	10.82
Greater Copenhagen	Dragoer	Dragoer	Glass	1.98	0.68	0.71	0.81	0.69	0.68	0.84
Greater Copenhagen	Dragoer	Dragoer	Garden	25.74	27.02	25	25.2	26.11	24.22	24.19
Greater Copenhagen	Dragoer	Dragoer	Soil	13.78	15.09	15.33	13.93	15.98	15.77	14.98
Greater Copenhagen	Dragoer	Dragoer	C&D	20.07	23.63	22.42	23.3	23.16	24.14	23.21
Greater Copenhagen	Dragoer	Dragoer	SMC	12.9	11.84	12.04	11.48	10.74	10.46	10.52
Greater Copenhagen	Dragoer	Dragoer	Bulky	6.06	0.93	0.19	0.81	0.81	0.77	0.89
Greater Copenhagen	Dragoer	Dragoer	OW	10.98	6.75	7.47	6.82	5.47	5.97	6.81
Greater Copenhagen	Hvidovre	Hvidovre	Fibres	1.96	1.95	2.27	2.37	2.29	2.07	2.43
Greater Copenhagen	Hvidovre	Hvidovre	Plastic	0.07	0.08	0.08	0.65	0.91	0.88	0.95
Greater Copenhagen	Hvidovre	Hvidovre	Metal	4.26	4.02	3.73	3.73	3.49	3.37	3.72
Greater Copenhagen	Hvidovre	Hvidovre	Wood	3.6	12.41	12	12.32	12.47	13.45	13.89
Greater Copenhagen	Hvidovre	Hvidovre	Glass	1.52	1.59	1.06	1.08	1.03	1.16	1.13
Greater Copenhagen	Hvidovre	Hvidovre	Garden	12.29	13.44	12.3	14.18	14.09	14.25	14.37
Greater Copenhagen	Hvidovre	Hvidovre	Soil	15.51	14.75	17.44	16.66	15.91	15.3	15.62

Greater Copenhagen	Hvidovre	Hvidovre	C&D	26.07	32.65	32.97	32.23	34.5	34.64	32
Greater Copenhagen	Hvidovre	Hvidovre	SMC	11.95	10.64	9.54	8.93	7.76	6.88	6.74
Greater Copenhagen	Hvidovre	Hvidovre	Bulky	6.74	1.1	0.23	0.91	1.07	0.99	1.08
Greater Copenhagen	Hvidovre	Hvidovre	OW	16.03	7.37	8.37	6.93	6.48	7.03	8.08
Greater Copenhagen	Koebenhavn	Borgervaenget	Fibres	5.83	5.63	4.15	3.69	3.86	3.55	4.01
Greater Copenhagen	Koebenhavn	Chrisiania	Fibres	3.47		4.92	0.52	3.12	3.51	3.41
Greater Copenhagen	Koebenhavn	Kulbanevej	Fibres	3.74	3.15	2.96	3.06	2.73	2.62	2.81
Greater Copenhagen	Koebenhavn	Vasbygade	Fibres	7.79	6.44	5.94	6.13	4.96	5.01	5.73
Greater Copenhagen	Koebenhavn	Vermlandsgade	Fibres	4.03	3.33	3.19	3.41	3.08	3.06	3.49
Greater Copenhagen	Koebenhavn	Borgervaenget	Plastic	0.17	0.26	0.53	0.85	0.95	1.04	0.92
Greater Copenhagen	Koebenhavn	Chrisiania	Plastic					0	0.3	0.6
Greater Copenhagen	Koebenhavn	Kulbanevej	Plastic	0.1	0.1	0.06	0.66	0.91	0.88	0.86
Greater Copenhagen	Koebenhavn	Vasbygade	Plastic	0.35	0.28	0.08	0.6	1.13	1.27	1.09
Greater Copenhagen	Koebenhavn	Vermlandsgade	Plastic	0.14	0.11	0.49	0.96	0.98	1.01	1.13
Greater Copenhagen	Koebenhavn	Borgervaenget	Metal	4.86	4.89	4.7	4.37	4.44	4.26	5.14
Greater Copenhagen	Koebenhavn	Chrisiania	Metal	8.48	8.1	7.64	6.15	5.38	5.11	4.81
Greater Copenhagen	Koebenhavn	Kulbanevej	Metal	5.01	4.63	4.09	3.95	3.62	3.61	3.71
Greater Copenhagen	Koebenhavn	Vasbygade	Metal	6.64	6.11	6.32	5.58	5.24	5.91	4.93
Greater Copenhagen	Koebenhavn	Vermlandsgade	Metal	5.8	5.08	4.62	4.53	4.11	4.02	4.74
Greater Copenhagen	Koebenhavn	Borgervaenget	Wood	17.04	18.68	19.62	19.91	20.19	19.96	19.78
Greater Copenhagen	Koebenhavn	Kulbanevej	Wood	4.36	14.97	14.59	14.92	14.76	15.62	15.68
Greater Copenhagen	Koebenhavn	Vasbygade	Wood	5.86	20.82	22.42	23.28	21.93	23.51	21.26
Greater Copenhagen	Koebenhavn	Vermlandsgade	Wood	5.49	16.81	17.97	18.39	19.14	18.77	19.68
Greater Copenhagen	Koebenhavn	Borgervaenget	Glass	1.14	1.28	1.16	1.39	1.39	1.66	1.19
Greater Copenhagen	Koebenhavn	Kulbanevej	Glass	1.07	1.29	1.05	1.16	1.02	0.95	0.98
Greater Copenhagen	Koebenhavn	Vasbygade	Glass	1.21	1.31	1.25	1.39	1.6	1.56	1.05
Greater Copenhagen	Koebenhavn	Vermlandsgade	Glass	1.49	1.72	1.46	1.14	1.1	1.31	1.15
Greater Copenhagen	Koebenhavn	Borgervaenget	Garden	7.2	7.16	5.5	6.05	6.42	6.19	7.32
Greater Copenhagen	Koebenhavn	Chrisiania	Garden	0.96	0.37	0.51	2.23			
Greater Copenhagen	Koebenhavn	Kulbanevej	Garden	8.87	9.61	9.22	10.14	12.18	10.44	10.72
Greater Copenhagen	Koebenhavn	Vasbygade	Garden	3.87	3.9	3.22	3.67	5.04	3.73	3.16
Greater Copenhagen	Koebenhavn	Vermlandsgade	Garden	5.78	5.88	5.65	6.44	6.27	6.57	7.27

Greater Copenhagen	Koebenhavn	Borgervaenget	Soil	10.52	9.75	7.47	9.02	8.51	9.39	9.92
Greater Copenhagen	Koebenhavn	Chrisiania	Soil					16.15	25.65	35.87
Greater Copenhagen	Koebenhavn	Kulbanevej	Soil	10.96	11.13	13.57	13.4	12.64	14.31	15.05
Greater Copenhagen	Koebenhavn	Vasbygade	Soil	5.73	5.09	5.44	5.44	6.92	3.98	4.88
Greater Copenhagen	Koebenhavn	Vermlandsgade	Soil	9.9	11.69	14.48	11.61	12.92	15.5	9.88
Greater Copenhagen	Koebenhavn	Borgervaenget	C&D	25.33	30.33	37.81	36.51	35.5	36.77	33.81
Greater Copenhagen	Koebenhavn	Chrisiania	C&D	20.42	20.44	24.45	28.8	22.8	23.45	20.64
Greater Copenhagen	Koebenhavn	Kulbanevej	C&D	24.24	33.91	36.7	35.09	35.69	36.2	32.68
Greater Copenhagen	Koebenhavn	Vasbygade	C&D	19.06	30.95	33.42	32.53	32.96	31.35	30.61
Greater Copenhagen	Koebenhavn	Vermlandsgade	C&D	25.07	34.85	34.22	35.15	35.33	33.33	30.75
Greater Copenhagen	Koebenhavn	Borgervaenget	SMC	9.78	12.62	10.73	9.89	10.42	9.47	8.54
Greater Copenhagen	Koebenhavn	Chrisiania	SMC	24.86	29.65	22.07	23.3	28.75	24.85	19.64
Greater Copenhagen	Koebenhavn	Kulbanevej	SMC	14.11	12.04	9.34	8.94	8.31	7.45	7.51
Greater Copenhagen	Koebenhavn	Vasbygade	SMC	20.09	14.73	11.67	11.2	10.71	10.96	10.19
Greater Copenhagen	Koebenhavn	Vermlandsgade	SMC	12.72	10.95	9.54	9.68	8.93	8.17	8.73
Greater Copenhagen	Koebenhavn	Borgervaenget	Bulky	2.12	0.88	0.37	1.38	1.77	1.58	1.84
Greater Copenhagen	Koebenhavn	Chrisiania	Bulky	21	23.76	21.9	18.32	12.18	9.92	7.72
Greater Copenhagen	Koebenhavn	Kulbanevej	Bulky	8.41	1.08	0.4	1.4	1.45	1.35	1.43
Greater Copenhagen	Koebenhavn	Vasbygade	Bulky	10.33	2.29	1.09	2.6	2.42	2.83	2.82
Greater Copenhagen	Koebenhavn	Vermlandsgade	Bulky	11.1	1.96	0.57	1.67	1.92	1.62	2.09
Greater Copenhagen	Koebenhavn	Borgervaenget	OW	16.01	8.53	7.96	6.95	6.56	6.11	7.52
Greater Copenhagen	Koebenhavn	Chrisiania	OW	20.81	17.68	18.51	20.68	11.61	7.21	7.31
Greater Copenhagen	Koebenhavn	Kulbanevej	OW	19.12	8.09	8.02	7.28	6.68	6.56	8.56
Greater Copenhagen	Koebenhavn	Vasbygade	OW	19.06	8.1	9.16	7.57	7.08	9.89	14.27
Greater Copenhagen	Koebenhavn	Vermlandsgade	OW	18.46	7.61	7.8	7.02	6.22	6.64	11.09
Greater Copenhagen	Taarnby	Kirstinehoej	Fibres	1.6	1.58	1.62	1.86	1.9	1.98	1.93
Greater Copenhagen	Taarnby	Vaegtergangen	Fibres	2.85	3.79	3.23	3.69	3.54	3.48	4.08
Greater Copenhagen	Taarnby	Kirstinehoej	Plastic	0.03	0.02	0.45	0.81	0.84	0.91	0.99
Greater Copenhagen	Taarnby	Vaegtergangen	Plastic				0.54	1.18	1.29	1.57
Greater Copenhagen	Taarnby	Kirstinehoej	Metal	4.4	4.1	3.99	4.02	3.79	3.91	4.01
Greater Copenhagen	Taarnby	Vaegtergangen	Metal	6	6.07	5.83	5.1	4.72	4.48	4.92
Greater Copenhagen	Taarnby	Kirstinehoej	Wood	2.99	11.19	12.12	13.17	13.19	14.93	14.64

Greater Copenhagen	Taarnby	Vaegtergangen	Wood	2.03	10.62	11.66	14.98	11.37	10.85	11.62
Greater Copenhagen	Taarnby	Kirstinehoej	Glass	1.27	1.28	1.21	1.03	0.92	1.04	1.02
Greater Copenhagen	Taarnby	Vaegtergangen	Glass	2.95	0.11					
Greater Copenhagen	Taarnby	Kirstinehoej	Garden	16.43	17.9	16.15	16.42	16.85	15.9	16.24
Greater Copenhagen	Taarnby	Vaegtergangen	Garden	23.78	27.63	24.57	22.58	28.43	35.02	34.24
Greater Copenhagen	Taarnby	Kirstinehoej	Soil	19.27	18.95	18.72	17.6	19.09	17.37	17.3
Greater Copenhagen	Taarnby	Vaegtergangen	Soil	12.8	6.28	10.42	12.49	9.87	12.24	10.16
Greater Copenhagen	Taarnby	Kirstinehoej	C&D	24.18	28.51	29.86	29.34	28.38	29.35	29.04
Greater Copenhagen	Taarnby	Vaegtergangen	C&D	12.8	13.65	14.64	16.07	18.78	12.74	12.15
Greater Copenhagen	Taarnby	Kirstinehoej	SMC	10.06	9.05	8.25	8.27	7.94	7.36	6.87
Greater Copenhagen	Taarnby	Vaegtergangen	SMC	17.58	18.2	15.76	13.57	11.16	10.65	9.84
Greater Copenhagen	Taarnby	Kirstinehoej	Bulky	7.55	0.61	0.24	0.85	1.01	0.99	0.96
Greater Copenhagen	Taarnby	Vaegtergangen	Bulky	5.89	0		1.74	1.5	1.19	1.68
Greater Copenhagen	Taarnby	Kirstinehoej	OW	12.23	6.79	7.38	6.64	6.1	6.26	7
Greater Copenhagen	Taarnby	Vaegtergangen	OW	13.31	13.65	13.9	9.23	9.44	8.06	9.74
Central Zealand	Koege	Bjaeverskov	Fibres	1.65	1.45	2.01	1.7	1.66	1.58	1.29
Central Zealand	Koege	Koege	Fibres	1.43	1.24	1.22	1.22	1.26	1.24	1.15
Central Zealand	Koege	Bjaeverskov	Plastic	0	0.06	0	0	0.01	0.03	0.02
Central Zealand	Koege	Koege	Plastic	0.02	0.01	0.01	0.04	0.06	0.08	0.09
Central Zealand	Koege	Bjaeverskov	Metal	5.01	4.89	5.27	4.52	5.15	4.72	4.11
Central Zealand	Koege	Koege	Metal	4	3.93	4.07	3.07	3.94	4.09	4.35
Central Zealand	Koege	Bjaeverskov	Wood	0			0	0	1.37	2.2
Central Zealand	Koege	Koege	Wood	0			0	0	0.98	4.87
Central Zealand	Koege	Bjaeverskov	Glass	0.73	0.96	1.89	2.11	1.74	1.3	2.23
Central Zealand	Koege	Koege	Glass	1.46	1.54	1.73	1.22	1.67	1.74	1.56
Central Zealand	Koege	Bjaeverskov	Garden	29.3	28.25	26.6	26.79	31.5	31.46	27.78
Central Zealand	Koege	Koege	Garden	27.81	23.27	21.9	22.27	23.19	23.4	24.58
Central Zealand	Koege	Bjaeverskov	Soil	9.33	12.54	10.78	7.93	10.08	10.9	11.67
Central Zealand	Koege	Koege	Soil	9.64	8.43	8.18	8.15	9.1	9.07	8.65
Central Zealand	Koege	Bjaeverskov	C&D	21.34	17.74	19.34	25.02	22.24	21.78	25.12
Central Zealand	Koege	Koege	C&D	24.62	30	29.98	30.17	29.28	28.43	28.94
Central Zealand	Koege	Bjaeverskov	SMC	9.87	13.67	11.25	10.43	10.31	14.62	11.36

Central Zealand	Koege	Koege	SMC	9.4	11.38	9.52	9.26	10.5	13.21	7.41
Central Zealand	Koege	Bjaeverskov	Bulky	12.95	10.55	13.73	11.7	11.23	6.56	9.09
Central Zealand	Koege	Koege	Bulky	13.41	11.4	15.97	15.05	13.49	11.94	12.37
Central Zealand	Koege	Bjaeverskov	OW	9.82	9.89	9.14	9.78	6.07	5.69	5.14
Central Zealand	Koege	Koege	OW	8.21	8.79	7.41	9.54	7.51	5.83	6.03
Central Zealand	Kalundborg	Bregninge	Fibres	2.73	2.55	2.91	2.61	2.41	2.49	2.59
Central Zealand	Kalundborg	Goerlev	Fibres	4.27	4.03	4.02	3.73	3.26	3.28	2.94
Central Zealand	Kalundborg	Hoeng	Fibres	5.53	5.64	5.93	5.06	4.34	3.65	3.64
Central Zealand	Kalundborg	Kalundborg	Fibres	4.41	4.47	4.44	4.67	3.8	3.45	3.51
Central Zealand	Kalundborg	Sejeroe	Fibres	3.52	7.59	4.31	2.36	2.04	1.67	7.81
Central Zealand	Kalundborg	Ubby	Fibres	4.54	4.44	4.29	5.26	3.36	3.31	3.84
Central Zealand	Kalundborg	Bregninge	Plastic	0.09	0.03	0.04	0.12	0.15	0.18	0.15
Central Zealand	Kalundborg	Goerlev	Plastic	0.11	0.13	0.12	0.29	0.14	0.16	0.19
Central Zealand	Kalundborg	Hoeng	Plastic	0.13	0.08	0.19	0.19	0.23	0.23	0.24
Central Zealand	Kalundborg	Kalundborg	Plastic	0	0.01	0.01	0.05	0.07	0.11	0.09
Central Zealand	Kalundborg	Sejeroe	Plastic	0	0	0	0	0	0	0
Central Zealand	Kalundborg	Ubby	Plastic	0.07	0.12	0.17	0.31	0.28	0.17	0.16
Central Zealand	Kalundborg	Bregninge	Metal	4.89	5.24	4.71	8.46	4.15	4.88	4.95
Central Zealand	Kalundborg	Goerlev	Metal	4.53	4.73	4.69	3.16	4.27	4.57	4.99
Central Zealand	Kalundborg	Hoeng	Metal	5.01	4.93	4.85	3.38	4.18	4.64	4.74
Central Zealand	Kalundborg	Kalundborg	Metal	3.19	4.25	3.87	4.13	4.74	3.87	5.22
Central Zealand	Kalundborg	Sejeroe	Metal	7.48	9.17	4.05	10.46	8.31	9.16	10.84
Central Zealand	Kalundborg	Ubby	Metal	4.63	5.72	4.78	4.01	4.63	3.77	5.1
Central Zealand	Kalundborg	Bregninge	Wood	0			0	0	2.58	10.91
Central Zealand	Kalundborg	Goerlev	Wood	0			0	0	2.18	6.05
Central Zealand	Kalundborg	Hoeng	Wood	0			0	0	2.06	8.31
Central Zealand	Kalundborg	Kalundborg	Wood	0			0	0	2.36	9.44
Central Zealand	Kalundborg	Sejeroe	Wood	0			0	0	0	0
Central Zealand	Kalundborg	Ubby	Wood	0			0	0	2.39	9.02
Central Zealand	Kalundborg	Bregninge	Glass	1.19	1.12	1.16	1.27	2.38	2.75	2.01
Central Zealand	Kalundborg	Goerlev	Glass	1.22	1.54	1.55	1.61	2.47	2.96	2.05
Central Zealand	Kalundborg	Hoeng	Glass	0.79	1.21	0.92	0.64	2.28	2.84	2.56

Central Zealand	Kalundborg	Kalundborg	Glass	6.01	6.35	8.38	5.34	2.75	2.76	2.39
Central Zealand	Kalundborg	Sejeroe	Glass	1.93	1.2	0.82	1.05	2.29	1.6	1.55
Central Zealand	Kalundborg	Ubby	Glass	0.93	0.77	0.8	0.7	3.42	2.67	2.43
Central Zealand	Kalundborg	Bregninge	Garden	29.68	27.45	29.05	32.17	31.48	29.36	28.3
Central Zealand	Kalundborg	Goerlev	Garden	28.35	30.29	30.23	32.67	33.24	32.76	28.97
Central Zealand	Kalundborg	Hoeng	Garden	24.97	25.96	26.97	27.26	26.68	27.08	26.79
Central Zealand	Kalundborg	Kalundborg	Garden	23.38	22.97	25.47	28.89	27.15	25.64	27.03
Central Zealand	Kalundborg	Sejeroe	Garden	27.96	0	54.92	0	0	0	0
Central Zealand	Kalundborg	Ubby	Garden	24.41	22.96	27.63	29.7	22.9	28.34	26.03
Central Zealand	Kalundborg	Bregninge	Soil	2.94	6.61	6.41	7.1	7	6.59	6.95
Central Zealand	Kalundborg	Goerlev	Soil	3.77	4.94	5.78	5.65	5.02	5	4.76
Central Zealand	Kalundborg	Hoeng	Soil	4.43	8.09	7.1	5.73	9.09	7.77	7.56
Central Zealand	Kalundborg	Kalundborg	Soil	9.6	7.26	6.19	7.91	6.37	5.36	6.25
Central Zealand	Kalundborg	Sejeroe	Soil	5.44	0	0	0	0	0	0
Central Zealand	Kalundborg	Ubby	Soil	5.43	6.26	7.73	8.21	9.12	5.25	6.87
Central Zealand	Kalundborg	Bregninge	C&D	22.64	21.58	21.08	10.07	18.26	19.67	20.28
Central Zealand	Kalundborg	Goerlev	C&D	21.02	20.23	19.32	19.2	19.59	18.67	24.26
Central Zealand	Kalundborg	Hoeng	C&D	25.26	21.01	19.52	22.85	20.37	21.21	20.27
Central Zealand	Kalundborg	Kalundborg	C&D	23.65	22.55	20.8	13.19	24.19	29.51	23.1
Central Zealand	Kalundborg	Sejeroe	C&D	20.43	28.47	10.4	26.71	38.66	30.27	28.04
Central Zealand	Kalundborg	Ubby	C&D	26.22	24.53	18.79	13.9	25.18	24.18	23.44
Central Zealand	Kalundborg	Bregninge	SMC	15.03	13.38	14.39	14.66	18.46	14.5	13.32
Central Zealand	Kalundborg	Goerlev	SMC	13.01	12.92	15.6	14.35	13.64	13.61	8.66
Central Zealand	Kalundborg	Hoeng	SMC	12.63	11.73	14.11	14.7	15.47	15.09	11.32
Central Zealand	Kalundborg	Kalundborg	SMC	14.62	21.28	11.99	14.89	16.54	12.75	11.9
Central Zealand	Kalundborg	Sejeroe	SMC	21.1	42.27	18.49	42.18	29.77	40.62	42.5
Central Zealand	Kalundborg	Ubby	SMC	13.6	15.77	16.32	16.08	13.25	14.1	10.02
Central Zealand	Kalundborg	Bregninge	Bulky	11.5	12.02	11.57	12.85	7.44	9.73	2.81
Central Zealand	Kalundborg	Goerlev	Bulky	9.57	9.41	8.76	8.25	9.79	8.01	9.12
Central Zealand	Kalundborg	Hoeng	Bulky	9.76	11.05	11.75	9.11	9.7	7.74	7.86
Central Zealand	Kalundborg	Kalundborg	Bulky	7.9	2.4	12.13	12.46	8.6	9.01	5.28
Central Zealand	Kalundborg	Sejeroe	Bulky	1.15	0	0.47	0.77	3.87	8.03	3.93

Central Zealand	Kalundborg	Ubby	Bulky	9.76	8.15	9.23	9.02	10.34	7.91	5.16
Central Zealand	Kalundborg	Bregninge	OW	9.32	10.02	8.67	10.68	8.29	7.28	7.73
Central Zealand	Kalundborg	Goerlev	OW	14.13	11.78	9.93	11.08	8.58	8.79	8.02
Central Zealand	Kalundborg	Hoeng	OW	11.49	10.31	8.66	11.07	7.65	7.69	6.71
Central Zealand	Kalundborg	Kalundborg	OW	7.24	8.46	6.73	8.48	5.78	5.19	5.78
Central Zealand	Kalundborg	Sejeroe	OW	10.99	11.29	6.53	16.46	15.06	8.65	5.34
Central Zealand	Kalundborg	Ubby	OW	10.4	11.27	10.25	12.82	7.51	7.9	7.92
Central Zealand	Lejre	Torkilstrup	Fibres	1.51	1.35	1.46	1.26	1.35	1.42	1.64
Central Zealand	Lejre	Torkilstrup	Plastic	0.07	0.1	0.1	0.17	0.13	0.19	0.14
Central Zealand	Lejre	Torkilstrup	Metal	4.94	5.18	5.17	4.17	4.29	4.6	5.2
Central Zealand	Lejre	Torkilstrup	Wood	0.1			0.03	0	3.12	7.15
Central Zealand	Lejre	Torkilstrup	Glass	1.64	2.45	2.47	2.26	2.63	2.68	2.23
Central Zealand	Lejre	Torkilstrup	Garden	25.44	26.32	27.56	25.12	28.52	30.15	30.08
Central Zealand	Lejre	Torkilstrup	Soil	10.39	9.52	7.7	7.14	7.63	9.34	8.72
Central Zealand	Lejre	Torkilstrup	C&D	20.7	18.96	20.68	25	21.02	16.94	19.5
Central Zealand	Lejre	Torkilstrup	SMC	13.01	17.35	12.42	12.31	12.58	14.92	13.13
Central Zealand	Lejre	Torkilstrup	Bulky	12.3	7.4	12.97	12.22	14.28	9.74	5.01
Central Zealand	Lejre	Torkilstrup	OW	9.91	11.37	9.48	10.33	7.56	6.93	7.21
Central Zealand	Stevns	Haarlev	Fibres	1.02	0.9	0.84	0.89	1.55	1.53	1.46
Central Zealand	Stevns	Store_Hedding	Fibres	1.9	1.68	1.79	1.65	1.66	1.71	1.8
Central Zealand	Stevns	Haarlev	Plastic	0	0	0	0	0	0.05	0.38
Central Zealand	Stevns	Store_Hedding	Plastic	0	0	0.03	0.04	0.08	0.11	0.14
Central Zealand	Stevns	Haarlev	Metal	3.55	4.3	3.9	3.24	5.72	6.9	6.57
Central Zealand	Stevns	Store_Hedding	Metal	4.91	4.59	6.23	4.13	5.17	5.63	5.43
Central Zealand	Stevns	Haarlev	Wood	0			0	0	3.4	3.74
Central Zealand	Stevns	Store_Hedding	Wood	0			0	0	2.9	5.52
Central Zealand	Stevns	Haarlev	Glass	1.82	2.35	2.22	3.04	2.91	3.22	2.13
Central Zealand	Stevns	Store_Hedding	Glass	2.18	2.34	2.49	3.06	2.98	3.08	2.18
Central Zealand	Stevns	Haarlev	Garden	42.93	42.31	43.92	31.19	27.41	27.08	28.54
Central Zealand	Stevns	Store_Hedding	Garden	24.55	26.92	24.41	27.19	29.48	27.58	27.34
Central Zealand	Stevns	Haarlev	Soil	5.46	5.26	4.91	3.67	4.27	7.6	5.86
Central Zealand	Stevns	Store_Hedding	Soil	8.55	9.73	9.16	6.96	7.16	8.12	8.2

Central Zealand	Stevns	Haarlev	C&D	17.2	15.97	20.17	33.64	20.55	15.32	20.49
Central Zealand	Stevns	Store_Hedding	C&D	21.98	20.39	20.22	20.77	21.03	19.79	20.59
Central Zealand	Stevns	Haarlev	SMC	8.5	11.03	8.24	8.33	16.38	15.91	11.69
Central Zealand	Stevns	Store_Hedding	SMC	13.15	13.5	11.38	13.16	19.1	19.7	12.51
Central Zealand	Stevns	Haarlev	Bulky	10.93	8.78	8.74	8.16	12.69	9.5	10.57
Central Zealand	Stevns	Store_Hedding	Bulky	12.06	9.06	13.15	10.82	5.24	4.44	7.99
Central Zealand	Stevns	Haarlev	OW	8.61	9.1	7.07	7.82	8.53	9.49	8.58
Central Zealand	Stevns	Store_Hedding	OW	10.72	11.79	11.14	12.22	8.1	6.94	8.31
Central Zealand	Roskilde	Jyllinge	Fibres	1.62	1.54	1.54	1.54	1.4	1.23	1.37
Central Zealand	Roskilde	Roskilde	Fibres	1.61	1.22	1.42	1.6	1.37	1.51	1.44
Central Zealand	Roskilde	Viby	Fibres	1.6	1.38	1.35	1.45	1.28	1.37	1.33
Central Zealand	Roskilde	Jyllinge	Plastic	0.19	0.2	0.17	0.11	0.08	0.11	0.14
Central Zealand	Roskilde	Roskilde	Plastic	0	0	0	0.01	0.05	0.09	0.12
Central Zealand	Roskilde	Viby	Plastic	0	0	0.01	0.06	0.06	0.05	0.07
Central Zealand	Roskilde	Jyllinge	Metal	3.99	4.69	4.95	2.96	4.05	3.81	4.6
Central Zealand	Roskilde	Roskilde	Metal	3.57	3.26	3.51	3.52	3.84	3.97	4.12
Central Zealand	Roskilde	Viby	Metal	4.06	4.97	4.64	4.64	4.46	4.43	4.51
Central Zealand	Roskilde	Jyllinge	Wood	0			0	0	2.39	5.72
Central Zealand	Roskilde	Roskilde	Wood	0.32			0	0	2.84	8.04
Central Zealand	Roskilde	Viby	Wood	0.11			0	0	2.5	4.15
Central Zealand	Roskilde	Jyllinge	Glass	1.81	1.78	1.76	1.75	1.9	1.76	1.97
Central Zealand	Roskilde	Roskilde	Glass	1.96	1.49	2.22	2.12	2.45	2.54	1.89
Central Zealand	Roskilde	Viby	Glass	1.68	2.57	2.49	2.63	2.27	2.44	2.16
Central Zealand	Roskilde	Jyllinge	Garden	30.89	30.2	29.43	27.25	27.45	25.91	29.01
Central Zealand	Roskilde	Roskilde	Garden	20.06	17.17	20.31	19.7	20.1	20.34	21.66
Central Zealand	Roskilde	Viby	Garden	25.58	24.22	25.83	26	29.29	26.89	25.07
Central Zealand	Roskilde	Jyllinge	Soil	10.04	9.82	10.01	8.24	9.14	8.86	7.84
Central Zealand	Roskilde	Roskilde	Soil	10.08	6.79	9.05	8.22	9.88	9.44	8.22
Central Zealand	Roskilde	Viby	Soil	9.01	7.63	8.14	5.73	7.68	6.91	9.92
Central Zealand	Roskilde	Jyllinge	C&D	22.61	21.81	23.79	24.52	24.83	31.44	24.92
Central Zealand	Roskilde	Roskilde	C&D	29.22	26.59	27.16	25.12	29.25	29.27	30.46
Central Zealand	Roskilde	Viby	C&D	23.8	24.17	25.74	28.07	24.42	27.79	24.37

Central Zealand	Roskilde	Jyllinge	SMC	10	13.17	9.66	10	10.81	10.71	9.72
Central Zealand	Roskilde	Roskilde	SMC	12.43	28.77	15.33	15.25	14.22	15.32	13.4
Central Zealand	Roskilde	Viby	SMC	10.66	14.59	10.9	10.71	10.83	12.92	9.77
Central Zealand	Roskilde	Jyllinge	Bulky	11.35	8.08	11.31	13.76	14.36	8.57	7.57
Central Zealand	Roskilde	Roskilde	Bulky	13.58	7.64	13.98	16.42	13.4	10.01	5.87
Central Zealand	Roskilde	Viby	Bulky	13.45	9.62	12.35	11.84	13.58	9.15	11.89
Central Zealand	Roskilde	Jyllinge	OW	7.5	8.71	7.38	9.86	5.99	5.19	7.15
Central Zealand	Roskilde	Roskilde	OW	7.17	7.08	7.01	8.05	5.44	4.68	4.79
Central Zealand	Roskilde	Viby	OW	10.05	10.86	8.56	8.87	6.12	5.55	6.76
Djursland	Syddjurs	Ebeltoft	Fibres	3.3	2.9	3.17	3.18	2.87	3.16	3.32
Djursland	Syddjurs	Hornslet	Fibres	1.81	1.84	1.71	1.99	1.67	1.8	2.19
Djursland	Syddjurs	Knebel	Fibres	2.3	2.73	2.4	2.2	2.15	2.15	2.74
Djursland	Syddjurs	Ryomgaard	Fibres	1.43	1.41	1.54	1.74	1.57	1.68	2.12
Djursland	Syddjurs	Ebeltoft	Plastic	0.8	0.92	0.99	0.98	0.87	0.95	0.99
Djursland	Syddjurs	Hornslet	Plastic	0.58	1.03	1.16	1.12	1.13	1.12	1.08
Djursland	Syddjurs	Knebel	Plastic	0.72	0.57	0.85	1	1.04	1.09	1.1
Djursland	Syddjurs	Ryomgaard	Plastic	0.76	0.98	0.97	0.97	0.84	1.06	1.02
Djursland	Syddjurs	Ebeltoft	Metal	4.12	4.61	4.6	4.58	4.52	4.85	4.64
Djursland	Syddjurs	Hornslet	Metal	4.49	4.84	4.77	4.92	4.89	5.42	4.88
Djursland	Syddjurs	Knebel	Metal	4.81	5.01	5.17	5.34	5.39	5.4	5.34
Djursland	Syddjurs	Ryomgaard	Metal	4.92	5.29	5.36	5.73	5.48	5.78	5.75
Djursland	Syddjurs	Ebeltoft	Wood	7.07	6.62	6.96	7.11	7.12	7.71	8.23
Djursland	Syddjurs	Hornslet	Wood	6.89	7.04	7.48	7.67	7.75	8.45	8.64
Djursland	Syddjurs	Knebel	Wood	7.4	7.18	7.49	7.54	7.04	7.52	8.91
Djursland	Syddjurs	Ryomgaard	Wood	7.12	6.73	7.66	7.81	8.05	8.96	9.44
Djursland	Syddjurs	Ebeltoft	Glass	1.01	1.62	1.85	1.85	1.8	1.74	2.36
Djursland	Syddjurs	Hornslet	Glass	0.67	1.46	1.65	1.77	1.76	2.13	2.22
Djursland	Syddjurs	Knebel	Glass	1.07	1.81	2.28	2.15	1.94	2.37	2.41
Djursland	Syddjurs	Ryomgaard	Glass	0.75	1.32	1.66	1.92	1.8	2.12	2.37
Djursland	Syddjurs	Ebeltoft	Garden	34.97	36.14	38.17	39	39.86	39.31	38.92
Djursland	Syddjurs	Hornslet	Garden	26.95	28.69	29.93	28	29.41	30.47	30.14
Djursland	Syddjurs	Knebel	Garden	25.87	27.19	30.82	29.99	31.2	31.13	30.58

Djursland	Syddjurs	Ryomgaard	Garden	27.43	26.83	28.93	26.7	31.19	29.43	29.33
Djursland	Syddjurs	Ebeltoft	Soil	6.57	4.9	3.56	2.82	3.9	3.81	2.89
Djursland	Syddjurs	Hornslet	Soil	14.61	9.59	9.21	9.29	9.51	7.81	9.17
Djursland	Syddjurs	Knebel	Soil	4.86	2.82	2.83	2.68	2.43	2.29	2.29
Djursland	Syddjurs	Ryomgaard	Soil	8.01	5.36	6.59	4.65	5.05	4.43	5.4
Djursland	Syddjurs	Ebeltoft	C&D	12.4	13.51	12.57	12.2	12.28	11.83	11.98
Djursland	Syddjurs	Hornslet	C&D	14.55	15.9	15.43	15.65	14.95	14.62	14.66
Djursland	Syddjurs	Knebel	C&D	16.41	18.38	15.21	14.86	17.35	14.96	13.52
Djursland	Syddjurs	Ryomgaard	C&D	14.6	17.67	15.44	16.81	14.13	15.03	14.09
Djursland	Syddjurs	Ebeltoft	SMC	5.55	5.75	6.02	6.31	5.81	5.76	5.28
Djursland	Syddjurs	Hornslet	SMC	6.65	6.81	6.91	6.9	6.49	6.31	5.54
Djursland	Syddjurs	Knebel	SMC	6.21	6.28	6.11	5.57	5.79	5.6	6.41
Djursland	Syddjurs	Ryomgaard	SMC	6.16	6.5	6.59	7.23	6.8	6.59	6.44
Djursland	Syddjurs	Ebeltoft	Bulky	3.4	3.66	3.41	3.75	3.57	3.27	3.17
Djursland	Syddjurs	Hornslet	Bulky	2.71	2.76	2.85	2.93	2.72	2.61	2.88
Djursland	Syddjurs	Knebel	Bulky	4.68	3.85	3.75	4.35	3.55	3.59	3.74
Djursland	Syddjurs	Ryomgaard	Bulky	3.82	3.89	4.22	4.37	4.45	3.63	3.38
Djursland	Syddjurs	Ebeltoft	OW	20.82	19.37	18.69	18.23	17.4	17.61	18.22
Djursland	Syddjurs	Hornslet	OW	20.09	20.05	18.9	19.75	19.71	19.25	18.59
Djursland	Syddjurs	Knebel	OW	25.68	24.17	23.09	24.32	22.13	23.91	22.97
Djursland	Syddjurs	Ryomgaard	OW	24.99	24.01	21.05	22.08	20.64	21.29	20.65
Djursland	Norddjurs	Glesborg	Fibres	1.33	1.38	1.3	1.24	1.45	1.25	1.41
Djursland	Norddjurs	Grenaa	Fibres	1.79	1.38	1.25	1.26	1.07	1.33	1.83
Djursland	Norddjurs	Roende	Fibres	1.5	2.17	1.81	1.92	1.81	1.94	2.44
Djursland	Norddjurs	Tirstrup	Fibres	1.34	0.93	1.36	1.47	1.51	1.35	2.07
Djursland	Norddjurs	Glesborg	Plastic	0.89	0.77	1.08	1.13	1.12	1.08	1.13
Djursland	Norddjurs	Grenaa	Plastic	0.69	0.81	0.65	0.72	0.63	0.75	0.85
Djursland	Norddjurs	Roende	Plastic	0.54	0.81	0.77	0.85	0.89	0.82	0.97
Djursland	Norddjurs	Tirstrup	Plastic	0.78	0.87	0.98	1.31	1.28	1.17	1.48
Djursland	Norddjurs	Glesborg	Metal	5.11	5.15	5.42	4.95	5.11	5.37	5.69
Djursland	Norddjurs	Grenaa	Metal	3.96	4.25	3.48	3.15	3.13	4.24	4.56
Djursland	Norddjurs	Roende	Metal	3.37	4.24	3.99	4.41	4.57	4.77	4.86

Djursland	Norddjurs	Tirstrup	Metal	5.07	5.54	4.12	4.94	5.1	5.41	6.29
Djursland	Norddjurs	Glesborg	Wood	6.54	6.85	7.04	7.4	6.57	7.71	8.26
Djursland	Norddjurs	Grenaa	Wood	7.55	7.69	6.64	6.31	5.87	7.49	9.1
Djursland	Norddjurs	Roende	Wood	5.88	6.88	6.16	7.45	7.53	7.95	7.68
Djursland	Norddjurs	Tirstrup	Wood	6.72	7.03	7.36	7.48	7.94	8.12	8.04
Djursland	Norddjurs	Glesborg	Glass	0.7	1.53	1.73	1.92	2.15	2.25	1.87
Djursland	Norddjurs	Grenaa	Glass	0.68	1.29	1.43	1.27	1.27	1.54	1.85
Djursland	Norddjurs	Roende	Glass	0.7	2.24	3.17	2.32	1.99	2.03	2.77
Djursland	Norddjurs	Tirstrup	Glass	0.52	1.39	1.48	1.91	1.48	2.45	2.71
Djursland	Norddjurs	Glesborg	Garden	31.33	32.62	33.09	33.38	37.15	34.32	36.47
Djursland	Norddjurs	Grenaa	Garden	24.19	24.94	35.27	42.12	47.47	35.24	29.77
Djursland	Norddjurs	Roende	Garden	29.46	32.32	32.66	31.3	33.01	31.89	31.42
Djursland	Norddjurs	Tirstrup	Garden	29.63	29.52	29.53	28.39	29.92	27.29	29.45
Djursland	Norddjurs	Glesborg	Soil	3.09	2.18	3.41	3.19	3.12	3.1	3.59
Djursland	Norddjurs	Grenaa	Soil	13.42	11.24	10.09	8.92	7.47	10.39	10.89
Djursland	Norddjurs	Roende	Soil	14.1	7.98	8.84	6.51	9.33	7.84	7.79
Djursland	Norddjurs	Tirstrup	Soil	5.27	4.15	6.04	4.28	4.64	4.97	3.34
Djursland	Norddjurs	Glesborg	C&D	12.79	13.99	14.12	13.65	11.95	13.37	11.65
Djursland	Norddjurs	Grenaa	C&D	15.92	17.6	16.07	13.63	13.26	14.6	14.9
Djursland	Norddjurs	Roende	C&D	15.4	15.53	15.99	16.73	15.33	16.23	14.63
Djursland	Norddjurs	Tirstrup	C&D	16.88	15.43	16.8	16.24	16.56	16.79	12.87
Djursland	Norddjurs	Glesborg	SMC	6.58	6.24	6.15	6.21	5.44	5.42	5.19
Djursland	Norddjurs	Grenaa	SMC	5.52	5.71	4.75	4.23	3.72	4.6	4.83
Djursland	Norddjurs	Roende	SMC	5.76	5.72	5.64	6.21	5.73	5.47	5.41
Djursland	Norddjurs	Tirstrup	SMC	6.64	6.39	6.28	6.32	6.13	5.62	5.9
Djursland	Norddjurs	Glesborg	Bulky	4.27	3.8	3.78	3.57	3.34	3.55	3.74
Djursland	Norddjurs	Grenaa	Bulky	3.33	3.33	2.92	2.51	2.22	2.62	3.15
Djursland	Norddjurs	Roende	Bulky	3.35	2.88	2.92	3.12	2.71	2.63	2.88
Djursland	Norddjurs	Tirstrup	Bulky	3.17	2.45	2.83	2.89	2.75	2.39	2.86
Djursland	Norddjurs	Glesborg	OW	27.37	25.49	22.87	23.36	22.6	22.57	21
Djursland	Norddjurs	Grenaa	OW	22.96	21.76	17.45	15.89	13.89	17.2	18.27
Djursland	Norddjurs	Roende	OW	19.94	19.25	18.05	19.19	17.1	18.44	19.15

Djursland	Norddjurs	Tirstrup	OW	23.97	26.3	23.21	24.76	22.69	24.44	24.98
Silkeborg	Silkeborg	Gjern	Fibres	2.18	2.56	3.68	3.7	4	3.3	3.72
Silkeborg	Silkeborg	Tandskov	Fibres	2.65	2.78	3.35	3.22	3.73	3.34	3.46
Silkeborg	Silkeborg	Them	Fibres	3.02	2.74	3.17	3.97	3.89	4.17	3.63
Silkeborg	Silkeborg	Tietgensvej	Fibres	5.41	2.89	3.53	4.68	4.5	3.85	4.35
Silkeborg	Silkeborg	Gjern	Plastic	0.07	0.08	1.1	1.07	1.29	1.46	1.62
Silkeborg	Silkeborg	Tandskov	Plastic	0.11	0.16	1.15	1.07	1.14	1.27	1.17
Silkeborg	Silkeborg	Them	Plastic	0	0	0.73	1.7	1.36	1.32	1.24
Silkeborg	Silkeborg	Tietgensvej	Plastic	0.25	0.22	0.92	1.11	1.13	1.18	1.21
Silkeborg	Silkeborg	Gjern	Metal	5.12	4.9	4.79	4.44	4.16	4.76	4.47
Silkeborg	Silkeborg	Tandskov	Metal	3.98	3.81	3.56	3.78	3.59	3.44	4.01
Silkeborg	Silkeborg	Them	Metal	5.27	5.27	4.39	4.71	4.11	4.75	4.64
Silkeborg	Silkeborg	Tietgensvej	Metal	3.87	3.75	3.87	3.64	3.63	3.79	3.66
Silkeborg	Silkeborg	Gjern	Wood	4.24	9.88	10.14	10.61	11.77	12.78	13.26
Silkeborg	Silkeborg	Tandskov	Wood	6.32	8.24	9.66	10.45	10.42	10.07	9.57
Silkeborg	Silkeborg	Them	Wood	6.1	7.08	10.01	10.77	12.4	11.28	12.2
Silkeborg	Silkeborg	Tietgensvej	Wood	6.2	8.22	9.42	11.29	11.82	11.78	11.84
Silkeborg	Silkeborg	Gjern	Glass	0.96	1.99	2.19	2.13	2.34	2.28	2.25
Silkeborg	Silkeborg	Tandskov	Glass	1.75	1.97	2.14	2.24	2.2	2.08	2.15
Silkeborg	Silkeborg	Them	Glass	0	0	2.81	2.87	2.75	2.84	2.59
Silkeborg	Silkeborg	Tietgensvej	Glass	2.29	2.6	2.89	2.8	2.74	2.77	2.74
Silkeborg	Silkeborg	Gjern	Garden	24.05	23.86	24.34	23.22	24.55	26.17	25.42
Silkeborg	Silkeborg	Tandskov	Garden	25.17	26.35	28.54	28.28	29.54	28.34	27.33
Silkeborg	Silkeborg	Them	Garden	29.19	30.12	30.8	27.32	26.66	27.41	27.66
Silkeborg	Silkeborg	Tietgensvej	Garden	26.54	27.76	28.37	25.31	26.88	27.21	26.91
Silkeborg	Silkeborg	Gjern	Soil	8.43	8.43	12	10.55	10.51	10.46	10.42
Silkeborg	Silkeborg	Tandskov	Soil	9.15	10.66	10.43	9.48	10.46	11.5	10.78
Silkeborg	Silkeborg	Them	Soil	13.39	11.38	11.67	12.13	12.99	11.63	11.68
Silkeborg	Silkeborg	Tietgensvej	Soil	11.07	10.66	10.57	13.22	13.14	11.98	11.5
Silkeborg	Silkeborg	Gjern	C&D	25.64	26.37	22.99	25.97	24.93	22.32	22.99
Silkeborg	Silkeborg	Tandskov	C&D	20.14	23.34	22.54	21.55	19.97	22.2	21.68
Silkeborg	Silkeborg	Them	C&D	17.91	18.02	18.66	20.08	21.68	21.23	22.15

Silkeborg	Silkeborg	Tietgensvej	C&D	20.33	21.11	21.34	20.5	20.54	21.39	22.45
Silkeborg	Silkeborg	Gjern	SMC	10.46	9.86	7.94	7.88	7.27	6.38	5.53
Silkeborg	Silkeborg	Tandskov	SMC	9.89	9.33	7.12	7.56	6.77	6.57	6.16
Silkeborg	Silkeborg	Them	SMC	10.26	10.89	7.73	7.19	5.89	6.22	4.65
Silkeborg	Silkeborg	Tietgensvej	SMC	11.12	10.97	9.54	8.78	7.38	7.02	6.5
Silkeborg	Silkeborg	Gjern	Bulky	8.71	4.26	3.66	3.29	2.9	3.66	3.97
Silkeborg	Silkeborg	Tandskov	Bulky	6.92	4.91	3.54	3.58	3.44	3.54	3.98
Silkeborg	Silkeborg	Them	Bulky	8.37	7.57	3.38	2.84	2.39	3.09	3.08
Silkeborg	Silkeborg	Tietgensvej	Bulky	5.43	4.5	3.05	2.43	2.16	2.55	2.62
Silkeborg	Silkeborg	Gjern	OW	10.14	7.8	7.18	7.14	6.29	6.42	6.36
Silkeborg	Silkeborg	Tandskov	OW	13.94	8.45	7.97	8.78	8.74	7.64	9.72
Silkeborg	Silkeborg	Them	OW	6.5	6.93	6.66	6.42	5.87	6.07	6.49
Silkeborg	Silkeborg	Tietgensvej	OW	7.48	7.32	6.49	6.22	6.07	6.47	6.23

Table S15: Detail composition based on 59 waste fractions for each regions from 2010 to 2016 (wet mass composition %)

Area	Fractions	2010	2011	2012	2013	2014	2015	2016
Greater Copenhagen	Anti-freeze	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Asbestos waste	0.600	0.600	0.600	0.600	0.500	0.500	0.500
	Asphalt residues	0.100	0.600	0.500	0.400	0.400	0.500	0.300
	Batteries	0.100	0.100	0.100	0.100	0.100	0.100	0.100
	Brics	0.000	0.000	0.000	0.100	1.200	2.400	2.400
	Brics, blocks and tiles	10.700	0.200	0.200	0.400	0.300	0.300	0.300
	Bulky	7.900	1.200	0.400	0.000	0.000	0.000	0.000
	Cables	0.000	0.000	0.000	0.000	0.100	0.100	0.100
	Chemichal fertilizer	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Clinical waste	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Concrete	2.300	12.600	13.000	12.100	12.700	12.900	12.400
	Cooling and heating white goods	1.000	0.900	1.000	1.000	0.900	1.100	1.100
	Dense plastics	0.000	0.000	0.200	0.700	0.800	0.800	0.900
	Fire extinguisher	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Fireworks	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Furniture	0.100	0.000	0.000	1.300	1.400	1.300	1.400
	Garden herbicides and pesticides	0.000	0.000	0.000	0.000	0.000	0.000	0.000

	Garden waste	12.300	12.900	11.900	12.600	13.000	12.600	12.900
	Gas bottles	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Glass packaging	0.300	0.200	0.000	0.000	0.000	0.000	0.000
	Gypsum waste	2.500	2.500	2.300	2.400	2.500	2.400	2.500
	Landfilled waste	10.300	1.300	1.300	1.400	1.400	1.300	2.200
	Lighting equipment	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Mattresses	0.400	0.600	0.900	0.100	0.000	0.000	0.000
	Metal containers and cans	4.700	4.400	4.200	4.100	3.800	3.800	4.100
	Mineral oil	0.000	0.000	0.000	0.000	0.000	0.200	0.600
	Miscellaneous combustible	12.400	11.000	9.600	9.400	8.700	8.100	7.800
	Other wood	0.600	0.500	0.600	0.300	0.000	0.000	0.000
	Paints	0.400	0.400	0.500	0.500	0.600	0.600	0.700
	Paper and board	2.600	2.400	2.300	2.400	2.300	2.200	2.400
	Plastic packaging	0.100	0.100	0.100	0.100	0.100	0.100	0.100
	Plastics films	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Polystyrene	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Polyvinylchloride (PVC)	0.200	0.200	0.100	0.000	0.000	0.000	0.000
	Printer cartridges	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Sanitary ware	3.100	7.400	8.100	8.300	8.900	9.300	8.300
	Small household appliances	1.600	1.500	1.400	1.400	1.200	1.200	1.100
	Soil	14.100	14.000	15.400	14.100	14.500	14.500	13.900
	Solvent-based waste	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Spray can	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Textiles	0.200	0.200	0.300	0.400	0.400	0.400	0.500
	Tiles	5.700	8.200	8.400	8.300	6.100	4.300	4.300
	Treated wood	0.100	0.200	0.200	0.200	0.200	0.300	0.300
	Tyres	0.200	0.200	0.200	0.200	0.200	0.200	0.200
	Untreated wood	4.300	14.300	15.000	15.800	16.100	16.900	17.300
	Waste exchange	0.000	0.000	0.000	0.100	0.600	0.600	0.300
	Windows glass	1.100	1.200	1.100	1.100	1.000	1.100	1.000
	Windows glass with PCB	0.000	0.000	0.100	0.000	0.000	0.000	0.000
		100	**100**	**100**	**100**	**100**	**100**	**100**
Djursland	Asbestos waste	3.500	4.100	3.400	3.100	3.100	3.400	3.200
	Brics	0.000	0.000	0.000	0.000	0.000	0.300	1.200
	Bulky	3.500	3.300	3.300	3.300	3.000	3.000	3.200
	Cables	0.100	0.100	0.100	0.100	0.100	0.100	0.100
	Clinical waste	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Concrete	13.700	15.000	14.200	13.600	13.100	13.100	11.500
	Cooling and heating white goods	1.500	1.300	1.400	1.700	1.200	1.400	1.100
	Dense plastics	0.600	0.700	0.700	0.700	0.700	0.700	0.800
	Ferrous metal	4.300	4.700	4.400	4.400	4.400	4.900	5.000
	Garden waste	28.500	29.600	33.100	34.400	37.500	33.300	32.300

	Gas bottles	0.100	0.100	0.200	0.100	0.100	0.000	0.000
	Glass packaging	0.300	0.400	0.300	0.400	0.300	0.600	0.800
	Gypsum waste	1.100	1.100	1.000	1.000	0.900	1.100	1.000
	Landfilled waste	11.900	10.700	9.600	8.600	7.500	7.800	7.700
	Miscellaneous combustible	6.000	6.100	5.800	5.800	5.400	5.500	5.500
	Paper and board	1.900	1.900	1.800	1.800	1.700	1.800	1.900
	Plastics films	0.100	0.200	0.200	0.300	0.200	0.200	0.300
	Polyvinylchloride (PVC)	0.200	0.000	0.200	0.200	0.200	0.200	0.200
	Small household appliances	1.500	1.500	0.400	1.600	1.300	1.500	1.800
	Soil	9.700	6.900	7.000	6.000	6.200	6.400	6.500
	Textiles	0.000	0.000	0.000	0.000	0.000	0.000	0.300
	Thermal insulation materials	0.000	0.000	0.000	0.200	0.300	0.300	0.300
	Treated wood	3.700	4.000	4.000	3.900	4.200	4.600	4.900
	Tires	0.300	0.300	0.300	0.300	0.300	0.400	0.300
	Untreated wood	7.000	7.100	7.000	7.200	7.000	7.900	8.700
	Waste accumulators	0.100	0.100	0.100	0.100	0.100	0.100	0.100
	Windows glass	0.400	1.200	1.500	1.400	1.400	1.300	1.400
		100	**100**	**100**	**100**	**100**	**100**	**100**
Central Zealand	Asbestos waste	2.100	1.900	1.700	1.800	1.900	1.600	1.700
	Asphalt residues	0.100	0.200	0.100	0.200	0.200	0.200	0.100
	Bigbags	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Brics, blocks and tiles	12.300	15.000	21.100	17.400	19.500	20.300	20.100
	Bulky	11.700	8.400	12.900	13.100	11.900	9.500	7.900
	Cables	0.000	0.000	0.000	0.000	0.000	0.000	0.100
	Concrete	10.200	7.100	1.400	4.200	3.000	2.800	2.800
	Ferrous metal	4.100	4.300	4.300	3.900	4.300	4.300	4.600
	Garden waste	26.000	24.200	25.700	25.300	25.800	25.500	25.900
	Gas bottles	0.100	0.100	0.000	0.600	0.100	0.000	0.000
	Glass packaging	1.000	1.100	1.300	0.900	0.900	1.000	0.700
	Gypsum waste	1.500	1.400	1.400	1.500	1.500	1.600	1.600
	Landfilled waste	2.900	2.400	1.800	1.200	0.900	0.700	0.600
	Large household Appliances	0.400	0.900	0.700	2.600	0.100	0.200	0.200
	Mineral oil	0.800	0.600	0.900	1.300	1.200	1.200	1.100
	Miscellaneous combustible	12.000	17.900	12.300	12.600	13.600	14.200	11.100
	Mixed waste	0.000	0.100	0.000	0.000	0.000	0.000	0.000
	Non-ferrous metal	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Paper and board	2.300	2.000	2.100	2.100	1.900	1.900	1.800
	Pastics composite	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Plastics films	0.000	0.000	0.000	0.100	0.100	0.100	0.100
	Polyvinylchloride (PVC)	0.300	0.200	0.300	0.400	0.500	0.500	0.500
	Residual Household waste	0.100	0.100	0.000	0.000	0.000	0.000	0.000
	Sanitary ware	0.000	0.000	0.000	0.700	0.900	0.900	0.800

	Slugde	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Small household appliances	0.500	1.400	1.000	0.000	0.000	0.000	0.000
	Soil	8.600	7.800	7.900	7.300	8.200	8.100	8.100
	Treated wood	1.300	1.200	1.200	1.300	1.500	1.400	1.700
	Tires	0.400	0.400	0.300	0.200	0.400	0.400	0.400
	Untreated wood	0.100	0.000	0.000	0.000	0.000	2.300	6.600
	Waste accumulators	0.000	0.000	0.000	0.000	0.000	0.100	0.100
	Windows glass	1.200	1.200	1.400	1.400	1.400	1.500	1.300
		100	**100**	**100**	**100**	**100**	**100**	**100**
Silkeborg	Asbestos waste	2.400	0.500	0.500	0.600	0.500	0.400	1.100
	Batteries	0.000	0.100	0.000	0.100	0.100	0.100	0.100
	Brics, blocks and tiles	19.500	20.400	19.400	19.000	18.600	19.200	19.700
	Bulky	6.700	5.000	3.400	3.000	2.800	3.100	3.400
	Cables	0.000	0.000	0.100	0.100	0.100	0.100	0.100
	CDs and DVDs	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Dense plastics	0.100	0.100	0.700	0.800	0.700	0.700	0.800
	Ferrous metal	4.000	3.900	3.700	3.700	3.600	3.800	4.000
	Garden waste	26.000	27.000	28.300	26.500	27.700	27.600	27.000
	Glass packaging	1.000	1.200	1.500	1.500	1.400	1.500	1.500
	Gypsum waste	0.900	1.000	1.100	1.100	1.000	1.100	1.100
	Landfilled waste	4.300	2.600	1.900	1.900	1.900	1.800	1.700
	Metal containers and cans	0.100	0.100	0.100	0.200	0.100	0.000	0.000
	Miscellaneous combustible	10.500	10.100	8.100	8.000	6.900	6.700	6.000
	Paper and board	3.500	2.500	3.000	3.400	3.600	3.200	3.400
	Plastics films	0.000	0.000	0.200	0.300	0.300	0.400	0.300
	Plastics garden furniture	0.000	0.000	0.000	0.000	0.100	0.100	0.100
	Polystyrene	0.000	0.000	0.100	0.100	0.100	0.000	0.000
	Polyvinylchloride (PVC)	0.100	0.200	0.200	0.200	0.200	0.200	0.200
	Sanitary ware	0.100	0.900	1.200	1.400	1.300	1.500	1.400
	Small household appliances	1.700	2.700	3.000	3.000	2.700	2.600	2.500
	Soil	10.300	10.500	10.800	11.300	11.700	11.600	11.100
	Textiles	0.200	0.300	0.500	0.500	0.500	0.500	0.400
	Thermal insulation materials	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Treated wood	1.300	1.300	1.100	1.200	1.400	1.400	1.600
	Tyres	0.400	0.400	0.400	0.400	0.300	0.300	0.400
	Untreated wood	6.000	8.300	9.700	10.800	11.300	11.100	11.100
	Waste accumulators	0.100	0.100	0.100	0.100	0.100	0.100	0.100
	Windows glass	0.700	0.800	1.000	1.000	1.000	0.900	0.900
	Windows glass with PCB	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		100	**100**	**100**	**100**	**100**	**100**	**100**

Table S16: Distribution of plastic bags used to bring the waste at the household waste recycling centres

Household waste Recycling centers	Plastic bags			
	Without	Mixed	Clear	Black
Dalskov	50	18	23	9
Hvidovre	41	19	36	3
Hvidovre_II	42	24	26	7
Jyllinge	56	18	19	7
Lemvig	53	26	11	10
Tandskov	55	19	21	6
Viby	57	12	27	5

Table S17: Summary of miscellaneous waste composition based on disposal waste containers

Parameters	Type of waste containers			
	Mixed transparent	Loose	Transparent	Black
n	7.00	7.00	7.00	7.00
vars	1.00	1.00	1.00	1.00
maximum	25.90	56.80	36.00	9.60
mean	19.36	50.53	23.41	6.69
median	18.80	53.00	23.50	6.90
minimum	11.90	41.50	11.50	3.30
q1	17.65	45.90	20.00	5.35
q3	21.80	55.30	26.45	8.15
kurtosis	-1.29	-1.75	-1.00	-1.59
mad	1.78	4.60	4.60	2.82
max	25.90	56.80	36.00	9.60
range	14.00	15.30	24.50	6.30
sd	4.64	6.43	7.56	2.22
se	1.75	2.43	2.86	0.84
skew	-0.03	-0.48	0.09	-0.16
trimmed	19.36	50.53	23.41	6.69

Table S18: Summary of misplaced waste in small miscellaneous combustible waste

Descriptive statistics	Misplaced	Small Miscellaneous Combustible
n	7	7
vars	1	1
mean	67.5	32.5
sd	9.7	9.7
median	64.2	35.8
mad	12.5	12.5
trimmed	67.5	32.5
min	55.8	19.0
max	81.0	44.2
range	25.2	25.2
kurtosis	-1.9	-1.9
skew	0.1	-0.1
se	3.7	3.7

Table S19 Univariate Box-Pierce test considering percentage composition

Affaldsselskab	Kommune	HWRCs	Bulky	C&D	Garden	OW	SC	Soil	TWF
	Norddjurs	Glesborg	0.0725	0.4736	0.0000	0.0001	0.0002	0.5821	0.0001
	Norddjurs	Grenaa	0.2808	0.2240	0.1022	0.3186	0.0153	0.6070	0.1637
	Norddjurs	Roende	0.0001	0.0014	0.0000	0.6070	0.0000	0.8818	0.0001
	Norddjurs	Tirstrup	0.1176	0.0216	0.0311	0.3476	0.0004	0.8612	0.5491
	Syddjurs	Ebeltoft	0.0090	0.0503	0.0000	0.0222	0.0000	0.7402	0.0005
	Syddjurs	Hornslet	0.0000	0.6389	0.0000	0.0023	0.0000	0.2535	0.0017
	Syddjurs	Knebel	0.8816	0.9647	0.0000	0.1518	0.0000	0.5222	0.0439
Djursland	Syddjurs	Ryomgaard	0.0130	0.0231	0.0000	0.0000	0.0000	0.7626	0.0000
	Silkeborg	Tandskov	0.0000	0.1054	0.0000	0.0011	0.0000	0.0011	0.0000
	Silkeborg	Tietgensvej	0.0000	0.2715	0.0000	0.0000	0.0000	0.0000	0.0000
Silkeborg	Silkeborg	Gjern	0.0000	0.1480	0.0000	0.0006	0.0000	0.0829	0.0000
	Silkeborg	Them	0.0000	0.0269	0.0005	0.0286	0.0000	0.0051	0.0000
	Dragoer	Dragoer	0.0000	0.0057	0.0000	0.0000	0.0000	0.0000	0.0000
	Frederiksberg	Bispeengen	0.7922	0.4451	0.0000	0.1891	0.0550	0.0023	0.8770
	Hvidovre	Hvidovre	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Koebenhavn	Borgervaenget	0.4133	0.0078	0.3887	0.0138	0.0602	0.9655	0.5983
	Koebenhavn	Chrisiania	0.0000	0.2586	0.2339	0.0004	0.8880	0.0302	0.6199
	Koebenhavn	Kulbanevej	0.0000	0.0000	0.0009	0.0000	0.0000	0.0000	0.0000
	Koebenhavn	Vasbygade	0.0000	0.0004	0.0328	0.0000	0.0000	0.5113	0.0000
Greater	Koebenhavn	Vermlandsgade	0.0000	0.0000	0.0015	0.0000	0.0000	0.0000	0.0000
Copenhagen	Taarnby	Kirstinehoej	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Taarnby	Vaegtergangen	0.0000	0.8406	0.0000	0.2754	0.0000	0.0984	0.0000
	Kalundborg	Bregninge	0.0000	0.0007	0.0000	0.0092	0.0002	0.0005	0.0000
	Kalundborg	Goerlev	0.0439	0.1942	0.0000	0.0001	0.0007	0.0015	0.0000
	Kalundborg	Hoeng	0.0008	0.6586	0.1207	0.2275	0.0011	0.0002	0.0001
	Kalundborg	Kalundborg	0.0000	0.0038	0.0000	0.0523	0.0000	0.0004	0.0096
	Kalundborg	Sejeroe	0.5824	0.0622	0.8210	0.2448	0.2808	0.0060	0.0553
	Kalundborg	Ubby	0.4432	0.0434	0.0713	0.8824	0.0020	0.4779	0.1002
	Koege	Bjaeverskov	0.0006	0.4046	0.0011	0.0003	0.0000	0.0651	0.5371
	Koege	Koege	0.0000	0.1841	0.0002	0.3070	0.0000	0.0000	0.0140
	Lejre	Torkilstrup	0.0000	0.4045	0.0000	0.0002	0.0000	0.0000	0.0000
	Roskilde	Jyllinge	0.0000	0.2086	0.0009	0.2412	0.0006	0.0000	0.0004
	Roskilde	Roskilde	0.0000	0.0892	0.0003	0.0544	0.0000	0.0000	0.0004
	Roskilde	Viby	0.0002	0.7676	0.0065	0.0026	0.0033	0.0048	0.0003
Central Zealand	Stevns	Haarlev	0.0059	0.1766	0.2734	0.0191	0.0004	0.0039	0.0000
	Stevns	Store_Hedding	0.0003	0.0662	0.0003	0.0250	0.0001	0.0383	0.0000

Table S20 Univariate Box-Pierce test considering waste generation (mass)

Affaldsselskab	Kommune	Genbrugspladser	Bulky	C&D	Garden	OW	SC	Soil	TWF
Djursland	Norddjurs	Glesborg	0.0029	0.0000	0.0000	0.0019	0.0002	0.8754	0.0058
	Norddjurs	Grenaa	0.0004	0.0000	0.1755	0.0003	0.0003	0.8121	0.0043
	Norddjurs	Roende	0.0000	0.0000	0.0000	0.0000	0.0000	0.8915	0.0000
	Norddjurs	Tirstrup	0.0463	0.0000	0.0000	0.0166	0.0005	0.9727	0.0003
	Syddjurs	Ebeltoft	0.0077	0.0000	0.0000	0.0035	0.0687	0.8886	0.0051
	Syddjurs	Hornslet	0.0690	0.0000	0.0000	0.2558	0.0411	0.8057	0.0102
	Syddjurs	Knebel	0.0001	0.0000	0.0000	0.0051	0.0868	0.7089	0.1349
	Syddjurs	Ryomgaard	0.0053	0.0000	0.0000	0.0327	0.0102	0.8682	0.0020
Silkeborg	Silkeborg	Tandskov	0.0000	0.0000	0.0000	0.0004	0.0000	0.0000	0.0000
	Silkeborg	Tietgensvej	0.0000	0.0000	0.0000	0.0079	0.0000	0.0000	0.0227
	Silkeborg	Gjern	0.0000	0.0302	0.0000	0.9182	0.0267	0.0023	0.0000
	Silkeborg	Them	0.0000	0.0174	0.0000	0.0457	0.0000	0.0015	2.4840
Greater Copenhagen	Dragoer	Dragoer	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
	Frederiksberg	Bispeengen	0.0086	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Hvidovre	Hvidovre	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Koebenhavn	Borgervaenget	0.0049	0.0000	0.0325	0.4107	0.0016	0.0159	0.0000
	Koebenhavn	Chrisiania	0.0049	0.7613	0.2002	0.0797	0.0038	0.0254	0.0174
	Koebenhavn	Kulbanevej	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Koebenhavn	Vasbygade	0.0000	0.0000	0.7143	0.0000	0.0000	0.0063	0.0000
	Koebenhavn	Vermlandsgade	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Taarnby	Kirstinehoej	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Taarnby	Vaegtergangen	0.0000	0.0021	0.0000	0.1496	0.0000	0.0458	0.0007
Roskilde	Kalundborg	Bregninge	0.0000	0.0000	0.0000	0.1628	0.0000	0.0000	0.0003
	Kalundborg	Goerlev	0.0000	0.0200	0.0000	0.0006	0.0000	0.0000	0.0057
	Kalundborg	Hoeng	0.0000	0.6949	0.0000	0.7201	0.0131	0.0000	0.0000
	Kalundborg	Kalundborg	0.0000	0.0010	0.0000	0.0097	0.0000	0.0000	0.3676
	Kalundborg	Sejeroe	0.5814	0.1841	0.8504	0.2030	0.6379	0.0004	0.3664
	Kalundborg	Ubby	0.0009	0.0005	0.0000	0.4380	0.0192	0.0190	0.9741
	Koege	Bjaeverskov	0.0057	0.0000	0.0000	0.1792	0.0008	0.0001	0.0003
	Koege	Koege	0.0001	0.0087	0.0000	0.6597	0.0001	0.0000	0.0000
	Lejre	Torkilstrup	0.0000	0.0113	0.0000	0.5975	0.0001	0.0000	0.0000
	Roskilde	Jyllinge	0.0000	0.0000	0.0000	0.5271	0.0003	0.0000	0.0000
	Roskilde	Roskilde	0.0001	0.0694	0.0000	0.8769	0.0000	0.0000	0.0000
	Roskilde	Viby	0.0000	0.0078	0.0000	0.2960	0.0001	0.0000	0.0000
	Stevns	Haarlev	0.0051	0.0215	0.1192	0.7459	0.0044	0.0002	0.0676
	Stevns	Store_Hedding	0.0001	0.0805	0.0000	0.1183	0.0214	0.0001	0.0002

Figure S1: Graph showing the number of visitors per households and per population

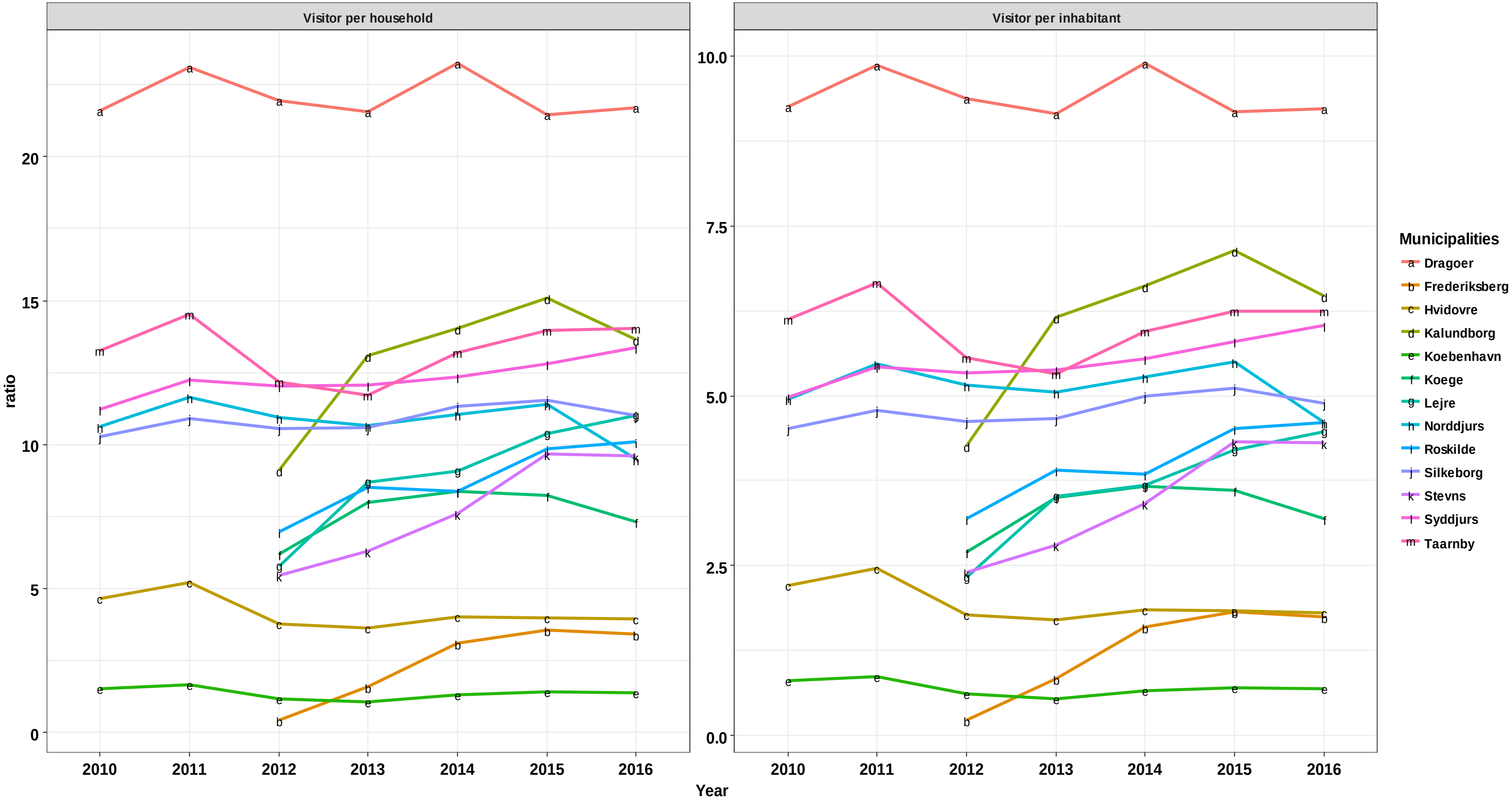


Figure S2: Graph showing the waste generation rates as function of number of visitors, households and person in municipalities

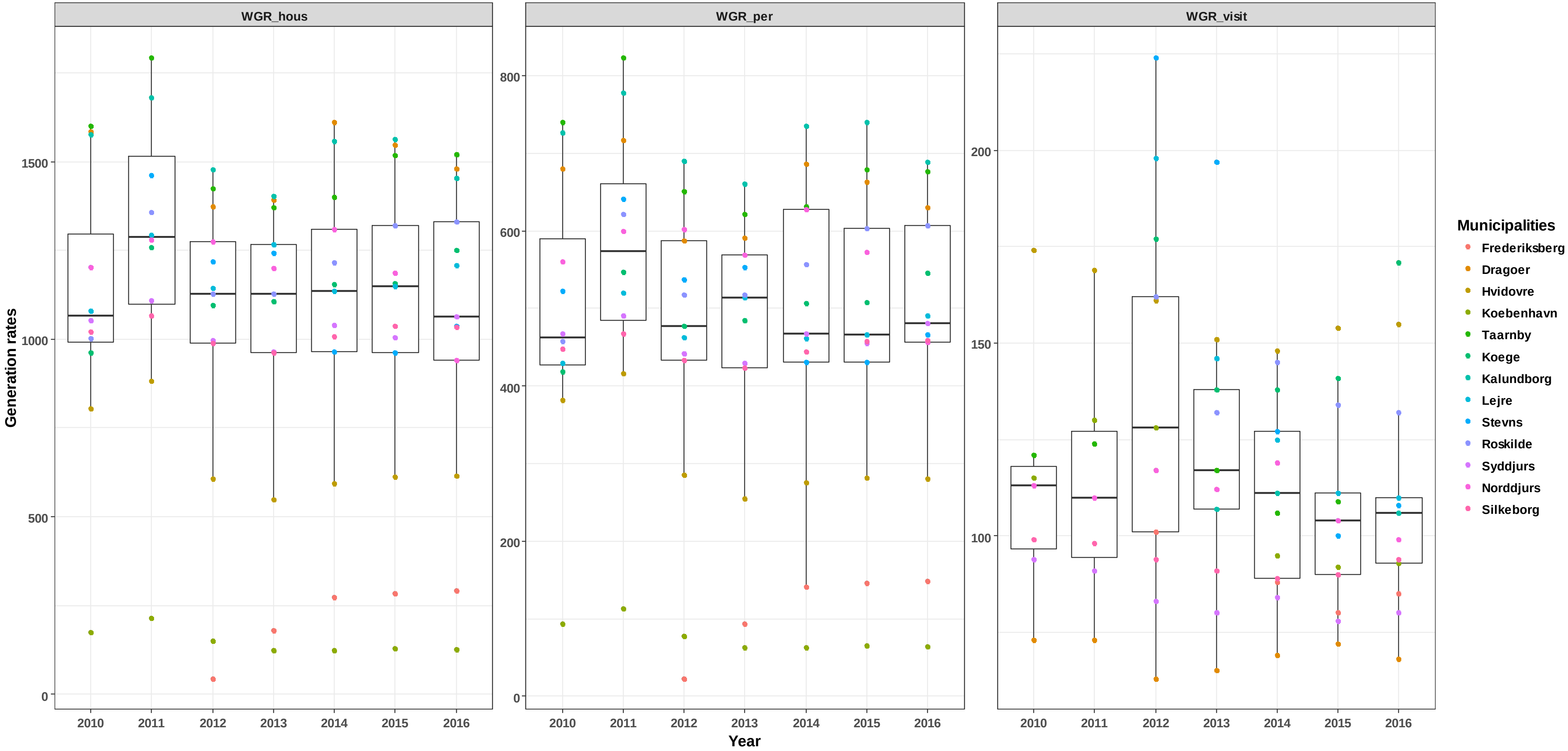


Figure S3: Percentage of single-family houses and people living in single-family houses

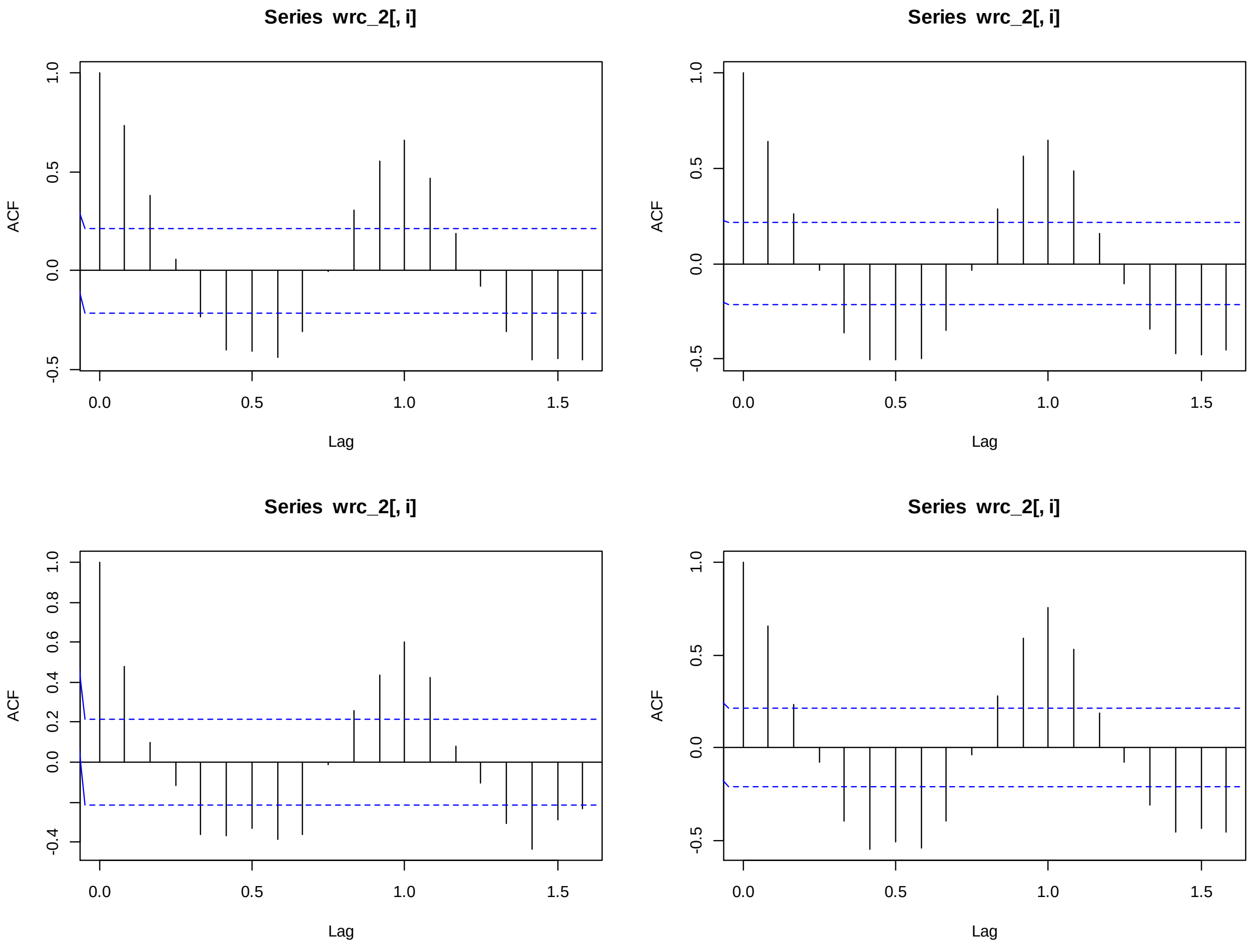


Figure S4: Decomposition of main fractions generation in Silkeborg

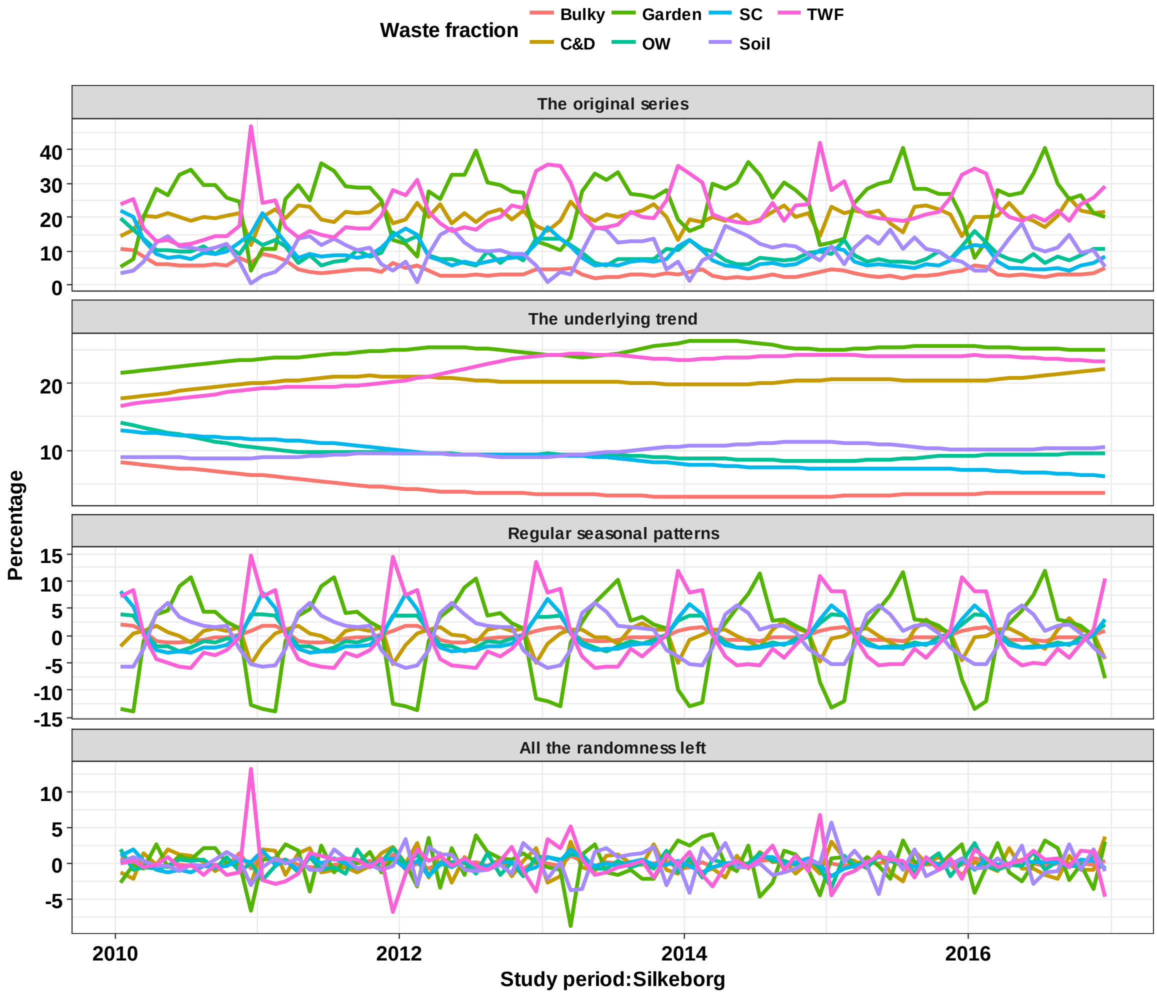


Figure S5: Decomposition of main fractions generation in Greater Copenhagen

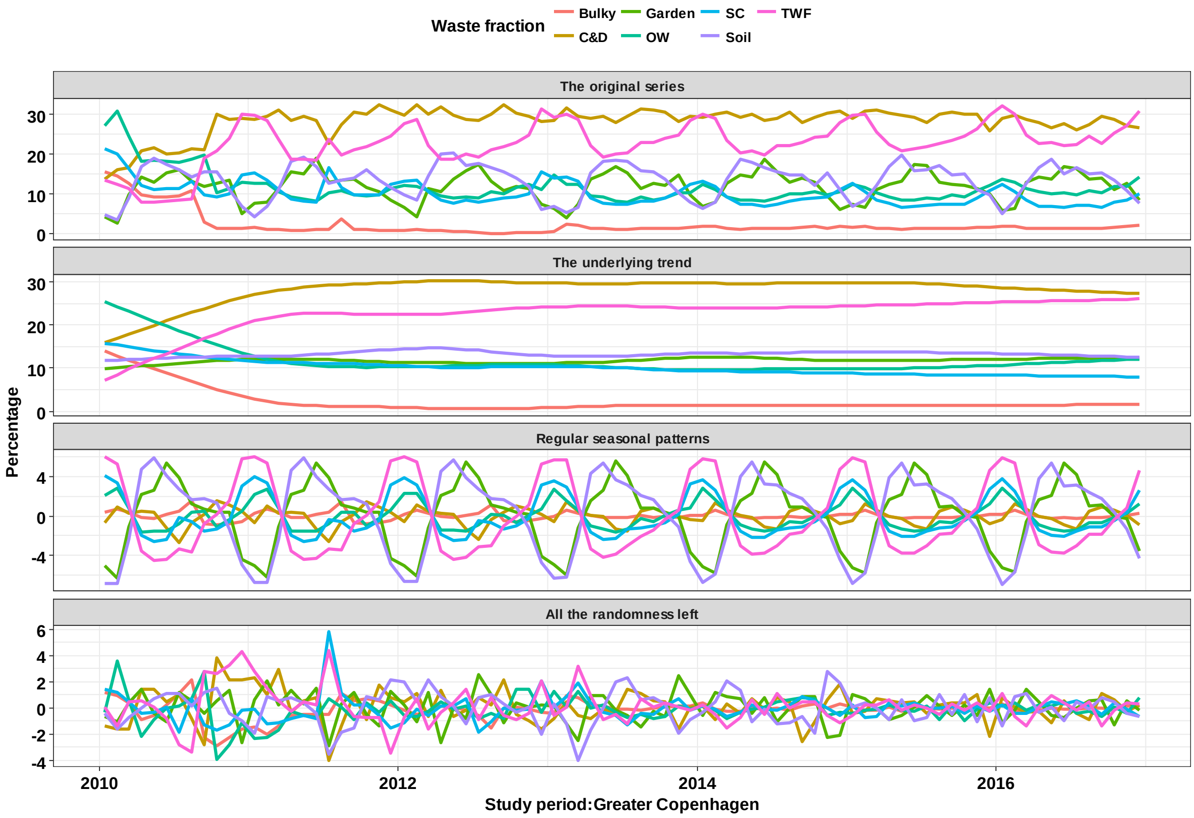


Figure S6: Decomposition of main fractions generation in Central Zealand

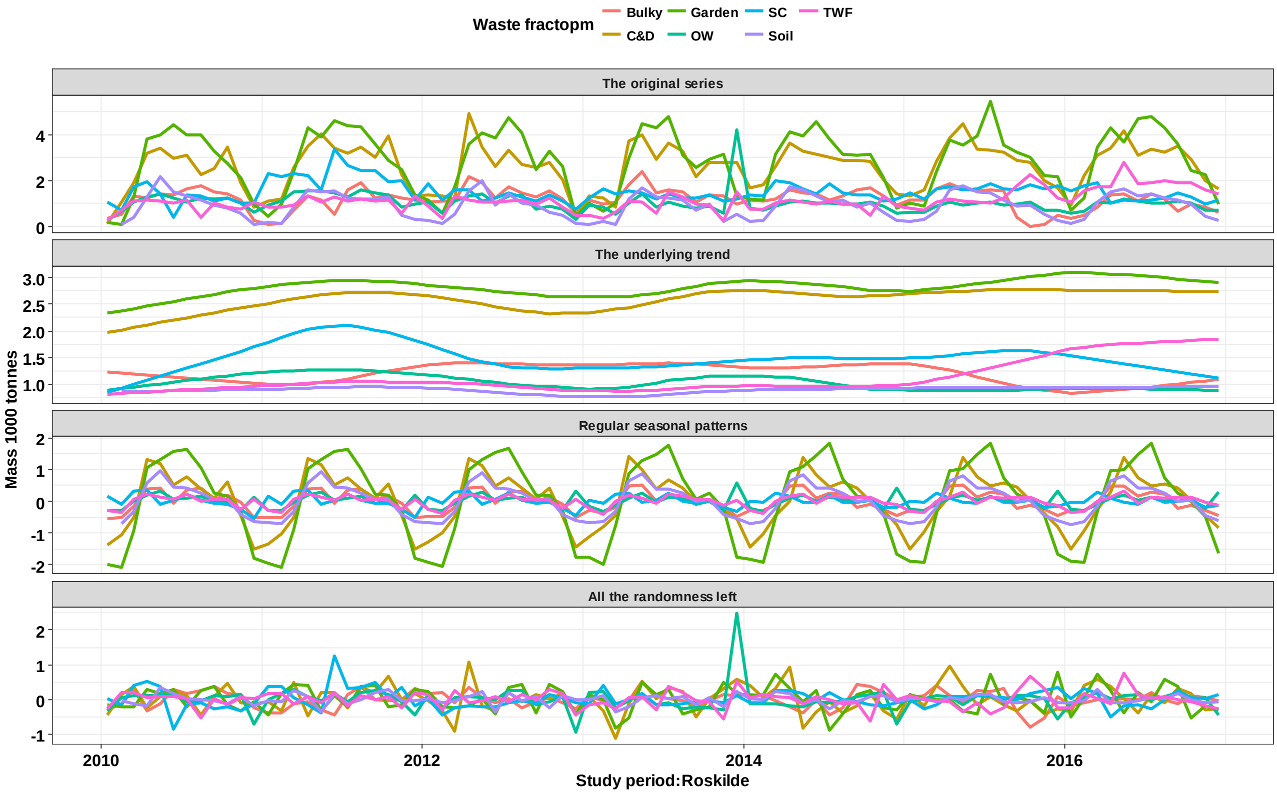


Figure S7: Decomposition of main fractions generation in Djursland

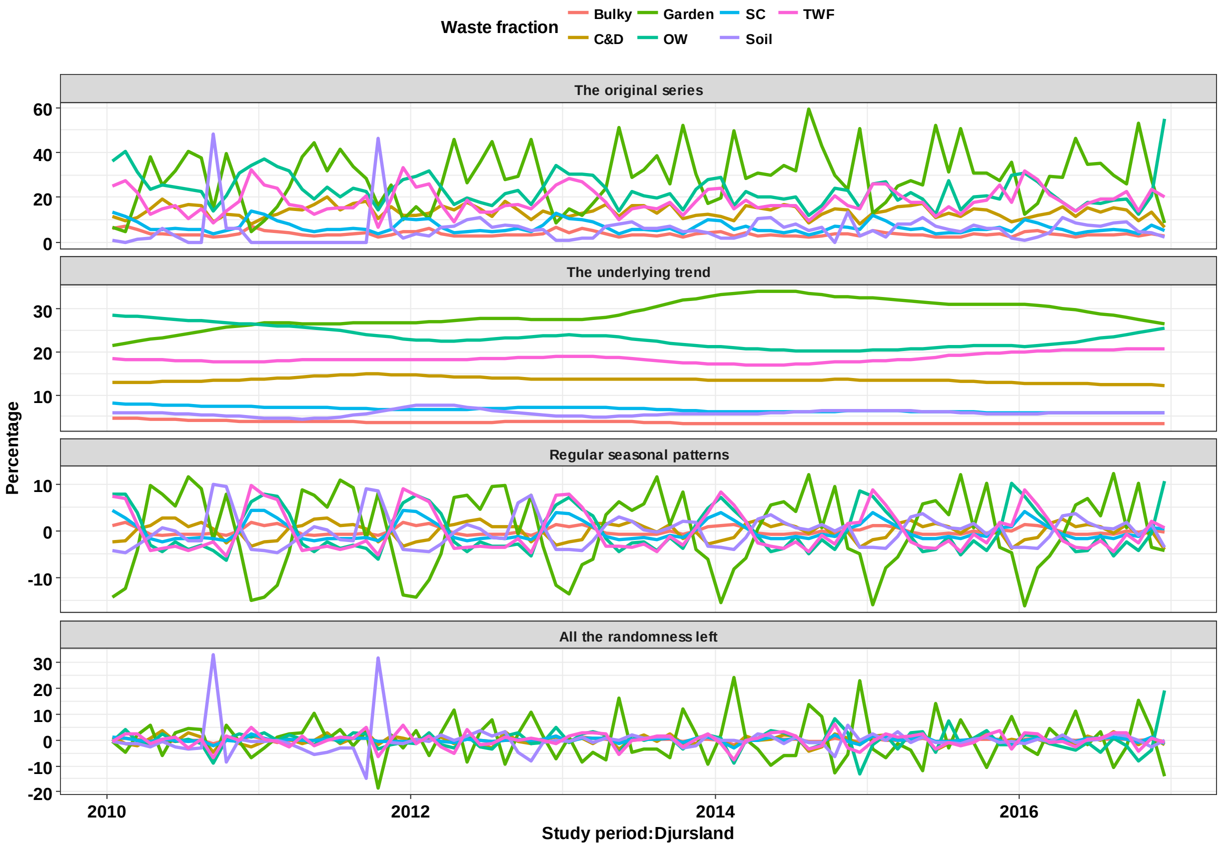


Figure S8: Plot from the multivariate Q-statistics and their p-values of aggregated waste generation in study areas. The dashed line denotes type I errors of 5%.

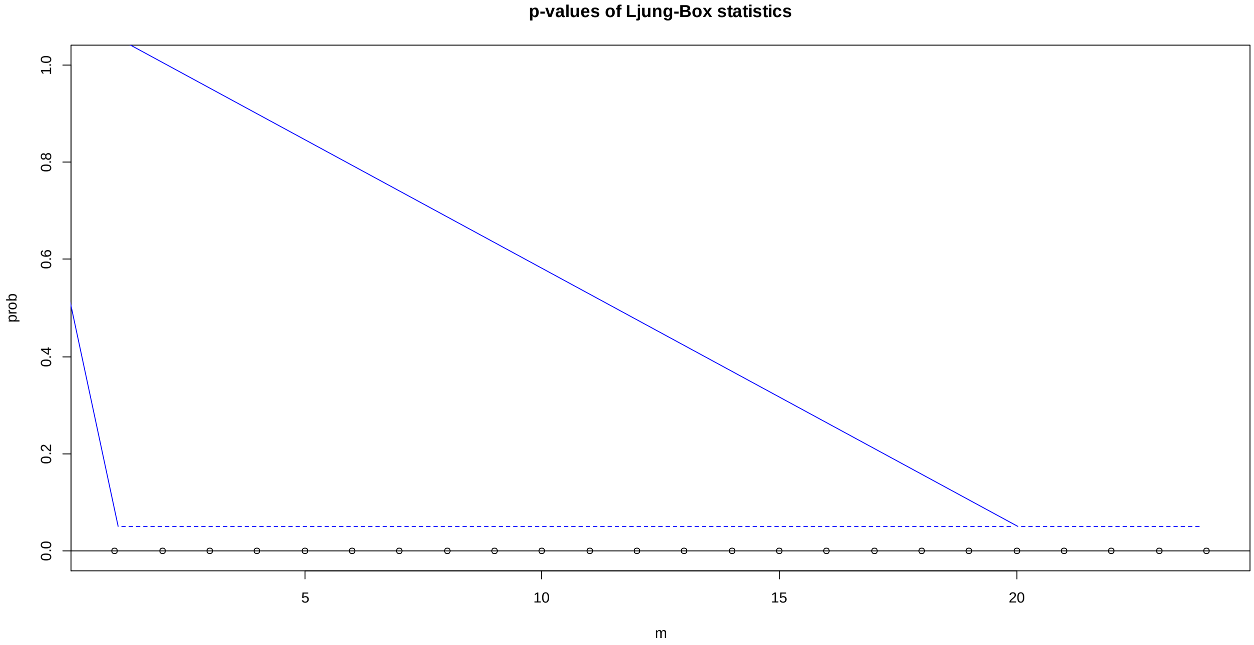


Figure S9: Seasonal generation of total waste at household waste recycling centers

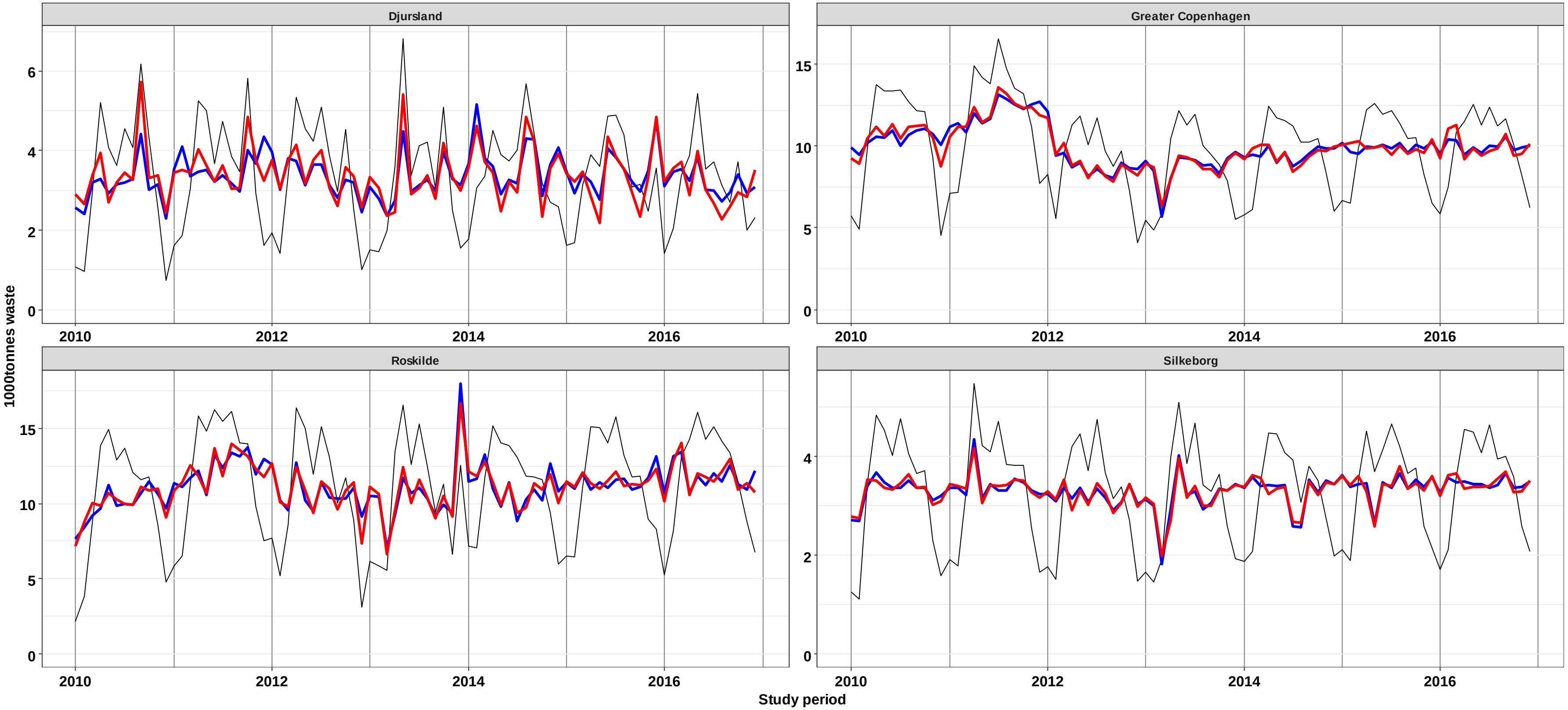


Figure S10: Seasonal generation of total waste at household waste recycling centers

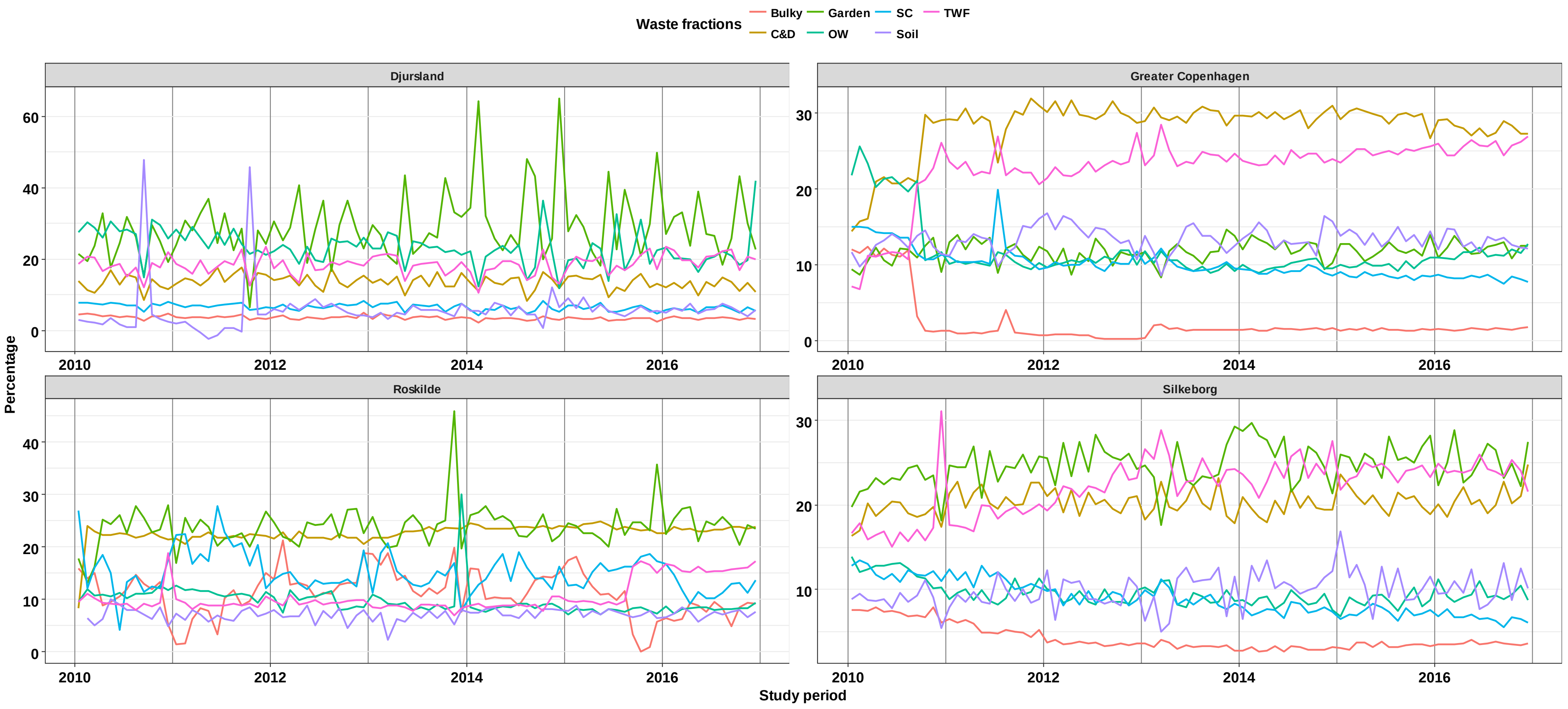


Figure S11: Waste generation cross-correlation plots for the period 2010-2016. The dashed lines indicate pointwise 95% confidence intervals

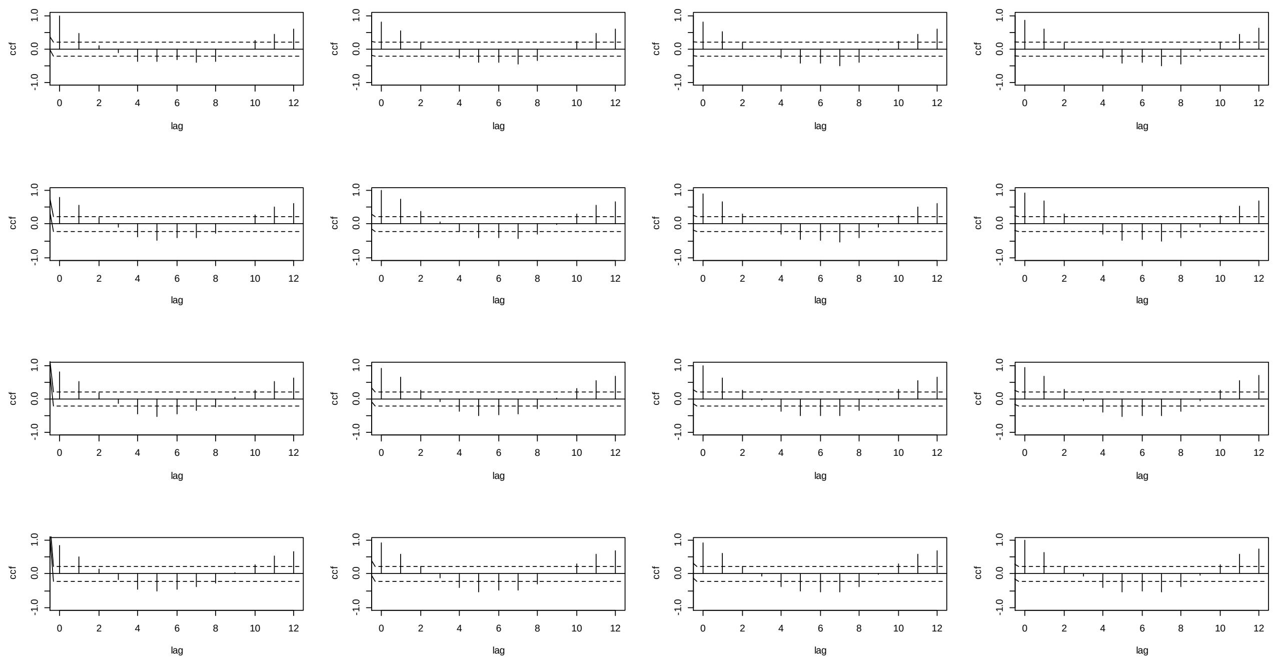
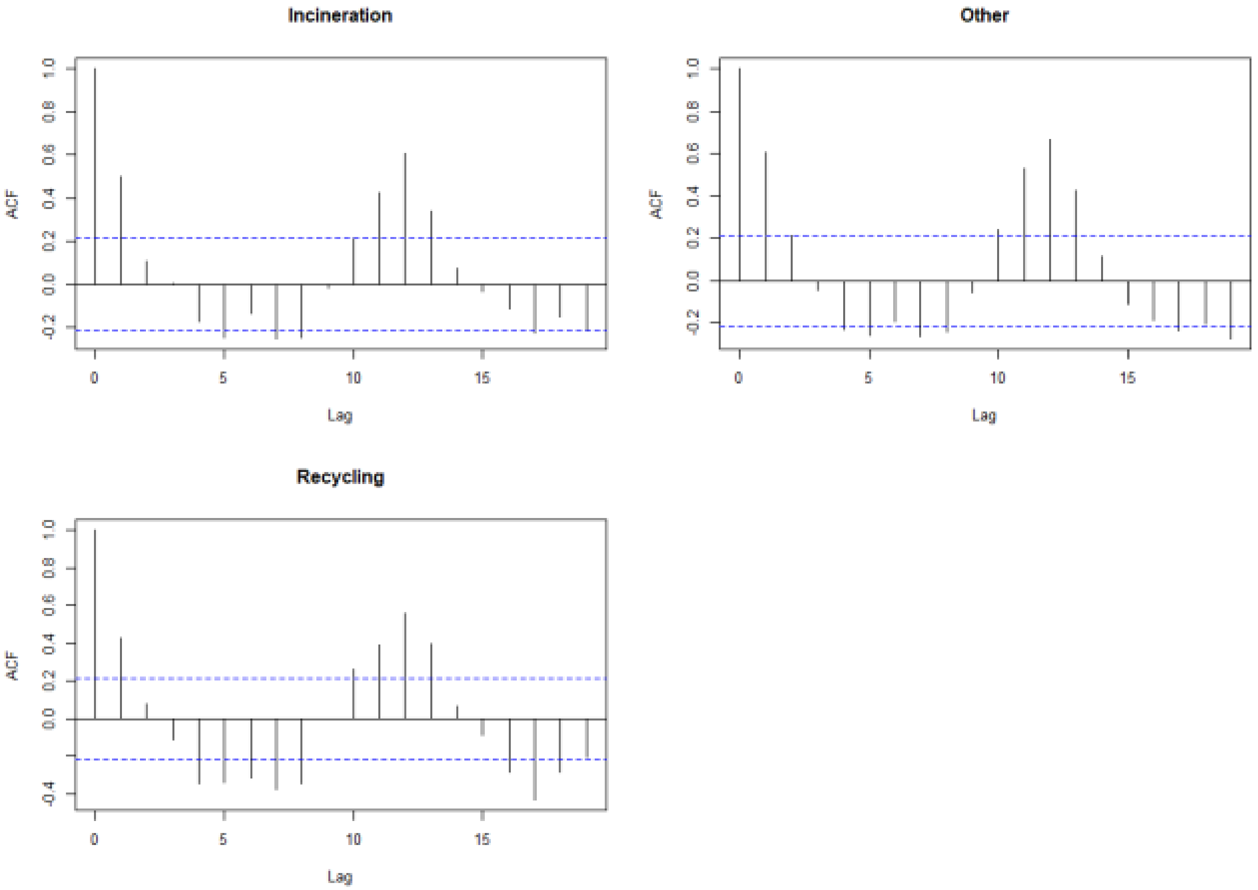


Figure S12: Waste treatment forms cross-correlation plots for the period 2010-2016. The dashed lines indicate pointwise 95% confidence intervals



```
rm(list = ls())##Clear all history
"%!in%" <- function(x,table) match(x,table, nomatch = 0) == 0##Function enabling
#to exclude or omit multiple rows
#Loading library
library(tidyverse)
library(lubridate)
library(forcats)
library(ggseas)
library(magrittr)
library(stringr)
library(stringi)
library(readxl)
library(mapDK)#This package requires "devtools" #
#install.packages("devtools")
#library(devtools)
#devtools::install_github("sebastianbarfort/mapDK")
library(mapproj)
#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
##FIGURE 1: Map of Denmark ##################################################
##Loading data
#Population from DST BOL103
DK_2018 <- read_excel("H:/Paper and Article/Paper_HRC/Arkive/data_all/DK_2018.xlsx",
  range = "B3:K696", col_types = c("text","numeric","text", "numeric", "numeric",
    "numeric", "numeric", "numeric",
    "numeric", "numeric"))

#Data cleaning and calculation to obtain the number of population and
#inhabitants for all municipalities in Denmark
DK_population=
  DK_2018%>%
  mutate(Kommune=str_replace_all(Kommune,
    c("æ"="ae","å"="aa","ø"="oe","Å"="Aa","Ø"="Oe","Æ"="Ae")))%>%
  gather(Year,Pop,`2010`:`2016`)%>%
  mutate(Pep=Pop*Antal_pers)%>%select(-Antal,-Antal_pers)%>%
  group_by(Year,Kommune)%>%summarise(Household=sum(Pop),Person=sum(Pep))

##Select only data for 2016
DK_population2016=
  DK_population%>%
  filter(Year%in% "2016")

#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
##Loading data for geocode for all HWRC
##
geocode_2018 <- read_excel("H:/Paper and Article/Paper_HRC/Arkive/data_all/geocode_2018.xlsx",
  sheet = "Sheet2")

###Cleaning data process for geocode of HWRC
#geocode_2018%>%View()# To view all dataset
```

```
#geocode_2018%>%head()#to view the first 10 rows
##Cleaning a data and calculations:

maps_data2=
  geocode_2018%>%
  mutate(Address=str_replace_all(Address,
    c("æ"="ae","å"="aa","ø"="oe","Å"="Aa","Ø"="Oe","Æ"="Ae")))%>%
  #Replcace all danish letters with english letter
  mutate(`Returned address`=str_replace_all(`Returned address`,
    c("æ"="ae","å"="aa","ø"="oe","Å"="Aa","Ø"="Oe","Æ"="Ae")))%>%
  separate(Address, c("Street","Nummer","Country"),
    sep = ",", remove = FALSE, convert = FALSE)%>%
  #Replcace all danish letters with english letter
  select(-Country,-`Returned address`)%>%
  #drop columns: countries and Returned address
  distinct(Address,.keep_all = TRUE)%>%#eleminate duplicate given address
  distinct(Latitude,Longitude,.keep_all = TRUE)%>%#eleminate duplicate for altitued
  mutate(By=str_extract(Nummer, "[a-z,A-Z]+" ))%>%as.data.frame()%>%
  #extract only letter in the string (column)
  mutate(Post=str_extract(Nummer, "[0-9]+" ))%>%as.data.frame()%>%
  #extract only number in the string (column)
  distinct(By,Street,.keep_all = TRUE)%>%#eleminate duplicate for city and street
  filter(Address%!in% c("Borgervaenget 29, 2100 Koebenhavn Oe, Danmark",
    "Graaskegaardevej 6, 8400 Ebeltoft, Danmark"))%>%#exclude this HWRC
  #because of change in address. The new address is  Sibeliusgade 80
  mutate(New_area=ifelse(By%in%c("Kastrup","Hvidovre","Frederiksberg",
    "Koebenhavn","Dragoer","Valby"),"Greater Copenhagen",
    ifelse(By%in%c("Silkeborg","Them"),"Silkeborg",
      ifelse(By%in%c("Eskebjerg","Kalundborg","Koege","Roskilde","Haarlev","Hoeng",
        "Sejeroe","Store","Kirke","Bjaeverskov","Goerlev","Jyllinge"),"Central Zealand",
        ifelse(By%in% c("Anholt","Allingaabro","Ebeltof","Roende",
          "Glesborg","Grenaa","Hornslet","Knebel","Ryomgaard"),"Djursland",
          "Not included")))))%>%
  mutate(New_area=ifelse(Address%in%c("Rugvaenget 1, 4490 Jerslev Sj, Danmark",
    "Vestergade 25B, 4130 Viby Sjaelland",
    "Brohaven 2, Jyllinge, Danmark"),
    "Central Zealand",paste0(New_area)))%>%
  mutate(sorting=ifelse(Address %in%
      c("Tandskovvej 17, 8600 Silkeborg, Danmark",
        "Tietgensvej 7, 8600 Silkeborg, Danmark",
        "Herjedalgade 2-4, 2300 Koebenhavn S, Danmark",
        "Avedoereholmen 97, 2650 Hvidovre, Danmark",
        "Kalorievej 2, 8500 Grenaa, Danmark",
        "Vestergade 25B, 4130 Viby Sjaelland",
        "Brohaven 2, Jyllinge, Danmark"),"WS","Not"))
#end of the first data cleaning
unique(maps_data2$New_area)
##Forced the order of variables
maps_data2$New_area=factor(maps_data2$New_area,levels=c(
  "Greater Copenhagen","Central Zealand","Djursland","Silkeborg","Not included"))
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
###FIGURE 1*****************************************************************
mapDK(values = "Person", id = "Kommune", data = DK_population2016)+
  geom_point(data =maps_data2,
```

```
    aes(Longitude,Latitude,group=New_area,
      colour=New_area,shape=sorting),size=3,fill="black",
    alpha=I(0.7))+
  scale_shape_manual(values=c(20,17))+
  scale_color_manual(values=c("red","green","magenta","blue","grey"))+
  theme(axis.text = element_text(""))+
  theme_bw()+
  labs(x="Longitude",y="Latitude",colour="Study areas",
    group="Number of inhabitant per municipality")+
  theme(text =element_text(colour = "black", face = "bold", size = 12))

#End of Figure 1
#%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%
#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
##Loading data
wrc2018_v8= read.table("H:/Paper and Article/Paper_HRC/Arkive/data_all/wrc2018_v8.txt")
wrc2018_v8=wrc2018_v8%>%
  mutate(date1=ymd( paste(Year, Months, "15", sep="-")))%>%
  mutate(Kommune=fct_recode(Kommune,
    "Koebenhavn"="Copenhagen"))#%
#create a new column of type date
wrc2018_v8$Months=factor(wrc2018_v8$Months,levels=c("Jan","Feb","Mar","Apr","Maj"
  ,"Jun","Jul","Aug","Sep","Okt","Nov","Dec"))
#Arrange the order of months
month=c("Jan","Feb","Mar","Apr","Maj",
  "Jun","Jul","Aug","Sep","Okt","Nov","Dec")
wrc2018_v8%>%View()

##Order of municipalities
muni=c("Frederiksberg","Dragoer","Hvidovre",
  "Koebenhavn","Taarnby","Koege","Kalundborg","Lejre",
  "Stevns","Roskilde","Syddjurs","Norddjurs","Silkeborg")


##Table 2: Total waste per year per recycling centre#***************************
Table2=
  wrc2018_v8%>%
  group_by(Year,Affaldsselskab,Kommune,Genbrugspladser)%>%
  summarise(Tot=sum(Maengde))%>%
  spread(Year,Tot,fill = 0)%>%
  ungroup()%>%#ungroup grouping factor
  mutate(Kommune=factor(Kommune,levels = muni))%>%
  #set a new order of municipalities
  arrange(Kommune)#show Kommune with desired order
#+++
Table2_update=
  wrc2018_v8%>%
  group_by(Year,Affaldsselskab)%>%
  summarise(Tot=sum(Maengde))%>%
  spread(Year,Tot,fill = 0)%>%
  mutate(Affaldsselskab=factor(Affaldsselskab,
```

```
   levels = c("Greater Copenhagen","Central Zealand","Djursland","Silkeborg")))#show Kommune with desir

Table2_update%>%View()
#+++++
##Export Table 2 in Excel file
library(writexl)
write_xlsx(Table2, "H:/Paper and Article/Paper_HRC/Results/2018-05-Results/Table2.xlsx")
#End of Table 2
#%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
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#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
##Figure 2
##This code generate a table which can be used to make Figure 2 in Excel
wrc2018_v8%>%
  group_by(Year,Affaldsselskab)%>%
  summarise(Tot=sum(Maengde)/1000)%>%#1000Mg
  mutate(Affaldsselskab=fct_recode(Affaldsselskab,
    "Central Zealand"="Roskilde"))%>%
  ungroup()%>%#ungroup grouping factor
  mutate(Affaldsselskab=factor(Affaldsselskab,
    levels = c("Greater Copenhagen","Central Zealand","Djursland","Silkeborg")))%>%
  spread(Affaldsselskab,Tot,fill = 0)%>%View()#show Kommune with desired order
##End of table enabling to build Figure 2
#%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
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%%%%%%%%%%%%%%%%%%%%%%%%
#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#Table 3
##Aggregated (yearly) Data per year for visitors, inhabitants and area
#Visitors and mass of waste for Greater Copenhagen, RenoDjurs and Silkeborg
para2 <- read.csv("H:/Paper and Article/Paper_HRC/arkive/data_all/para2.txt", sep="")

##Loading monthly waste data from Central Zealand and Silkeborg
visit_v1 <- read_excel("H:/Paper and Article/Paper_HRC/Arkive/data_all/visit_v1.xlsx")
visit_v1=visit_v1%>% mutate(date1=ymd( paste(Year, Months, "15", sep="-")))#%>
visit_v1$Months=factor(visit_v1$Months,levels=c("Jan","Feb","Mar","Apr","Maj"
  ,"Jun","Jul","Aug","Sep","Okt","Nov","Dec"))
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
##data for housing type distribution:
##Loading number of person and housing type for all Denmark from 2010-2017
DK_houses <- read_excel("H:/Paper and Article/Paper_HRC/Arkive/data_all/DK_houses.xlsx",
  range = "B3:L300")

DK_houses%>%head()
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#Import data for areal of municipalities from 2010 to 2016
#http://www.statistikbanken.dk/statbank5a/selectvarval/saveselections.asp
library(stringr)
DK_areal <- read_excel("H:/Paper and Article/Paper_HRC/Arkive/data_all/DK_areal.xlsx",
  range = "A3:J102", col_types = c("text",
```

```
    "numeric", "numeric", "numeric",
    "numeric", "numeric", "numeric",
    "numeric", "numeric", "numeric"))


##Cleaning data
Dk_area=
  DK_areal%>%
  mutate(Kommune=
      str_replace_all(Name,#Find all danish characters and replace them with
        #The tricky part is to remember to have mutate at the beginning
        #For more inf. page 215, R for Data Science
        c("æ"="ae","å"="aa","ø"="oe","Å"="Aa","Ø"="Oe","Æ"="Ae")))%>%
  gather(Year,area_km2, `2008`:`2016`)


##Table containing data for Silkeborg and central zealand
table3_1=
  wrc2018_v8%>%
  mutate(Year=as.character(Year))%>%
  filter(Affaldsselskab%in% c("Roskilde","Silkeborg"))%>%
  mutate(Affaldsselskab=fct_recode(Affaldsselskab,
    "Central Zealand"="Roskilde"))%>%
  group_by(Year,Affaldsselskab,Kommune)%>%
  summarise(Tot=sum(Maengde))%>%
  #calculate mass
  left_join(Dk_area[,-1],by = c("Year", "Kommune"))%>%
  #add areal for each municipality
  #Afterwards, we added a table cointing number of visitors
  left_join(visit_v1%>%
      filter(Affaldsselskab%in% c("Central Zealand","Silkeborg"))%>%
      group_by(Year,Affaldsselskab,Kommune)%>%
      summarise(Visitors=sum(Visit)))%>%
  #The next step is to add data of inhabitant and number of houses
  left_join(DK_population)
##show the first 10 lines of the results
table3_1%>%head()
##Table containing data for Greater Copenhagen and Djursland
table3_2=
  wrc2018_v8%>%
  mutate(Year=as.character(Year))%>%
  filter(Affaldsselskab%!in% c("Roskilde","Silkeborg"))%>%
  group_by(Year,Affaldsselskab,Kommune)%>%
  summarise(Tot=sum(Maengde))%>%
  #calculate mass
  left_join(Dk_area[,-1],by = c("Year", "Kommune"))%>%
  #add areal for each municipality
  #Afterwards, we added a table (para2) cointing number of visitors,inhabitant
  #total mass per year, number of household
  left_join(para2%>%
      mutate(Year=as.character(Year))%>%
      filter(Affaldsselskab%!in% c("Silkeborg"))%>%
      mutate(Affaldsselskab=fct_recode(Affaldsselskab,
        "Greater Copenhagen"="ARC",
```

```
    "Djursland"="RenoDjurs"))%>%
   select(-Areal_km2))
#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
###show the first 10 lines of the results
table3_2_1<-
 table3_2%>%View()
 group_by(Year,Affaldsselskab)%>%
 summarise(Tot=sum(Tot),
      area_km2=sum(area_km2),
      Maengde=sum(Maengde),
      Visitors=sum(Visitors),
      Household=sum(Household),
      Person=sum(Person))
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#Combine all data
Table3=
 table3_2_1%>%
 bind_cols(Maengde=rep(0,nrow(table3_2_1)))%>%
 bind_rows(table3_2_1)%>%
 mutate(WGR_hous=(Tot/Household)*1000,
    WGR_per=(Tot/Person)*1000,
    WGR_visit=(Tot/Visitors)*1000)%>%
 select(Year,Affaldsselskab,WGR_hous,WGR_per,WGR_visit)%>%
 gather(Parameters, Values,WGR_hous:WGR_visit)%>%View()
  tidyr::spread(Year,Values)%>%ungroup()%>%
 mutate(Affaldsselskab=factor(Affaldsselskab,
 levels = c("Greater Copenhagen","Central Zealand","Djursland","Silkeborg")))%>%
 arrange(Affaldsselskab,Kommune)%>%
 mutate_if(is.numeric, funs(round(., 0)))##Rounding numbers to zero
#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
table3_2_update=
 wrc2018_v8%>%
 mutate(Year=as.character(Year))%>%
 filter(Affaldsselskab%!in% c("Roskilde","Silkeborg"))%>%
 group_by(Year,Affaldsselskab)%>%
 summarise(Tot=sum(Maengde))%>%
 #calculate mass
 left_join(Dk_area[,-1],by = c("Year"))%>%
 #add areal for each municipality
 #Afterwards, we added a table (para2) cointing number of visitors,inhabitant
 #total mass per year, number of household
 left_join(para2%>%
   mutate(Year=as.character(Year))%>%
   filter(Affaldsselskab%!in% c("Silkeborg"))%>%
   mutate(Affaldsselskab=fct_recode(Affaldsselskab,
    "Greater Copenhagen"="ARC",
    "Djursland"="RenoDjurs"))%>%
   select(-Areal_km2))


Table3_update=
 table3_1%>%
 bind_cols(Maengde=rep(0,nrow(table3_1)))%>%
 bind_rows(table3_2)%>%
```

```
  group_by(Year,Affaldsselskab)%>%
  summarise(Tot=sum(Tot),
            area_km2=sum(area_km2),
            Maengde=sum(Maengde),
            Visitors=sum(Visitors,na.rm = TRUE),
            Household=sum(Household),
            Person=sum(Person))%>%
  mutate(WGR_hous=(Tot/Household)*1000,
        WGR_per=(Tot/Person)*1000,
        WGR_visit=(Tot/Visitors)*1000)%>%
  select(Year,Affaldsselskab,WGR_hous,WGR_per,WGR_visit)%>%
  gather(Parameters, Values,WGR_hous:WGR_visit)%>%
  spread(Year,Values)%>%ungroup()%>%
  mutate(Affaldsselskab=factor(Affaldsselskab,
  levels = c("Greater Copenhagen","Central Zealand","Djursland","Silkeborg")))%>%
  arrange(Affaldsselskab)%>%
  mutate_if(is.numeric, funs(round(., 0)))##Rounding numbers to zero
Table3_update%>%View()

#+++
###show the first 10 lines of the results
Table3%>%head()
#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#End Table 3
#Export Table 3
library(writexl)
write_xlsx(Table3, "H:/Paper and Article/Paper_HRC/Results/2018-05-Results/Table3.xlsx")
#%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
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#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#Figure 3Decomposition of waste generation in four areas:
#Greater Copenhagen, Central Zealand, Silkeborg and Djursland
#Decomposition of waste generation for the four areas
library(ggseas)
library(lubridate)
yearcol=c("#d11141","#00b159", "#00aedb","#f37735","#ffc425","#cccccc","#8c8c8c")
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
##All waste

#Dataset to draw the figure 3
figure3=
  wrc2018_v8%>%
  mutate(date1=ymd( paste(Year, Months, "15", sep="-")))%>%
  group_by(date1,Affaldsselskab)%>%#head()
  summarise(tot=sum(Maengde)/1000)%>%
  mutate(Affaldsselskab=fct_recode(Affaldsselskab,
    "Central Zealand"="Roskilde"))#%>%head()
library(colorRamps)
#Fix the order of the "affaldsselskab": study areas
figure3$Affaldsselskab=factor(figure3$Affaldsselskab,,
    levels = c("Greater Copenhagen","Central Zealand","Djursland","Silkeborg"))
selk_colour=c("red","blue1","coral4","forestgreen")
```

```
#Figure 3
figure3%>%
  ggsdc(aes(x=date1,y=tot, colour=Affaldsselskab),
    method = "stl", s.window =7, frequency = 12,
    facet.titles = c("The original series", "The underlying trend",
      "Regular seasonal patterns", "All the randomness left")) +
  theme_bw()+
  scale_color_manual(values=c("red","blue1","coral4","forestgreen"))+
  geom_line(size=1.2)+
  labs(colour="Study areas",y="1000 Mg",x="Study period")+
  theme(legend.position="top")+
  theme(text =  element_text(colour = "black", face = "bold", size = 12))+
  theme(axis.text = element_text( color = "black", size = 12))
#END of figure 3
##%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%
#%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
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#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#Figure 4: Boxplot showing the change in mass of waste collected
#in and number of visitors for the period 2010-2016
#Boxplot for ratio mean for all HWRC
Waste_visit_v1=
  wrc2018_v8%>%
  group_by(Year,Months,date1,Affaldsselskab,Kommune,Genbrugspladser)%>%
  summarise(tot=sum(Maengde))%>%
  left_join(
    visit_v1%>%mutate(Year=as.double(Year))
  )%>%select(-Type)

##Compute ratio and boxplot
Waste_visit_v1%>%
  #Compute aeverage per month
  group_by(Months,Genbrugspladser)%>%
  summarise(tot1=mean(tot),visit1=mean(Visit))%>%
  #Compute average per HWRC
  group_by(Genbrugspladser)%>%
  summarise(tot2=mean(tot1),visit2=mean(visit1))%>%
  #Join
  right_join(
    Waste_visit_v1%>%
      group_by(Year,Months,Genbrugspladser)%>%
      summarise(mass=sum(tot),beso=sum(Visit))%>%
      group_by(Months,Genbrugspladser)%>%
      summarise(tot1=mean(mass),visit1=mean(beso)))%>%
  mutate(ratio1=tot1/tot2, ratio_be=visit1/visit2)%>%
  mutate(Waste= ifelse(ratio1>1, ((ratio1-1)*100),(-1*(1-ratio1)*100)))%>%#head()
  #We compute mean ratio ratio2 for mass and ratio_be2 for visitor
  mutate(Visitors= ifelse(ratio_be>1, ((ratio_be-1)*100),(-1*(1-ratio_be)*100)))%>%
  ##Now we select only the mean ratios ratio2 for mass and ratio_be2 for visitor
  select(Genbrugspladser,Months,Waste,Visitors)%>%
  #We combine both ratios
  gather(Ratio,tal, Waste:Visitors)%>%
  ggplot(aes(x=Months,y=tal))+
```

```
  geom_boxplot(aes(colour=Ratio),position=position_dodge(.9))+
  stat_summary(fun.y=mean, colour="darkred", geom="point",
    aes(group=Ratio), position=position_dodge(.8),
    shape=18, size=3,show_guide = FALSE)+
  geom_hline(yintercept = 0, colour="red",size=1)+
  theme_bw()+
  theme(legend.position="top")+
  labs(x="Months", y="Mean ratio in %")+
  theme(text =element_text(colour = "black", face = "bold", size = 12))
#END of figure 4

#++++++++++++++++++TOOOOOOO BE
CHECKED+++++++++++++++++++++++++++++++++++++++++++++++

##%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
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#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
##Figure 8
install.packages("ggtern")
library(ggtern)

figure8=
  wrc2018_v8%>%
  mutate(Affaldsselskab=fct_recode(Affaldsselskab,
    "Central Zealand"="Roskilde"))%>%
  group_by(Year,Affaldsselskab,Genbrugspladser,Treatment)%>%#head()
  summarise(Tot=sum(Maengde)/1000)%>%#head()
  group_by(Year,Affaldsselskab,Genbrugspladser) %>%
  transmute(Treatment, per_waste=(Tot/sum(Tot)*100))%>%
  spread(Treatment, per_waste, fill=0)
  #filter(Affaldsselskab %in% c("Greater Copenhagen"))%>%

fig8a=
  wrc2018_v8%>%
  mutate(Affaldsselskab=fct_recode(Affaldsselskab,
    "Central Zealand"="Roskilde"))%>%
  group_by(Year,Affaldsselskab,Genbrugspladser,Treatment)%>%#head()
  summarise(Tot=sum(Maengde)/1000)

ternaryplot(figure8[,c("Incineration","Other","Recycling")])

  ggtern(data=figure8,aes(y=Incineration,x=Other,z=Recycling))+
  geom_mask() +
  scale_shape_manual(values=c(49:55))+
  geom_point(aes(colour = factor(Year),
   shape=factor(Affaldsselskab,levels =c("Greater Copenhagen",
                  "Central Zealand","Djursland","Silkeborg") )),size=2) +
  #scale_shape_manual(values=c(103,99,100,115))+
  theme_bw()+
  theme_rgbw() +
  theme_rgbw(base_size = 11,base_family = "")+
```

```
  labs(shape="Study areas",colour="Years")+
  scale_T_continuous(limits=c(0.0,.8))+
  scale_L_continuous(limits=c(0.0,0.8))+
  scale_R_continuous(limits=c(0.2,1))

#END of Figure 7
##%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%
#%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%

unique(wrc2018_v8$Fraction)%>%View()





#Data for correlation analysis
library(readxl)
DK_all <- read_excel("H:/Paper and Article/Paper_HRC/data_all/DK_all.xlsx",
sheet = "Sheet1")

table2_4=
  table3_1%>%
  bind_cols(Maengde=rep(0,nrow(table3_1)))%>%
  bind_rows(table3_2)%>%
  left_join(
    DK_all%>%##Data cleaning and combination
      mutate(Kommune=
          str_replace_all(Kommune,#Find all danish characters and replace them with
            #The tricky part is to remember to have mutate at the beginning
            #For more inf. page 215, R for Data Science
            c("æ"="ae","å"="aa","ø"="oe","Å"="Aa","Ø"="Oe","Æ"="Ae")))%>%
      gather(Year, Values,`2010`:`2017`)%>%
      mutate(Pers=fct_recode(Pers,
        "7 personer"="7 personer og derover"))%>%
      separate(Pers,c("Number_pe","Per"),sep = " ")%>%
      mutate(Number_pe=as.double(Number_pe))%>%
      mutate(Housing_type=ifelse(Housing%in% "Etageboliger","MF","SF"))%>%
      mutate(Pp=Values*Number_pe)%>%
      group_by(Housing_type,Kommune,Year)%>%
      summarise(Person=sum(Pp),Household=sum(Values))%>%
      gather(Paaa, tot,c(Person,Household))%>%
      unite(Housing,Housing_type,Paaa,sep = "_")%>%
      spread(Housing,tot))

write_xlsx(table2_4, "H:/Paper and Article/Paper_HRC/Results/2018-05-Results/table2_4.xlsx")

##SM Figure
#Number of visitor per household and number of visitors per inhabitant

table2_4%>%
  mutate(visit_ho=Visitors/Household,visit_per=Visitors/Person)%>%
```

```
  select(Year,Affaldsselskab,Kommune,visit_ho,visit_per)%>%
  gather(visti,ratio,c(visit_ho,visit_per))%>%
  ungroup()%>%
  rename("Municipalities"="Kommune")%>%
  mutate(visti=fct_recode(visti,
    "Visitor per household"="visit_ho",
    "Visitor per inhabitant"="visit_per"))%>%
  ggplot(aes(Year,ratio))+
  geom_line(aes(group=Municipalities, colour=Municipalities),size=1.2)+
  scale_shape_manual(values=97:109)+
  geom_point(aes(group=Municipalities, shape=Municipalities),size=3)+
  facet_wrap(~ factor(visti), scales = "free")+
  theme_bw()+
  #labs(colour="Municipalities",shap)+
  theme(text =  element_text(colour = "black", face = "bold", size = 12))+
  theme(axis.text = element_text( color = "black", size = 12))




#%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%
par1=c("WGR_hous","WGR_per","WGR_visit","den_area","SF","ratio1","ratio2",
  "ratio3","ratio4")
table2=
  table2_DK%>%
  mutate(WGR_hous=(Tot/Household)*1000,
    WGR_per=(Tot/Person)*1000,
    WGR_visit=(Tot/Visitors)*1000,
    den_area=Person/area_km2)%>%
  mutate(ratio1=WGR_per/WGR_visit)%>%
  mutate(ratio2=WGR_per/WGR_hous)%>%
  mutate(ratio3=WGR_visit/WGR_hous)%>%
  mutate(ratio4=Visitors/Person)%>%
  mutate(ratio5=Visitors/Household)%>%
  mutate(SF=SF*100)%>%
  mutate_if(is.numeric, funs(round(., 2)))%>%
  #round all numeric data to 2 after digit
  select(Year,Affaldsselskab,Kommune,SF:ratio5)%>%
  gather(Para,mass,SF:ratio5)%>%
  spread(Year,mass)%>%
  mutate(Kommune=factor(Kommune,levels = muni))%>%
  #mutate(Para=factor(Para,levels = par1))%>%
  #set a new order of municipalities
  arrange(Kommune)#%>%View()#show Kommune with desired order

table2%>%
  filter(Para%in%c("ratio1","ratio2","ratio3"))%>%
  View()
library(writexl)
write_xlsx(table2, "H:/Paper and Article/Paper_HRC/Results/2018-05-Results/Table2.xlsx")

#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
```

```
library(psych)
##Summary: descriptive statisics
table2%>%
  gather(Year,Mass,`2010`:`2016`)%>%
  group_by(Para)%>%
  do(describe(.$Mass))%>%
  mutate(CV=sd/mean*100)

wrc2018_v8%>%
  group_by(Year,Affaldsselskab,Genbrugspladser,Treatment)%>%
  summarise(tot=sum(Maengde))%>%
  group_by(Year,Affaldsselskab,Genbrugspladser)%>%
  transmute(Treatment, Co1=tot/sum(tot)*100)%>%#head()
  group_by(Year,Treatment)%>%
  do(describe(.$Co1))%>%View()

#++++++Graph showing descriptive statistics
table2%>%
  filter(Para%in% c("WGR_per","WGR_visit","WGR_hous"))%>%
  gather(Year,Mass,`2010`:`2016`)%>%
  mutate(Para=fct_recode(Para,
    "WGR Person"="WGR_per","WGR Houseold"="WGR_hous",
    "WGR Visitor"="WGR_visit"))%>%
  ggplot(aes(x=factor(Year), y=Mass))+
  scale_shape_manual(values=1:nlevels(table2$Kommune))+
  geom_boxplot()+
  geom_point(aes(shape=Kommune))+
  facet_wrap(~ Para,scales = "free")+
  theme_bw()+
  labs(colour="Municipalities",x="Year",y="Generation rates")+
  #labs(x="Number of inhabitants per km2", y="ratio")+
  #theme(legend.position="top")+
  theme(text =element_text(colour = "black", face = "bold", size = 12))
#++++++Graph showing descriptive statistics
table2%>%
  filter(Para%in% c("WGR_per","WGR_visit","WGR_hous"))%>%
  gather(Year,Mass,`2010`:`2016`)%>%
  mutate(Para=fct_recode(Para,
    "WGR Person"="WGR_per","WGR Houseold"="WGR_hous",
    "WGR Visitor"="WGR_visit"))%>%
  ggplot(aes(x=factor(Year), y=Mass))+
  #scale_shape_manual(values=1:nlevels(table2$Kommune))+
  geom_boxplot()+
  geom_point(aes(color=Kommune))+
  facet_wrap(~ Para,scales = "free")+
  theme_bw()+
  labs(colour="Municipalities",x="Year",y="Generation rates")+
  #labs(x="Number of inhabitants per km2", y="ratio")+
  #theme(legend.position="top")+
  theme(text =element_text(colour = "black", face = "bold", size = 12))

#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
```

```
#Graph to show
table2_DK%>%
  mutate(WGR_hous=(Tot/Household)*1000,
    WGR_per=(Tot/Person)*1000,
    WGR_visit=(Tot/Visitors)*1000,
    den_area=Person/area_km2)%>%
  mutate(ratio1=WGR_per/WGR_visit)%>%
  mutate(ratio2=ratio1/den_area)%>%
  mutate_if(is.numeric, funs(round(., 2)))%>%
  ggplot(aes(x=den_area,y=ratio1))+geom_point()+
  geom_text(aes(label=Kommune),hjust=0, vjust=0)+
  geom_smooth(method="loess")+theme_bw()+
  theme_bw()+
  #labs(x="Number of inhabitants per km2", y="ratio")+
  #theme(legend.position="top")+
  theme(text =element_text(colour = "black", face = "bold", size = 12))
#++++++++++++++++++++++++++++++++++++++++++
table2_DK%>%
  mutate(WGR_hous=(Tot/Household)*1000,
    WGR_per=(Tot/Person)*1000,
    WGR_visit=(Tot/Visitors)*1000,
    den_area=Person/area_km2)%>%
  mutate(ratio1=WGR_per/WGR_visit)%>%
  mutate(ratio2=ratio1/den_area)%>%
  mutate_if(is.numeric, funs(round(., 2)))%>%
  ggplot(aes(x=Visitors,y=(SF*Household)))+geom_point()+
  geom_text(aes(label=Kommune),hjust=0, vjust=0)+
  geom_smooth(method="lm")+theme_bw()+
  theme_bw()+
  #labs(x="Number of inhabitants per km2", y="ratio")+
  #theme(legend.position="top")+
  theme(text =element_text(colour = "black", face = "bold", size = 12))
#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
table2_DK%>%
  mutate(WGR_hous=(Tot/Household)*1000,
    WGR_per=(Tot/Person)*1000,
    WGR_visit=(Tot/Visitors)*1000,
    den_area=Person/area_km2)%>%
  mutate(ratio1=WGR_per/WGR_visit)%>%
  mutate(ratio2=ratio1/den_area)%>%
  mutate_if(is.numeric, funs(round(., 2)))%>%
  ggplot(aes(x=ratio1,y=(SF),colour=factor(Year)))+
  geom_point()+
  geom_text(aes(label=Kommune),hjust=0, vjust=0)+
  geom_smooth(method="lm")+theme_bw()+
  theme_bw()+
  #labs(x="Number of inhabitants per km2", y="ratio")+
  #theme(legend.position="top")+
  theme(text =element_text(colour = "black", face = "bold", size = 12))

#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
table2_DK%>%
```

```
  mutate(WGR_hous=(Tot/Household)*1000,
    WGR_per=(Tot/Person)*1000,
    WGR_visit=(Tot/Visitors)*1000,
    den_area=Person/area_km2)%>%
  mutate(ratio1=WGR_per/WGR_visit)%>%
  mutate(ratio2=ratio1/den_area)%>%
  mutate_if(is.numeric, funs(round(., 2)))%>%
  ggplot(aes(x=ratio1,y=(SF)))+
  geom_point()+
  geom_text(aes(label=Kommune),hjust=0, vjust=0)+
  geom_smooth(method="lm")+theme_bw()+
  theme_bw()+
  #labs(x="Number of inhabitants per km2", y="ratio")+
  #theme(legend.position="top")+
  theme(text =element_text(colour = "black", face = "bold", size = 12))

#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
table2_DK%>%
  mutate(WGR_hous=(Tot/Household)*1000,
    WGR_per=(Tot/Person)*1000,
    WGR_visit=(Tot/Visitors)*1000,
    den_area=Person/area_km2)%>%
  mutate(ratio1=WGR_per/WGR_visit)%>%
  mutate(ratio2=ratio1/den_area)%>%
  mutate_if(is.numeric, funs(round(., 2)))%>%
  ggplot(aes(x=(den_area),y=ratio1))+
  geom_point()+
  geom_text(aes(label=Kommune),hjust=0, vjust=0)+
  geom_smooth(method="lm")+theme_bw()+
  theme_bw()+
  #labs(x="Number of inhabitants per km2", y="ratio")+
  #theme(legend.position="top")+
  theme(text =element_text(colour = "black", face = "bold", size = 12))

#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
table2_DK%>%
  mutate(WGR_hous=(Tot/Household)*1000,
    WGR_per=(Tot/Person)*1000,
    WGR_visit=(Tot/Visitors)*1000,
    den_area=Person/area_km2)%>%
  mutate(ratio1=WGR_per/WGR_visit)%>%
  mutate(ratio2=ratio1/den_area)%>%
  mutate_if(is.numeric, funs(round(., 2)))%>%
  ggplot(aes(x=Visitors,y=SF))+geom_point()+
  geom_text(aes(label=Kommune),hjust=0, vjust=0)+
  #geom_smooth(method="lm")+theme_bw()+
  theme_bw()+
  #labs(x="Number of inhabitants per km2", y="ratio")+
  #theme(legend.position="top")+
  theme(text =element_text(colour = "black", face = "bold", size = 12))


##+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
table2_4%>%head()
```

```
#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#Build a 3 D plot
library(scatterplot3d)
scatterplot3d(table2_4$Visitors, table2_4$SF_house, log(table2_4$den_area))
pairs(data.frame(table2_4$Visitors, table2_4$SF_house, log(table2_4$den_area)),
  panel=panel.smooth, oma=rep(2, 4))
#3Testing factors affecting the number of visitors
#++++++This is the best
fm1=lm((Visitors)~(SF_house)+log(den_area), data =table2_4 )
fm2=lm((Visitors)~(SF_house), data =table2_4 )
fm3=lm((Visitors)~(SF_house)+(MF_house)+log(den_area), data =table2_4 )
anova(fm3,fm1)

cbind(coef(fm))

summary(lm((Visitors)~(SF_house)+(MF_house)+log(den_area), data =table2_4 ))
summary(lm((Visitors)~(SF_house)+log(den_area), data =table2_4 ))
anova(lm((Visitors)~I(SF*Person)+log(den_area), data =table2_4 ))
drop1(lm((Visitors)~I(SF*Person)+log(den_area), data =table2_4 ))
confint(lm((Visitors)~I(SF*Person)+log(den_area), data =table2_4 ))
#%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%
#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#Decomposition of waste generation for the four areas
library(ggseas)
library(lubridate)
yearcol=c("#d11141","#00b159", "#00aedb","#f37735","#ffc425","#cccccc","#8c8c8c")
#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
##All waste
wrc2018_v8$Affaldsselskab=factor(wrc2018_v8$Affaldsselskab,,
   levels = c("Greater Copenhagen","Central Zealand","Djursland","Silkeborg"))

wrc2018_v8%>%
  mutate(date1=ymd( paste(Year, Months, "15", sep="-")))%>%
  group_by(date1,Affaldsselskab)%>%#head()
  summarise(tot=sum(Maengde)/1000)%>%head()
  mutate(Affaldsselskab=fct_recode(Affaldsselskab,
    "Central Zealand"="Roskilde"))%>%head()
  ggsdc(aes(x=date1,y=tot, colour=Affaldsselskab),
    method = "stl", s.window =7, frequency = 12,
    facet.titles = c("The original series", "The underlying trend",
      "Regular seasonal patterns", "All the randomness left")) +
  theme_bw()+
  geom_line(size=1.2)+
  labs(colour="Study areas",y="1000 Mg",x="Study period")+
  theme(legend.position="top")+
  theme(text =  element_text(colour = "black", face = "bold", size = 12))+
  theme(axis.text = element_text( color = "black", size = 12))
#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#Combine waste data and number of visitors
```

```
Waste_visit_v1=
  wrc2018_v8%>%
  group_by(Year,Months,date1,Affaldsselskab,Kommune,Genbrugspladser)%>%
  summarise(tot=sum(Maengde))%>%
  left_join(
    visit_v1%>%mutate(Year=as.double(Year))
  )%>%select(-Type)

##Compute ratio and boxplot
Waste_visit_v1%>%
  #Compute aeverage per month
  group_by(Months,Genbrugspladser)%>%
  summarise(tot1=mean(tot),visit1=mean(Visit))%>%
  #Compute average per HWRC
  group_by(Genbrugspladser)%>%
  summarise(tot2=mean(tot1),visit2=mean(visit1))%>%
  #Join
  right_join(
    Waste_visit_v1%>%
      group_by(Year,Months,Genbrugspladser)%>%
      summarise(mass=sum(tot),beso=sum(Visit))%>%
      group_by(Months,Genbrugspladser)%>%
      summarise(tot1=mean(mass),visit1=mean(beso)))%>%
  mutate(ratio1=tot1/tot2, ratio_be=visit1/visit2)%>%
  mutate(Waste= ifelse(ratio1>1, ((ratio1-1)*100),(-1*(1-ratio1)*100)))%>%#head()
  #We compute mean ratio ratio2 for mass and ratio_be2 for visitor
  mutate(Visitors= ifelse(ratio_be>1, ((ratio_be-1)*100),(-1*(1-ratio_be)*100)))%>%
  ##Now we select only the mean ratios ratio2 for mass and ratio_be2 for visitor
  select(Genbrugspladser,Months,Waste,Visitors)%>%
  #We combine both ratios
  gather(Ratio,tal, Waste:Visitors)%>%
  ggplot(aes(x=Months,y=tal))+
  geom_boxplot(aes(colour=Ratio),position=position_dodge(.9))+
  stat_summary(fun.y=mean, colour="darkred", geom="point",
    aes(group=Ratio), position=position_dodge(.8),
    shape=18, size=3,show_guide = FALSE)+
  geom_hline(yintercept = 0, colour="red",size=1)+
  theme_bw()+
  theme(legend.position="top")+
  labs(x="Months", y="Mean ratio in %")+
  theme(text =element_text(colour = "black", face = "bold", size = 12))
#%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%



#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
eco_mass2018= read.table("H:/Paper and Article/Paper_HRC/data_all/eco_mass2018.txt")
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
eco_mass2018%>%head()
group_by(Fraction,Sække)%>%
```

```
  summarise(tt=sum(Maengde))%>%View()

eco_mass2018%>%#names()
  group_by(Fraction,Sække)%>%
  summarise(tt=mean(Maengde))%>%View()

#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
##Test the calculation
eco_mass2018%>%#head()
  mutate(Genbrugspladser=fct_recode(Genbrugspladser,
    "Grenaa"="Lemvig",
    "Vermlandsgade"="Hvidovre_II"))%>%
  group_by(Genbrugspladser,Fraction)%>%
  summarise(Tom=sum(Maengde))%>%
  group_by(Genbrugspladser)%>%
  transmute(Fraction,per_Tom=Tom/sum(Tom))%>%
  group_by(Genbrugspladser)%>%summarise(test=sum(per_Tom))%>%
  spread(Genbrugspladser,test)
head()
#mutate(Pot=`2016`*per_Tom)%>%mutate_if(is.numeric, funs(round(., 2))

#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
##Combine waste datasets

wrc_eco=
  wrc2018_v8%>%
  group_by(Year,Fraktioner,Fraction,Fraktioner2,Treatment,Genbrugspladser)%>%
  summarise(Tot=sum(Maengde))%>%#distinct(Genbrugspladser)%>%View()
  filter(Genbrugspladser %in%
      c("Hvidovre","Jyllinge","Viby","Tietgensvej","Tandskov","Vermlandsgade",
        "Grenaa"))%>%  spread(Year, Tot, fill = 0)%>%
  left_join(eco_mass2018%>%
      mutate(Genbrugspladser=fct_recode(Genbrugspladser,
        "Grenaa"="Lemvig",
        "Vermlandsgade"="Hvidovre_II"))%>%
      group_by(Genbrugspladser,Fraction)%>%
      summarise(Tom=sum(Maengde))%>%#head()
      group_by(Genbrugspladser)%>%
      transmute(Fraction,per_Tom=Tom/sum(Tom)))%>% replace(., is.na(.), 1)%>%
  mutate(Pot=`2016`*per_Tom)%>%mutate_if(is.numeric, funs(round(., 2)))
#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#Redistrubute all incineration to other fractions
Inc_port=
  wrc_eco%>%mutate(Pot0=`2016`)%>%
  gather(Year,Mass,-c(Fraktioner:Genbrugspladser,per_Tom))%>%
  group_by(Year,Genbrugspladser,Treatment)%>%
  summarise(Mass=sum(Mass))%>%
  filter(Treatment%in%"Incineration",Year%in% c("Pot0"))%>%#head()
  select(-c(Treatment))%>%
  left_join(
    eco_mass2018%>%add_column(type=rep("New",nrow(eco_mass2018)))%>%
      mutate(Genbrugspladser=fct_recode(Genbrugspladser,
```

```
    "Grenaa"="Lemvig",
    "Vermlandsgade"="Hvidovre_II"))%>%
   mutate(Treatment=ifelse(Fraction%in%c("Residual Household waste",
    "Miscellaneous combustible"),"Incineration",
    ifelse(Fraction%in% c("Untreated wood",
     "Landfilled waste","Small household appliances",
     "Chemichal fertilizer","Treated wood",
     "Polyvinylchloride (PVC)"),"Other","Recycling")))%>%
   group_by(Genbrugspladser,Treatment,type)%>%
   summarise(tot1=sum(Maengde))%>%
   group_by(Genbrugspladser,type)%>%
   transmute(Treatment,tot1_per=tot1/sum(tot1))#%>%head()
 )%>%#head()
 mutate(Pot0=tot1_per*Mass)
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#
potent_dat=
 Inc_port%>%select(-c(Mass,tot1_per))%>%
 rename(Mass=Pot0)%>%
 select(Year,Genbrugspladser,Treatment,type,Mass)%>%
 mutate(Treatment=as.factor(Treatment))%>%
 bind_rows(
  wrc_eco%>%
   add_column(type=rep("old",nrow(wrc_eco)))%>%
   mutate(Pot0=`2016`)%>%select(-c(per_Tom,Pot))%>%#head()
   gather(Year,Mass,-c(Fraktioner:Genbrugspladser,type))%>%
   group_by(Year,Genbrugspladser,Treatment,type)%>%
   summarise(Mass=sum(Mass))%>%
   mutate(Me2=ifelse(Year %in% "Pot0"&Treatment %in% "Incineration","0","1"))%>%
   filter(Me2%in%"1")%>%select(-Me2)
 )%>%#
 group_by(Year,Genbrugspladser,Treatment)%>%
 summarise(MassMg=sum(Mass))%>%spread(Year,MassMg)
##----------------------------------------------------------------------------
#Suite of calcuati
library(ggtern)
Yearcol=c("#140A00","#2121D9", "#9999FF", "#D92121", "#21D921", "#FFFF4D", "#FF9326","#963700")
tt1=c("black","navy","orangered","purple4","blue","deeppink4","green4","red")
potent_dat%>%as.data.frame()%>%
 gather(Year,Mass,-c(Genbrugspladser,Treatment))%>%#head()
 spread(Treatment,Mass)%>%#head()
 ggtern(aes(y=Incineration,x=Other,z=Recycling))+
 geom_mask() +
 scale_shape_manual(values=1:7)+
 geom_point(aes(colour = factor(Year),shape=Genbrugspladser),size=2) +
 #geom_line(aes(colour = factor(Genbrugspladser)))+
 theme_bw()+ theme_rgbw() +
 theme_rgbw(base_size = 11,base_family = "")+
 scale_colour_manual(values = tt1)+
 #scale_colour_brewer(palette="set2")+
 #scale_colour_gradient(colours=rainbow(8))+
 labs(shape="Areas",colour="Years")+
 scale_T_continuous(limits=c(0.0,.5))+
 scale_L_continuous(limits=c(0.0,0.5))+
```

```
  scale_R_continuous(limits=c(0.5,1))

##Reduce to three years
potent_dat%>%as.data.frame()%>%
  gather(Year,Mass,-c(Genbrugspladser,Treatment))%>%#head()
  spread(Treatment,Mass)%>%filter(Year%in%c("2015","2016","Pot0"))%>%
  ggtern(aes(y=Incineration,x=Other,z=Recycling))+
  geom_mask() +
  scale_shape_manual(values=c(49:55))+
  geom_point(aes(colour = factor(Year),shape=Genbrugspladser),size=4) +
  #geom_line(aes(colour = factor(Genbrugspladser)))+
  theme_bw()+ theme_rgbw() +
  theme_rgbw(base_size = 11,base_family = "")+
  scale_colour_manual(values = c("blue","green4","red"))+
  #scale_colour_brewer(palette="set2")+
  #scale_colour_gradient(colours=rainbow(8))+
  labs(shape="Areas",colour="Years")+
  scale_T_continuous(limits=c(0.0,.5))+
  scale_L_continuous(limits=c(0.0,0.5))+
  scale_R_continuous(limits=c(0.5,1))

++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
  #Total Waste per area
  Area_year=wrc2018_v8 %>%
  group_by(Year,Affaldsselskab)%>%
  summarise(waste_year=sum(Maengde)/1000)%>%
  spread(Affaldsselskab,waste_year,fill = 0)
setwd("H:/Paper and Article/Paper_HRC/Results")
library(writexl)
write_xlsx(Area_year, "Area_year.xlsx")


##Exclude gardening waste
wrc2018_v8%>%#distinct(Fraction)%>%arrange(Fraction)
  filter(Fraction%!in% "Garden waste")%>%
  mutate(date1=ymd( paste(Year, Months, "15", sep="-")))%>%
  group_by(date1,Affaldsselskab)%>%#head()
  summarise(tot=sum(Maengde)/1000)%>%#head()
  ggsdc(aes(x=date1,y=tot, colour=Affaldsselskab),
    method = "stl", s.window =7, frequency = 12,
    facet.titles = c("The original series", "The underlying trend",
      "Regular seasonal patterns", "All the randomness left")) +
  theme_bw()+
  geom_line(size=1.2)+
  labs(colour="Study areas",y="1000 Mg (Without garden waste)",x="Study period")+
  theme(legend.position="top")+
  theme(text =  element_text(colour = "black", face = "bold", size = 12))+
  theme(axis.text = element_text( color = "black", size = 12))
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
# Ratio analysis: it is based on arithmetic mean ratio
#Cowpertwait and Metcalfe, (2009), page9
```

```
mean_ratio_ana=wrc2018_v8%>%
  group_by(Year,Months,Affaldsselskab)%>%
  summarise(mass=sum(Maengde))%>%#head()
  group_by(Months,Affaldsselskab)%>%
  summarise(tot1=mean(mass))%>%
  group_by(Affaldsselskab)%>%summarise(tot2=mean(tot1))%>%
  right_join(wrc2018_v8%>%
      group_by(Year,Months,Affaldsselskab)%>%
      summarise(mass=sum(Maengde))%>%#head()
      group_by(Months,Affaldsselskab)%>%
      summarise(tot1=mean(mass)))%>%
  mutate(ratio1=tot1/tot2)%>%
  mutate(ratio2= ifelse(ratio1>1, ((ratio1-1)*100),(-1*(1-ratio1)*100)))

mean_ratio_ana1=mean_ratio_ana %>%
  select(Affaldsselskab,ratio2,Months)%>%
  spread(Affaldsselskab,ratio2, fill = 0)%>%
  arrange(factor(Months, levels = month))
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
###Without garden waste

wrc2018_v8%>%
  filter(Fraction%!in% "Garden waste")%>%
  group_by(Year,Months,Affaldsselskab)%>%
  summarise(mass=sum(Maengde))%>%#head()
  group_by(Months,Affaldsselskab)%>%
  summarise(tot1=mean(mass))%>%
  group_by(Affaldsselskab)%>%summarise(tot2=mean(tot1))%>%
  right_join(wrc2018_v8%>%
      group_by(Year,Months,Affaldsselskab)%>%
      summarise(mass=sum(Maengde))%>%#head()
      group_by(Months,Affaldsselskab)%>%
      summarise(tot1=mean(mass)))%>%
  mutate(ratio1=tot1/tot2)%>%
  mutate(ratio2= ifelse(ratio1>1, ((ratio1-1)*100),(-1*(1-ratio1)*100)))%>%
  select(Affaldsselskab,ratio2,Months)%>%
  spread(Affaldsselskab,ratio2, fill = 0)%>%
  arrange(factor(Months, levels = month))%>%View()
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
##Ratio mean for each HWRC
HWRC_ratio_mean=wrc2018_v8%>%
  #filter(Fraction%!in% "Garden waste")%>%
  group_by(Year,Months,Genbrugspladser)%>%
  summarise(mass=sum(Maengde))%>%#head()
  group_by(Months,Genbrugspladser)%>%
  summarise(tot1=mean(mass))%>%
  group_by(Genbrugspladser)%>%summarise(tot2=mean(tot1))%>%
  right_join(wrc2018_v8%>%
      group_by(Year,Months,Genbrugspladser)%>%
      summarise(mass=sum(Maengde))%>%#head()
      group_by(Months,Genbrugspladser)%>%
      summarise(tot1=mean(mass)))%>%
  mutate(ratio1=tot1/tot2)%>%
  mutate(ratio2= ifelse(ratio1>1, ((ratio1-1)*100),(-1*(1-ratio1)*100)))%>%
```

```
  select(Genbrugspladser,ratio2,Months)%>%
  spread(Genbrugspladser,ratio2, fill = 0)%>%
  arrange(factor(Months, levels = month))#%>%View()
setwd("H:/Paper and Article/Paper_HRC/Results")
library(writexl)
write_xlsx(HWRC_ratio_mean, "HWRC_ratio_mean.xlsx")
#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#Boxplot for ratio mean for all HWRC
wrc2018_v8%>%
  #filter(Fraction%!in% "Garden waste")%>%
  group_by(Year,Months,Genbrugspladser)%>%
  summarise(mass=sum(Maengde))%>%#head()
  group_by(Months,Genbrugspladser)%>%
  summarise(tot1=mean(mass))%>%
  group_by(Genbrugspladser)%>%summarise(tot2=mean(tot1))%>%
  right_join(wrc2018_v8%>%
      group_by(Year,Months,Genbrugspladser)%>%
      summarise(mass=sum(Maengde))%>%#head()
      group_by(Months,Genbrugspladser)%>%
      summarise(tot1=mean(mass)))%>%
  mutate(ratio1=tot1/tot2)%>%
  mutate(ratio2= ifelse(ratio1>1, ((ratio1-1)*100),(-1*(1-ratio1)*100)))%>%#head()
  ggplot(aes(x=Months,y=ratio2))+
  geom_boxplot()+
  stat_summary(fun.y=mean, colour="darkred", geom="point",
    shape=18, size=3,show_guide = FALSE)+
  geom_hline(yintercept = 0, colour="red")+
  labs(x="Months",y="Mean ratio")+
  theme_classic()+
  labs(x="Months", y="Mean ratio in %")+
  theme(text =element_text(colour = "black", face = "bold", size = 12))
#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#Boxplot for ratio mean for all HWRC subdivided in area
wrc2018_v8%>%
  #filter(Fraction%!in% "Garden waste")%>%
  group_by(Year,Months,Affaldsselskab,Genbrugspladser)%>%
  summarise(mass=sum(Maengde))%>%#head()
  group_by(Months,Affaldsselskab,Genbrugspladser)%>%
  summarise(tot1=mean(mass))%>%
  group_by(Affaldsselskab,Genbrugspladser)%>%summarise(tot2=mean(tot1))%>%
  right_join(wrc2018_v8%>%
      group_by(Year,Months,Affaldsselskab,Genbrugspladser)%>%
      summarise(mass=sum(Maengde))%>%#head()
      group_by(Months,Affaldsselskab,Genbrugspladser)%>%
      summarise(tot1=mean(mass)))%>%
  mutate(ratio1=tot1/tot2)%>%
  mutate(ratio2= ifelse(ratio1>1, ((ratio1-1)*100),(-1*(1-ratio1)*100)))%>%#head()
  #filter(ratio2<100)%>%
  ggplot(aes(x=Months,y=ratio2))+
  geom_boxplot(aes(fill=factor(Affaldsselskab)),size=.5)+
  stat_summary(fun.y=mean, colour="darkred", geom="point",
    aes(group=Affaldsselskab), position=position_dodge(.7),
    shape=18, size=3,show_guide = FALSE)+
  geom_hline(yintercept = 0, colour="red",size=1)+
```

```
  theme_bw()+
  labs(fill="Areas",x="Months", y="Mean ratio in %")+
  theme(legend.position="top")+
  theme(text =element_text(colour = "black", face = "bold", size = 12))
#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
##Waste composition
wrc2018_v8%>% distinct(FraktionTWF2)
twf2=c("Fibres","Plastic","Metal","Wood","Glass","Garden","Soil","C&D","SC",
  "Bulky","OW")
wrc2018_v8%>%
  group_by(Year,Affaldsselskab,FraktionTWF2)%>%
  summarise(Tot=sum(Maengde))%>%
  group_by(Year,Affaldsselskab) %>%
  transmute(FraktionTWF2, per_waste=(Tot/sum(Tot))*100)%>%#head()
  mutate_if(is.numeric, funs(round(., 1)))%>%
  spread(Year,per_waste,fill = 0)%>%
  arrange(factor(FraktionTWF2,levels = twf2))%>%
  View()
#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
###SM material: waste composition based on detailed fractions
comp_fraction=wrc2018_v8%>%
  group_by(Year,Affaldsselskab,Fraction)%>%
  summarise(Tot=sum(Maengde))%>%
  group_by(Year,Affaldsselskab) %>%
  transmute(Fraction, per_waste=(Tot/sum(Tot))*100)%>%
  mutate_if(is.numeric, funs(round(., 1)))%>%
  spread(Year,per_waste,fill = 0)
setwd("H:/Paper and Article/Paper_HRC/Results")
library(writexl)
write_xlsx(comp_fraction, "comp_fraction.xlsx")
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
###Data for doing biplot: waste composition based on detailed fractions
#for each HWRC
Biplot_FraktionTWF2=
  wrc2018_v8%>%View()
group_by(Year,Affaldsselskab,Kommune,Genbrugspladser,FraktionTWF2)%>%
  summarise(Tot=sum(Maengde))%>%
  group_by(Year,Affaldsselskab,Kommune,Genbrugspladser) %>%
  transmute(FraktionTWF2, per_waste=(Tot/sum(Tot))*100)%>%
  mutate_if(is.numeric, funs(round(., 1)))%>%
  spread(FraktionTWF2,per_waste,fill = 0)
setwd("H:/Paper and Article/Paper_HRC/Results")
library(writexl)
write_xlsx(Biplot_FraktionTWF2, "Biplot_FraktionTWF2.xlsx")


#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Biplot_Fraktioner2=
  wrc2018_v8%>%
  mutate(Affaldsselskab=fct_recode(Affaldsselskab,
    "Central Zealand"="Roskilde"))%>%
  group_by(Year,Affaldsselskab,Kommune,Genbrugspladser,Fraktioner2)%>%
```

```
  summarise(Tot=sum(Maengde))%>%
  group_by(Year,Affaldsselskab,Kommune,Genbrugspladser) %>%
  transmute(Fraktioner2, per_waste=(Tot/sum(Tot))*100)%>%
  mutate_if(is.numeric, funs(round(., 1)))%>%
  spread(Fraktioner2,per_waste,fill = 0)
setwd("H:/Paper and Article/Paper_HRC/Results")
library(writexl)
write_xlsx(Biplot_Fraktioner2, "Biplot_Fraktioner2.xlsx")

Biplot_Fraktioner2%>%head()
#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
selk=c("Copenhagen","Roskilde","Djursland","Silkeborg")
bar_treat=
  wrc2018_v8%>%

  group_by(Year,Affaldsselskab,Treatment)%>%#head()
  summarise(Tot=sum(Maengde)/1000)%>%#head()
  group_by(Year,Affaldsselskab) %>%
  transmute(Treatment, per_waste=(Tot/sum(Tot)*100))%>%#head()
  ggplot(aes(x=factor(Year),y=(per_waste),
    fill=factor(Treatment,levels = c("Other","Incineration","Recycling"))))+
  geom_bar(position="fill",stat="identity")+ #geom_label(stat = "fill_labels")+
  facet_wrap(~ factor(Affaldsselskab,levels = selk), scales = "free")+
  theme_bw()+
  theme(legend.text=element_text(size=12))+
  theme(legend.position="top")+
  scale_y_continuous(labels = function(x) paste0(x*100, "%"))+
  scale_fill_manual("Waste treatments", values = c("blue","red","green4"))+
  guides(title="Waste treatments", fill = guide_legend(nrow = 1))+
  theme(text =  element_text(colour = "black", face = "bold", size = 12))+
  theme(axis.text = element_text( color = "black", size = 12))+
  theme(legend.text=element_text(size=12))+
  theme(strip.text = element_text( color = "black", size = 12),
    strip.background = element_rect(color="black",fill="white"))+
  ylab("Composition")+  xlab("Years")
ggsave("bar_treat.wmf",width = 30, height = 20, units = "cm")

#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
##Treatment
yearcol=c("#d11141","#00b159", "#00aedb","#f37735","#ffc425","#cccccc","#8c8c8c")
library(compositions)
library(robCompositions)
geometric_treat=
  wrc2018_v8%>%
  group_by(Year,Affaldsselskab,Treatment)%>%#head()
  summarise(Tot=sum(Maengde)/1000)%>%#head()
  group_by(Year,Affaldsselskab) %>%
  transmute(Treatment, per_waste=(Tot/sum(Tot)*100))%>%
  group_by(Year, Affaldsselskab,Treatment)%>%
  summarise(per_waste2=mean.acomp(per_waste))%>%#head()
  #spread(Treatment,per_waste2)%>%View()
  left_join(
```

```
  wrc2018_v8%>%
    group_by(Year,Affaldsselskab,Treatment)%>%#head()
    summarise(Tot=sum(Maengde)/1000)%>%
    group_by(Year,Affaldsselskab) %>%
    transmute(Treatment, per_waste=(Tot/sum(Tot)*100))%>%
    group_by(Affaldsselskab,Treatment)%>%
    summarise(per_waste3=mean.acomp(per_waste)))%>%
 mutate(ratio=log(per_waste2/per_waste3))%>%
 mutate(tto=exp(ratio))%>%#head()
 mutate(procent=ifelse(tto>1,round((tto-1)*100,0),
  -round((1-tto)*100,0)))%>%#head()
 ggplot(aes(x=factor(Treatment,levels = c("Recycling","Incineration","Other")),
  y=ratio,fill=factor(Year)))+
 geom_bar(position="dodge", stat="identity")+
 geom_text(aes(x=factor(Treatment,levels = c("Recycling","Incineration","Other")),
  y=ratio,ymax=ratio,
  label = procent,procent=procent+.05,
  #hjust=ifelse(sign(procent)>0, 1, 0)
  vjust=0),
  colour="black",position =position_dodge(width=0.85))+
 labs(colour="År")+ylab("Ratio")+xlab("Waste fraction")+
 facet_wrap(~ factor(Affaldsselskab,levels = selk))+#scales = "free"
 theme_bw()+
 theme(legend.text=element_text(size=12))+
 theme(legend.position="top")+
 scale_fill_manual("Years", values = yearcol)+
 guides(title="Years", fill = guide_legend(nrow = 1))+
 ylab("Ratio")+xlab("Affaldsfraktioner")+
 theme(text =  element_text(colour = "black", face = "bold", size = 14))+
 theme(axis.text = element_text( color = "black", size = 12))+
 theme(legend.text=element_text(size=12))+
 ylab("Log-ratio")+
 xlab("Waste fractions")
ggsave("geometric_treat.wmf",width = 20, height = 20, units = "cm")
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
library(ggtern)

wrc2018_v8%>%
 group_by(Year,Affaldsselskab,Genbrugspladser,Treatment)%>%#head()
 summarise(Tot=sum(Maengde)/1000)%>%#head()
 group_by(Year,Affaldsselskab,Genbrugspladser) %>%
 transmute(Treatment, per_waste=(Tot/sum(Tot)*100))%>%
 spread(Treatment, per_waste, fill=0)%>%
 ungroup()%>%
 mutate(Affaldsselskab=fct_recode(Affaldsselskab,
  "Central Zealand"="Roskilde"))%>%
 #filter(Affaldsselskab %in% c("Greater Copenhagen"))%>%
 ggtern(aes(y=Incineration,x=Other,z=Recycling))+
 geom_mask() +
 scale_shape_manual(values=c(49:55))+
 geom_point(aes(colour = factor(Year),
  shape=factor(Affaldsselskab,levels =c("Copenhagen",
```

```
                    "Roskilde","Djursland","Silkeborg") )),size=2) +
  #scale_shape_manual(values=c(103,99,100,115))+
  theme_bw()+
  theme_rgbw() +
  theme_rgbw(base_size = 11,base_family = "")+
  labs(shape="Areas")+
  scale_T_continuous(limits=c(0.0,.8))+
  scale_L_continuous(limits=c(0.0,0.8))+
  scale_R_continuous(limits=c(0.2,1))


##
#,levels = c("Greater Copenhagen",
#     "Central Zealand","Djursland";"Silkeborg"))
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#Correlation test between waste fractions
library(robCompositions)
library(compositions)

wrc2018_m=
  wrc2018_v8%>%#head()
  mutate(date1=ymd( paste(Year, Months, "15", sep="-")))%>%
  group_by(Year,Affaldsselskab)%>%
  summarise(Total=sum(Maengde)/1000)%>%
  mutate(Total=log(Total))%>%
  left_join(
    wrc2018_v8%>%#head()
      mutate(date1=ymd( paste(Year, Months, "15", sep="-")))%>%
      group_by(Year, Affaldsselskab,FraktionTWF2)%>%
      summarise(tot=sum(Maengde)/1000)
  )%>%
  spread((FraktionTWF2),tot, fill = 0)%>%
  mutate(Total=log(Total))

#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
library(corrplot)
library(broom)
library(tidyverse)
#++++++++++++++++++++++++
#Correlation based on CODA
frak=c("Total","Bulky","`C&D`","Garden","OW","SMC","Soil",
  "TWF")
frak_twf2=c("Total","Bulky","`C&D`","Fibres","Garden","Glass","Metal","OW",
  "Plastic","SMC","Soil","Wood")

#Correlation using Fraction with detailed target waste fractions
wrc2018_v8%>%
  mutate(date1=ymd( paste(Year, Months, "15", sep="-")))%>%
  group_by(Year,Affaldsselskab)%>%
  summarise(Total=sum(Maengde)/1000)%>%
  mutate(Total=log(Total))%>%
```

```
  left_join(
    wrc2018_v8%>%#head()
      mutate(date1=ymd( paste(Year, Months, "15", sep="-")))%>%
      group_by(Year, Affaldsselskab,FraktionTWF2)%>%
      summarise(tot=sum(Maengde)/1000)
  )%>%
  spread((FraktionTWF2),tot, fill = 0)%>%
  mutate(Total=log(Total))%>%
  ungroup()%>%
  mutate(Year=as.character(Year))%>%
  filter(Affaldsselskab %in% "Djursland")%>%
  select(Total:Wood)%>%
  as.matrix()%>%corCoDa()%>%
  as.data.frame()%>%
  mutate_if(is.numeric, funs(round(., 2)))%>%
  `colnames<-`(frak_twf2)%>%
  bind_cols(Fractions=frak_twf2)%>%View()

##correlation using grouped target waste fractions
wrc2018_v8%>%
  mutate(date1=ymd( paste(Year, Months, "15", sep="-")))%>%
  group_by(Year,Affaldsselskab)%>%
  summarise(Total=sum(Maengde)/1000)%>%
  mutate(Total=log(Total))%>%
  left_join(
    wrc2018_v8%>%#head()
      mutate(date1=ymd( paste(Year, Months, "15", sep="-")))%>%
      group_by(Year, Affaldsselskab,Fraktioner2)%>%
      summarise(tot=sum(Maengde)/1000)
  )%>%
  spread((Fraktioner2),tot, fill = 0)%>%
  mutate(Total=log(Total))%>%
  ungroup()%>%
  mutate(Year=as.character(Year))%>%
  filter(Affaldsselskab %in% "Djursland")%>%
  select(Total:TWF)%>%
  as.matrix()%>%corCoDa()%>%
  as.data.frame()%>%
  mutate_if(is.numeric, funs(round(., 2)))%>%
  `colnames<-`(frak)%>%
  bind_cols(Fractions=frak)%>%View()


#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#Silkeborg
setwd("H:/Paper and Article/Paper_HRC/data_all")
library(readxl)
Bil1 <- read_excel("Bil1.xlsx", sheet = "Sheet2")

Bil2= Bil1%>% gather(Genbrugspladser,Visit,-c(Year,Months,Anlæg))

Bil3= Bil2%>% cbind(tibble(Type=rep("Visit",nrow(Bil2)),
```

```
  Affaldsselskab=rep("Silkeborg",nrow(Bil2))))
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Bil3%>%head()
unique(Bil3$Year)
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
##Number of cars
mean_ratio_visit=
  Bil3%>%
  mutate(Genbrugspladser=fct_recode(Genbrugspladser,
    "Tandskov"="ACTA",
    "Tietgensvej"="ACTI",
    "Them"="Them"))%>%
  mutate(Kommune=rep("Silkeborg",nrow(Bil3)))%>%
  filter(Year%in% 2010:2016)%>%
  group_by(Year,Months,Type,Affaldsselskab)%>%
  summarise(mass=sum(Visit))%>%#head()
  group_by(Months,Type,Affaldsselskab)%>%
  summarise(tot1=mean(mass))%>%head()
group_by(Type)%>%summarise(tot2=mean(tot1))%>%#head()
  right_join(Bil3%>%
      group_by(Year,Months,Type,Affaldsselskab)%>%
      summarise(mass=sum(Visit))%>%#head()
      group_by(Months,Type,Affaldsselskab)%>%
      summarise(tot1=mean(mass)))%>%
  mutate(ratio1=tot1/tot2)%>%
  mutate(ratio2= ifelse(ratio1>1, ((ratio1-1)*100),(-1*(1-ratio1)*100)))
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#Mass of waste
mean_ratio_ana=wrc2018_v8%>%
  group_by(Year,Months,Affaldsselskab)%>%
  summarise(mass=sum(Maengde))%>%#head()
  group_by(Months,Affaldsselskab)%>%
  summarise(tot1=mean(mass))%>%
  group_by(Affaldsselskab)%>%summarise(tot2=mean(tot1))%>%
  right_join(wrc2018_v8%>%
      group_by(Year,Months,Affaldsselskab)%>%
      summarise(mass=sum(Maengde))%>%#head()
      group_by(Months,Affaldsselskab)%>%
      summarise(tot1=mean(mass)))%>%
  mutate(ratio1=tot1/tot2)%>%
  mutate(ratio2= ifelse(ratio1>1, ((ratio1-1)*100),(-1*(1-ratio1)*100)))
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
mean_ratio_visit%>%View()
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#Create a new colomn to specfiy that it is waste data
mean_ratio_ana=mean_ratio_ana%>%
  cbind(tibble(Type=rep("Waste",nrow(mean_ratio_ana))))
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#Combine number of cars and mass of waste collected
mean_visit_mass_silk=mean_ratio_ana%>%rbind(mean_ratio_visit)
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

#Combine number of cars and mass of waste collected
library(ggthemes)
```

```
mean_visit_mass_silk%>%
  arrange(factor(Months, levels = month))%>%
  filter(Affaldsselskab%in% "Silkeborg")%>%
  mutate(Type=fct_recode(Type,
    "Number of visit"="Visit",
    "Mass of total waste"="Waste"))%>%
  ggplot(aes(x=Months, y=ratio2))+
  geom_point(mapping=aes(colour=Type))+
  geom_line(aes(group=Type, colour=Type),size=1.2)+
  geom_hline(yintercept = 0, colour="red")+
  theme_base()+
  theme(legend.position="top")+
  #scale_color_manual("Ratio for", values =c("red","blue"))+
  scale_color_manual("Ratio in Silkeborg", values =c("#d33682","#268bd2"))+
  labs(colour="Ratio for",x="Months", y="Ratio in %")+
  theme(text =element_text(colour = "black", face = "bold", size = 12))
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
###Mass
#Mass of waste
mean_ratio_ana=
  wrc2018_v8%>%
  group_by(Year,Months,Affaldsselskab,Fraktioner2)%>%
  summarise(mass=sum(Maengde))%>%head()
group_by(Months,Affaldsselskab)%>%
  summarise(tot1=mean(mass))%>%
  group_by(Affaldsselskab)%>%summarise(tot2=mean(tot1))%>%
  right_join(wrc2018_v8%>%
      group_by(Year,Months,Affaldsselskab)%>%
      summarise(mass=sum(Maengde))%>%#head()
      group_by(Months,Affaldsselskab)%>%
      summarise(tot1=mean(mass)))%>%
  mutate(ratio1=tot1/tot2)%>%
  mutate(ratio2= ifelse(ratio1>1, ((ratio1-1)*100),(-1*(1-ratio1)*100)))
#
##Correlation between number of visitors and mass
##Correlation test
#Visitors and mass of waste
para2 <- read.csv("H:/Paper and Article/Paper_HRC/data_all/para2.txt", sep="")

#++++++++++++++++++Data analysis: Correlation++++++++++++++++++++++++++++++++++
para2%>%View()
para2%>%
  mutate(Aff=ifelse(Kommune%in% c("Silkeborg"),"Silkeborg",
    ifelse(Kommune%in% c("Norddjurs","Syddjurs"),"Djursland","Copenhagen")))%>%
  group_by(Year,Aff)%>%
  summarise(Mass=sum(Maengde),Visit=sum(Visitors),Pers=sum(Person))%>%#View()
  group_by(Year,Aff)%>%
  summarise(wgr1=(Mass/Visit)*1000)%>%spread(Year, wgr1, fill=0)%>%View()

para2%>%
  mutate(Aff=ifelse(Kommune%in% c("Silkeborg"),"Silkeborg",
    ifelse(Kommune%in% c("Norddjurs","Syddjurs"),"Djursland","Copenhagen")))%>%
```

```
  group_by(Year,Aff)%>%
  summarise(Mass=sum(Maengde),Visit=sum(Visitors),Pers=sum(Person))%>%
  group_by(Year,Aff)%>%
  summarise(wgr2=(Mass/Pers)*1000)%>%spread(Year, wgr2, fill=0)%>%View()
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#Data for visit per month for Central Zealand and Silkeborf

visit_v1 <- read_excel("H:/Paper and Article/Paper_HRC/data_all/visit_v1.xlsx")

#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#Set order of months
month=c("Jan","Feb","Mar","Apr","Maj",
  "Jun","Jul","Aug","Sep","Okt","Nov","Dec")
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#Graph of variation according to months
visit_v1%>%
  group_by(Year,Months,Affaldsselskab,Genbrugspladser)%>%
  summarise(mass=sum(Visit))%>%
  group_by(Months,Affaldsselskab,Genbrugspladser)%>%
  summarise(tot1=mean(mass))%>%
  group_by(Affaldsselskab,Genbrugspladser)%>%summarise(tot2=mean(tot1))%>%
  right_join(visit_v1%>%
     group_by(Year,Months,Affaldsselskab,Genbrugspladser)%>%
     summarise(mass=sum(Visit))%>%#head()
     group_by(Months,Affaldsselskab,Genbrugspladser)%>%
     summarise(tot1=mean(mass)))%>%
  mutate(ratio1=tot1/tot2)%>%
  mutate(ratio2= ifelse(ratio1>1, ((ratio1-1)*100),(-1*(1-ratio1)*100)))%>%
  ggplot(aes(factor(Months,levels = month),ratio2, colour=Genbrugspladser))+
  geom_line(aes(group=Genbrugspladser, colour=Genbrugspladser),size=1.2)+geom_point()+
  facet_wrap(~Affaldsselskab, scales = "free")+
  geom_hline(yintercept = 0, colour="red")

#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
##Mean ratio for individual fractions
wrc2018_v8%>%
  group_by(Year,Months,Affaldsselskab,FraktionTWF2)%>%
  summarise(mass=sum(Maengde))%>%
  group_by(Months,Affaldsselskab,FraktionTWF2)%>%
  summarise(tot1=mean(mass))%>%
  group_by(Affaldsselskab,FraktionTWF2)%>%summarise(tot2=mean(tot1))%>%
  right_join(wrc2018_v8%>%
     group_by(Year,Months,Affaldsselskab,FraktionTWF2)%>%
     summarise(mass=sum(Maengde))%>%#head()
     group_by(Months,Affaldsselskab,FraktionTWF2)%>%
     summarise(tot1=mean(mass)))%>%
  mutate(ratio1=tot1/tot2)%>%
  mutate(ratio2= ifelse(ratio1>1, ((ratio1-1)*100),(-1*(1-ratio1)*100)))%>%
  ggplot(aes(Months,ratio2, colour=FraktionTWF2))+
  geom_line(aes(group=FraktionTWF2, colour=FraktionTWF2),size=1.2)+geom_point()+
  facet_wrap(~Affaldsselskab, scales = "free")+
  geom_hline(yintercept = 0, colour="red")
```

```
##Waste treatment forms
wrc2018_v8%>%
  group_by(Year,Months,Affaldsselskab,Treatment)%>%
  summarise(mass=sum(Maengde))%>%
  group_by(Months,Affaldsselskab,Treatment)%>%
  summarise(tot1=median(mass))%>%
  group_by(Affaldsselskab,Treatment)%>%summarise(tot2=median(tot1))%>%
  right_join(wrc2018_v8%>%
      group_by(Year,Months,Affaldsselskab,Treatment)%>%
      summarise(mass=sum(Maengde))%>%#head()
      group_by(Months,Affaldsselskab,Treatment)%>%
      summarise(tot1=median(mass)))%>%
  mutate(ratio1=tot1/tot2)%>%
  mutate(ratio2= ifelse(ratio1>1, ((ratio1-1)*100),(-1*(1-ratio1)*100)))%>%
  ggplot(aes(Months,ratio2, colour=Treatment))+
  geom_line(aes(group=Treatment, colour=Treatment),size=1.2)+geom_point()+
  facet_wrap(~Affaldsselskab, scales = "free")+
  geom_hline(yintercept = 0, colour="red")


##Waste fraction: Fraktioner2
wrc2018_v8%>%
  group_by(Year,Months,Affaldsselskab,Fraktioner2)%>%
  summarise(mass=sum(Maengde))%>%
  group_by(Months,Affaldsselskab,Fraktioner2)%>%
  summarise(tot1=median(mass))%>%
  group_by(Affaldsselskab,Fraktioner2)%>%summarise(tot2=median(tot1))%>%
  right_join(wrc2018_v8%>%
      group_by(Year,Months,Affaldsselskab,Fraktioner2)%>%
      summarise(mass=sum(Maengde))%>%#head()
      group_by(Months,Affaldsselskab,Fraktioner2)%>%
      summarise(tot1=median(mass)))%>%
  mutate(ratio1=tot1/tot2)%>%
  mutate(ratio2= ifelse(ratio1>1, ((ratio1-1)*100),(-1*(1-ratio1)*100)))%>%
  ggplot(aes(Months,ratio2, colour=Fraktioner2))+
  geom_line(aes(group=Fraktioner2, colour=Fraktioner2),size=1.2)+geom_point()+
  facet_wrap(~Affaldsselskab, scales = "free")+
  geom_hline(yintercept = 0, colour="red")
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#data:
library(readxl)
"%!in%" <- function(x,table) match(x,table, nomatch = 0) == 0
library(tidyverse)
library(lubridate)
library(forcats)
library(forecast)
library(ggfortify)
library(ggseas)
#+++++
visit_v1 <- read_excel("H:/Paper and Article/Paper_HRC/data_all/visit_v1.xlsx")
visit_v1=visit_v1%>% mutate(date1=ymd( paste(Year, Months, "15", sep="-")))#%>
visit_v1$Months=factor(visit_v1$Months,levels=c("Jan","Feb","Mar","Apr","Maj"
  ,"Jun","Jul","Aug","Sep","Okt","Nov","Dec"))
```

```
wrc2018_v8= read.table("H:/Paper and Article/Paper_HRC/data_all/wrc2018_v8.txt")
wrc2018_v8=wrc2018_v8%>% mutate(date1=ymd( paste(Year, Months, "15", sep="-")))
wrc2018_v8$Months=factor(wrc2018_v8$Months,levels=c("Jan","Feb","Mar","Apr","Maj"
 ,"Jun","Jul","Aug","Sep","Okt","Nov","Dec"))

#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

visit_v1%>%group_by(Year,Affaldsselskab,Kommune)%>%
 summarise(Visit=sum(Visit))%>%head()
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#Combine waste data and number of visitors
waste_visit=
 wrc2018_v8%>%
 mutate(date1=ymd( paste0(Year, Months, "15", sep="-")))%>%#transform to date
 group_by(Year,Months,date1,Affaldsselskab)%>%
 summarise(Total=sum(Maengde))%>%
 left_join(#combine two tables
  wrc2018_v8%>%#head()
   mutate(date1=ymd( paste0(Year, Months, "15", sep="-")))%>%#transform to date
   group_by(Year,Months,date1, Affaldsselskab,Fraktioner2)%>%
   summarise(tot=sum(Maengde)))%>%
 left_join(#combine two tables
  visit_v1%>%
   mutate(Affaldsselskab=fct_recode(Affaldsselskab,
    "Roskilde"="Central Zealand"))%>%#rename a row
   mutate(date1=ymd( paste0(Year, Months, "15", sep="-")))%>%
   mutate(Year=as.double(Year),Months=as.factor(Months))%>%
   group_by(Year,Months,date1,Affaldsselskab)%>%
   summarise(Visit=sum(Visit)))%>%
 filter(Affaldsselskab%!in% c("Copenhagen","Djursland"),
  Year%!in% c("2010","2011","2018"))%>%
 spread(Fraktioner2,tot,fill = 0)
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

##Table 2: Waste generation rates


#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
time_wrc=
 wrc2018_v8%>%#head()
 group_by(date1,Affaldsselskab)%>%
 summarise(tot=sum(Maengde)/1000)%>%
 select(date1,tot,Affaldsselskab)%>%
 spread(Affaldsselskab,tot)
waste_visit%>%head()
wrc_2=ts(waste_visit[,-c(1:4,6)],start=c(2010,1),frequency=12)
wrc_2%>%head()
#+
#Ccf between total mass and other parameters

#Visitors and other
par(mfrow=c(2,4))
```

```
for (i in 1:8){
  (ccf(wrc_2[,i],wrc_2[,1],type = c("correlation")))
}

#Total and other
par(mfrow=c(2,4))
for (i in 2:9){
  (ccf(wrc_2[,1],wrc_2[,i],type = c("correlation")))
}



#
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#Group data number of visitors and mass per waste frations
Visit_v2=
  visit_v1%>%
  mutate(Year=as.integer(Year))%>%
  mutate(Months=as.factor(Months))%>%
  mutate(Affaldsselskab=as.factor(Affaldsselskab))%>%
  mutate(Kommune =as.factor(Kommune))%>%
  select(-c(Type))

wrc2018_TWF2=#from 2012-2017, for Silkeborg and Roskilde
  wrc2018_v8%>%
  mutate(Affaldsselskab=fct_recode(Affaldsselskab,
    "Central Zealand"="Roskilde"))%>%
  group_by(Year,Months,date1,Genbrugspladser,Kommune,Affaldsselskab,FraktionTWF2)%>%
  summarise(Maengde=sum(Maengde))%>%
  spread(FraktionTWF2,Maengde,fill = 0)%>%
  left_join(Visit_v2)%>%
  filter(Year%!in% c("2010","2011","2018"),
    Affaldsselskab%!in% c("Copenhagen","Djursland"),
    Genbrugspladser%!in% c("Ubby","Sejeroe")) %>%
  gather(Waste,Mass,Bulky:Wood)%>%
  group_by(date1,Affaldsselskab,Waste)%>%
  summarise(Visit=sum(Visit),Mass=sum(Mass))

#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
wrc2018_TWF2%>%head()


#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
library(broom)
wrc2018_TWF2_v1=
  wrc2018_TWF2%>%
  gather(Type,Mass_visit,Visit:Mass)%>%
  group_by(date1,Affaldsselskab,Type)%>%
  summarise(Mass_visit=sum(Mass_visit))%>%
  spread(Type,Mass_visit,fill = 0)
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
cor(wrc2018_TWF2_v1[wrc2018_TWF2_v1$Affaldsselskab=="Silkeborg",
```

```
  5:16])
cor(wrc2018_TWF2_v1[wrc2018_TWF2_v1$Affaldsselskab=="Central Zealand",
  5:16])
#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
wrc2018_TWF2_v1%>%head()
wrc2018_TWF2%>%head()
library(tidyquant)
#Graphs
wrc2018_TWF2%>%
  gather(Type,Mass_visit,Bulky:Visit)%>%
  group_by(Year,Months,date1,Affaldsselskab,Type)%>%
  summarise(Mass_visit=sum(Mass_visit))%>%head()
ggplot(aes(x=date1, y=Mass_visit,color=Affaldsselskab))+
  geom_point(alpha = 0.5) +
  facet_wrap(~ Type, ncol = 3, scale = "free_y") +
  scale_color_tq() +
  theme_tq() +
  theme(legend.position="none")
#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
##Correlation for all
library(corrr)
test1=wrc2018_TWF2%>%
  gather(Type,Mass_visit,Bulky:Visit)%>%
  group_by(Year,Months,date1,Affaldsselskab,Type)%>%
  summarise(Mass_visit=sum(Mass_visit))%>%
  spread(key = Type, value = Mass_visit)%>%
  select(-c(Year,Months,date1,Affaldsselskab))

tidyverse_static_correlations=
  test1[,-c(1:5)]%>%correlate()
gg_all <- tidyverse_static_correlations %>%
  network_plot(colours = c(palette_light()[[2]], "white", palette_light()[[4]]), legend = TRUE) +
  labs(
    title = "Correlations of tidyverse Package Downloads to Total CRAN Downloads",
    subtitle = "Looking at January through June, tidyquant is a clear outlier"
  ) +
  expand_limits(x = c(-0.75, 0.25), y = c(-0.4, 0.4)) +
  theme_tq() +
  theme(legend.position = "bottom")
gg_all
#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#Correlation for silkeborg
test1_Silkeborg=wrc2018_TWF2%>%
  gather(Type,Mass_visit,Bulky:Visit)%>%
  group_by(Year,Months,date1,Affaldsselskab,Type)%>%
  summarise(Mass_visit=sum(Mass_visit))%>%
  spread(key = Type, value = Mass_visit)%>%
  filter(Affaldsselskab%in% "Silkeborg")

tidyverse_static_correlations_Silkeborg=
  test1_Silkeborg[,-c(1:5)]%>%correlate()
gg_Silkeborg <- tidyverse_static_correlations_Silkeborg %>%
  network_plot(colours = c(palette_light()[[2]], "white", palette_light()[[4]]), legend = TRUE) +
  labs(
```

```
    title = "Correlations of tidyverse Package Downloads to Total CRAN Downloads",
    subtitle = "Looking at January through June, tidyquant is a clear outlier"
  ) +
  expand_limits(x = c(-0.75, 0.25), y = c(-0.4, 0.4)) +
  theme_tq() +
  theme(legend.position = "bottom")
gg_Silkeborg

#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#Correlation for Central Zealand
test1_Central_Zealand=wrc2018_TWF2%>%
  gather(Type,Mass_visit,Bulky:Visit)%>%
  group_by(Year,Months,date1,Affaldsselskab,Type)%>%
  summarise(Mass_visit=sum(Mass_visit))%>%
  spread(key = Type, value = Mass_visit)%>%
  filter(Affaldsselskab%in% "Central Zealand")

tidyverse_static_correlations_Central_Zealand=
  test1_Central_Zealand[,-c(1:5)]%>%correlate()
gg_Central_Zealand <- tidyverse_static_correlations_Central_Zealand %>%
  network_plot(colours = c(palette_light()[[2]], "white", palette_light()[[4]]), legend = TRUE) +
  labs(
    title = "Correlations of tidyverse Package Downloads to Total CRAN Downloads",
    subtitle = "Looking at January through June, tidyquant is a clear outlier"
  ) +
  expand_limits(x = c(-0.75, 0.25), y = c(-0.4, 0.4)) +
  theme_tq() +
  theme(legend.position = "bottom")
gg_Central_Zealand
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#data:
library(readxl)
visit_v1 <- read_excel("H:/Paper and Article/Paper_HRC/data_all/visit_v1.xlsx")
wrc2018_v8= read.table("H:/Paper and Article/Paper_HRC/data_all/wrc2018_v8.txt")

#Group data number of visitors and mass per waste frations

Visit_all=
  visit_v1%>%head()
mutate(Year=as.integer(Year))%>%
  mutate(Months=as.factor(Months))%>%
  mutate(Affaldsselskab=as.factor(Affaldsselskab))%>%
  mutate(Kommune =as.factor(Kommune))%>%
  select(-c(Type))%>%
  group_by(Year,Months,Affaldsselskab)%>%
  summarise(Visit=sum(Visit))%>%
  filter(Year%!in% c("2017","2018"))

Visit_all%>%View()
#ONly waste for Silkebord and Roskilde from 2012 to 2016
```

```
Waste_all=
  wrc2018_v8%>%
  filter(Affaldsselskab%in% c("Silkeborg","Roskilde"))%>%
  mutate(Affaldsselskab=fct_recode(Affaldsselskab,
    "Central Zealand"="Roskilde"))%>%
  filter(Genbrugspladser%!in% c("Ubby","Sejeroe"),
    Year%!in% c("2010","2011","2018"))%>%
  group_by(Year,Months,date1,Affaldsselskab,FraktionTWF2)%>%
  summarise(Maengde=sum(Maengde))

#Combine visit and waste for Roskilde and Silkeborg
Waste_all1=
  Waste_all%>%
  # Data wrangling
  spread(key = FraktionTWF2, value = Maengde) %>%
  left_join(Visit_all, by =c("Year","Months","Affaldsselskab")) %>%
  mutate(Wood = replace(Wood,is.na(Wood),0))%>%
  arrange(date1)%>%
  head()
head(Waste_all1)
tidyverse_static_correlations_all <- Waste_all1[,-c(1:4)]%>%
  # Correlation and formating
  correlate()
#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
tidyverse_static_correlations_all
#
Waste_all1[-c(1:2)]%>%
  gather(Waste,Mass,Bulky:Wood)%>%
  filter(Affaldsselskab%in% "Silkeborg")%>%
  select(date1,Waste,Mass,Visit)%>%head()

tidyverse_rolling_corr_waste <- Waste_all1[-c(1:2)]%>%
  gather(Waste,Mass,Bulky:Wood)%>%
  filter(Affaldsselskab%in% "Silkeborg")%>%
  select(date1,Waste,Mass,Visit) %>%
  mutate(date1=as.Date(date1))%>%
  # Mutation
  tq_mutate_xy(
    x          = Mass,
    y          = Visit,
    mutate_fun = runCor,
    # runCor args
    n          = 48,
    use        = "pairwise.complete.obs",
    # tq_mutate args
    col_rename = "rolling_corr"
  )
tidyverse_rolling_corr_waste%>%View()
#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
# Join static correlations with rolling correlations
tidyverse_static_correlations_all <- tidyverse_static_correlations_all %>%
  select(rowname, Visit) %>%
  rename(Waste = rowname)
```

```
tidyverse_rolling_corr_waste <- tidyverse_rolling_corr_waste %>%
  left_join(tidyverse_static_correlations_all, by = "Waste") %>%
  rename(static_corr_visit = Visit.y)

# Plot
tidyverse_rolling_corr_waste %>%
  ggplot(aes(x = date1, color = Waste)) +
  # Data
  geom_line(aes(y = static_corr_visit), color = "red") +
  geom_point(aes(y = rolling_corr), alpha = 0.5) +
  facet_wrap(~ Waste, ncol = 3, scales = "free_y") +
  # Aesthetics
  scale_color_tq() +
  labs(
    title = "tidyverse: 30-Day Rolling Download Correlations, Package vs Total CRAN",
    subtitle = "Relationships are dynamic vs static correlation (red line)",
    x = "", y = "Correlation"
  ) +
  theme_tq() +
  theme(legend.position="none")


##SM FIGURE
#Inspired from Figure 6: Geometric bar plot exploring the relative changes in treatment
#forms in Copenhagen, Roskilde, Silkeborg and Djursland from 2010 to 2016
yearcol=c("#d11141","#00b159", "#00aedb","#f37735","#ffc425","#cccccc","#8c8c8c")
library(compositions)
library(robCompositions)
geometric_treat=
  wrc2018_v8%>%
  mutate(Affaldsselskab=fct_recode(Affaldsselskab,
    "Central Zealand"="Roskilde"))%>%
  group_by(Months,Affaldsselskab,Treatment)%>%#head()
  summarise(Tot=sum(Maengde)/1000)%>%#View()
  group_by(Months,Affaldsselskab) %>%
  transmute(Treatment, per_waste=(Tot/sum(Tot)*100))%>%
  group_by(Months, Affaldsselskab,Treatment)%>%
  summarise(per_waste2=mean.acomp(per_waste))%>%#View()
  #spread(Treatment,per_waste2)%>%View()
  left_join(
    wrc2018_v8%>%
      mutate(Affaldsselskab=fct_recode(Affaldsselskab,
    "Central Zealand"="Roskilde"))%>%
      group_by(Months,Affaldsselskab,Treatment)%>%#head()
      summarise(Tot=sum(Maengde)/1000)%>%
      group_by(Months,Affaldsselskab) %>%
      transmute(Treatment, per_waste=(Tot/sum(Tot)*100))%>%
      group_by(Affaldsselskab,Treatment)%>%
      summarise(per_waste3=mean.acomp(per_waste)))%>%
  mutate(ratio=log(per_waste2/per_waste3))%>%
  mutate(tto=exp(ratio))%>%#head()
  mutate(procent=ifelse(tto>1,round((tto-1)*100,0),
    -round((1-tto)*100,0)))%>%#View()
```

```
  ggplot(aes(x=factor(Treatment,levels = c("Recycling","Incineration","Other")),
    y=ratio,fill=factor(Months)))+
  geom_bar(position="dodge", stat="identity")+
  geom_text(aes(x=factor(Treatment,levels = c("Recycling","Incineration","Other")),
    y=ratio,ymax=ratio,
    label = procent,procent=procent+.05,
    #hjust=ifelse(sign(procent)>0, 1, 0)
    vjust=0),
    colour="black",position =position_dodge(width=0.85))+
  labs(colour="År")+ylab("Ratio")+xlab("Waste fraction")+
  facet_wrap(~ factor(Affaldsselskab,levels = selk))+#scales = "free"
  theme_bw()+
  theme(legend.text=element_text(size=12))+
  theme(legend.position="top")+
  scale_fill_manual("Months", values = yearcol)+
  guides(title="Months", fill = guide_legend(nrow = 1))+
  ylab("Ratio")+xlab("Affaldsfraktioner")+
  theme(text =  element_text(colour = "black", face = "bold", size = 14))+
  theme(axis.text = element_text( color = "black", size = 12))+
  theme(legend.text=element_text(size=12))+
  ylab("Log-ratio")+
  xlab("Waste fractions")
ggsave("geometric_treat.wmf",width = 20, height = 20, units = "cm")

#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
seascomp=
  wrc2018_v8%>%
  group_by(Year,Months,Affaldsselskab,Kommune,Genbrugspladser,FraktionTWF2)%>%
  summarise(tot=sum(Maengde))%>%
  spread(FraktionTWF2,tot)

library(writexl)
write_xlsx(seascomp, "H:/Paper and Article/Paper_HRC/Results/2018-05-Results/seascomp.xlsx")

seascomp_djur=seascomp%>%filter(Affaldsselskab%in%"Djursland" )
anova(lm(ilr((seascomp_djur[,5:15]))~Months, data=seascomp_djur))


seascomp%>%head()
#++++++++++++
library(compositions)
fitt= lm(ilr((seascomp[,5:15]))~Months, data=seascomp)
anova(lm(ilr((seascomp[,5:15]))~Months, data=seascomp))
anova(lm(ilr((seascomp[seascomp$Affaldsselskab=="Djursland",5:15]))~Months,
        data=seascomp))


###########################################################################
##SM
library(readxl)
Table2_4 <- read_excel("H:/Paper and Article/Paper_HRC/Results/2018-05-Results/table2_4.xlsx")

library(tidyverse)
library(caret)
```

```
library(corrplot)
library(corrr)
library(broom)
#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

SMTable2=
  Table2_4%>%
  mutate(Visi_house=Visitors/Household,Visi_pers=Visitors/Person)%>%
  select(Year,Affaldsselskab,Kommune,Visi_house,Visi_pers)%>%
  gather(Vaa, vaaa, c(Visi_house,Visi_pers))%>%spread(Year,vaaa)%>%
  mutate(Affaldsselskab=factor(Affaldsselskab,
  levels = c("Greater Copenhagen","Central Zealand","Djursland","Silkeborg")))%>%
  mutate(Kommune=factor(Kommune,levels = c("Frederiksberg","Dragoer","Hvidovre",
  "Koebenhavn","Taarnby","Koege","Kalundborg","Lejre",
  "Stevns","Roskilde","Syddjurs","Norddjurs","Silkeborg")))%>%
  arrange(Affaldsselskab,Kommune)%>%replace(., is.na(.), "-")%>%
  mutate_if(is.numeric, funs(round(., 2)))
SMTable2%>%View()

#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
##Population split into single and multi family
DK_all <- read_excel("H:/Paper and Article/Paper_HRC/data_all/DK_all.xlsx",
sheet = "Sheet1")



DK_2010_2017=
  DK_all%>%
  mutate(Kommune=str_replace_all(Kommune,
    c("æ"="ae","å"="aa","ø"="oe","Å"="Aa","Ø"="Oe","Æ"="Ae")))%>%#change danish
  #letters to english
  mutate(Pers=fct_recode(Pers,
    "7 personer"="7 personer og derover"))%>%#recode and change some rows
  separate(Pers, c("Numb_pers","Just_pers"),
    sep = " ", remove = FALSE, convert = FALSE)%>%#separate a column
  mutate(Numb_pers=as.double(Numb_pers))%>%
  mutate(housing_type=ifelse(Housing%in% c("Etageboliger"),"MF","SF"))%>%
  select(-House,-Person,-Just_pers)%>%
  gather(Year,Tot,`2010`:`2017`)%>%
  mutate(Number_pers=Numb_pers*Tot)%>%
  group_by(Kommune,housing_type,Year)%>%
  summarise(Household=sum(Tot),Person=sum(Number_pers))%>%
  gather(Hus_pers,antal,Household:Person)%>%
  unite(Housing,housing_type,Hus_pers,sep = "_")%>%
  spread(Housing,antal)
SMTable3=
  DK_2010_2017%>%
  mutate(Household=MF_Household+SF_Household)%>%
  mutate(Person=MF_Person+SF_Person)%>%
  mutate(House_pers=Person/Household,
        House_pers_SF=SF_Person/SF_Household,
        House_pers_MF=MF_Person/MF_Household)%>%
  select(Year,Kommune,House_pers,House_pers_SF,House_pers_MF)%>%
  gather(Vaa, vaaa, c(House_pers,House_pers_SF,House_pers_MF))%>%
  spread(Year,vaaa)%>%
```

```
  filter(Kommune%in%c("Frederiksberg","Dragoer","Hvidovre",
  "Koebenhavn","Taarnby","Koege","Kalundborg","Lejre",
  "Stevns","Roskilde","Syddjurs","Norddjurs","Silkeborg"))%>%
  ungroup()%>%
  mutate(Kommune=factor(Kommune,levels = c("Frederiksberg","Dragoer","Hvidovre",
  "Koebenhavn","Taarnby","Koege","Kalundborg","Lejre",
  "Stevns","Roskilde","Syddjurs","Norddjurs","Silkeborg")))%>%
  arrange(Kommune)%>%
  #replace(., is.na(.), "-")%>%
  mutate_if(is.numeric, funs(round(., 2)))
SMTable3%>%View()


#+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
wrc2018_v8= read.table("H:/Paper and Article/Paper_HRC/data_all/wrc2018_v8.txt")
wrc2018_v8=wrc2018_v8%>%
  mutate(date1=ymd( paste(Year, Months, "15", sep="-")))%>%
  mutate(Kommune=fct_recode(Kommune,
    "Koebenhavn"="Copenhagen"))#%
#create a new column of type date
wrc2018_v8$Months=factor(wrc2018_v8$Months,levels=c("Jan","Feb","Mar","Apr","Maj"
  ,"Jun","Jul","Aug","Sep","Okt","Nov","Dec"))
#Arrange the order of months
month=c("Jan","Feb","Mar","Apr","Maj",
  "Jun","Jul","Aug","Sep","Okt","Nov","Dec")


##Order of municipalities
muni=c("Frederiksberg","Dragoer","Hvidovre",
  "Koebenhavn","Taarnby","Koege","Kalundborg","Lejre",
  "Stevns","Roskilde","Syddjurs","Norddjurs","Silkeborg")


#SM Table 11

SMTable11=
  wrc2018_v8%>%
  mutate(Affaldsselskab=fct_recode(Affaldsselskab,
    "Central Zealand"="Roskilde"))%>%
  group_by(Year,Affaldsselskab,Kommune,Genbrugspladser,FraktionTWF2)%>%
  summarise(tot=sum(Maengde))%>%
  group_by(Year,Affaldsselskab,Kommune,Genbrugspladser)%>%
  transmute(FraktionTWF2, per_waste=(tot/sum(tot)*100))%>%
  spread(Year,per_waste)%>%
  mutate(FraktionTWF2=factor(FraktionTWF2,
  levels =c("Fibres","Plastic","Metal","Wood","Glass",
  "Garden", "Soil", "C&D","SMC","Bulky", "OW")))%>%
  ungroup()%>%
  mutate(Affaldsselskab=factor(Affaldsselskab,
  levels =c("Greater Copenhagen","Central Zealand","Djursland","Silkeborg")))%>%
  mutate(Kommune=factor(Kommune,
  levels =c("Frederiksberg","Dragoer","Hvidovre",
  "Koebenhavn","Taarnby","Koege","Kalundborg","Lejre",
  "Stevns","Roskilde","Syddjurs","Norddjurs","Silkeborg")))%>%
```

```
  arrange(Affaldsselskab,Kommune,FraktionTWF2)%>%
  mutate_if(is.numeric, funs(round(., 2)))
SMTable11%>%View()
#Export Table 3
library(writexl)
write_xlsx(SMTable11, "H:/Paper and Article/Paper_HRC/Results/2018-05-Results/SMTable11.xlsx")
#SM Table 11



##
Table2_4%>%
  select( Visitors, area_km2,Household, Person, MF_Household, MF_Person, SF_Household, SF_Person)%>%
  correlate() %>% focus(Visitors)
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Table2_4%>%
  group_by(Affaldsselskab)%>%
  #select( Visitors, area_km2,Household, Person, MF_Household, MF_Person, SF_Household, SF_Person)%>%
  do(tidy(cor(.$Visitors,.$Household)))


.$Person,
        .$MF_Household,.$MF_Person,.$SF_Household,.$SF_Person
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
regressions <- Table2_4 %>% group_by(Affaldsselskab) %>%
   do(fit = lm(Visitors~area_km2+Household+Person+ MF_Household+MF_Person+ SF_Household+ SF_Person, .))
regressions
regressions %>% tidy(fit)%>%View()
regressions %>% glance(fit)


#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
regressions1 <- Table2_4 %>% group_by(Affaldsselskab) %>%
   do(fit1 = lm(log(Visitors)~area_km2+log(Household)+log(Person)+ log(MF_Household)+log(MF_Person)+
              log(SF_Household)+ log(SF_Person), .))
regressions1
regressions1 %>% tidy(fit1)%>%View()
regressions %>% glance(fit)



#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
regressions2 <- Table2_4 %>% group_by(Year) %>%
   do(fit2 = lm(log(Visitors)~area_km2+log(Household)+log(Person)+ log(MF_Household)+log(MF_Person)+
              log(SF_Household)+ log(SF_Person), .))
regressions2
regressions2 %>% tidy(fit2)%>%View()
regressions2 %>% glance(fit2)

#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
regressions3 <- Table2_4 %>%
   do(fit3 = lm(log(Visitors)~area_km2+log(Household)+log(Person)+ log(MF_Household)+log(MF_Person)+
              log(SF_Household)+ log(SF_Person), .))
regressions3
```

```
regressions3 %>% tidy(fit3)%>%View()
regressions3 %>% glance(fit3)


Table2_4%>%
  select( Visitors, area_km2,Household, Person, MF_Household, MF_Person, SF_Household, SF_Person)%>%
  na.omit()%>%cor.test()-> M
corrplot(M, method="circle")
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
library(crosstalk)
library(GGally)
Table2_4%>%
  select(Visitors, area_km2,Household, Person, MF_Household, MF_Person, SF_Household, SF_Person)%>%
  #gather(para,tot)%>%
  ggpairs(aes(alpha=0.4))


head(Table2_4)
summary(lm(Visitors~area_km2+Household+Person+ MF_Household+MF_Person+ SF_Household+ SF_Person,
        data=Table2_4))

fm1=lm(Visitors~SF_Household*SF_Person, data=Table2_4)

fm2=lm(Visitors~SF_Household+SF_Person, data=Table2_4)
anova(fm2,fm1)


summary(lm(Visitors~SF_Household*SF_Person,
        data=Table2_4))
confint(lm(Visitors~SF_Household*SF_Person,
        data=Table2_4))

summary(lm(Visitors~area_km2+SF_house+MF_house+SF_pers+MF_pers,
        data=Table2_4))

summary(lm(Visitors~area_km2+SF_house+SF_pers,
        data=Table2_4))

confint(lm(Visitors~area_km2+SF_house+SF_pers,
        data=Table2_4))

summary(lm(Visitors~area_km2+MF_house+MF_pers,
        data=Table2_4))

confint(lm(Visitors~area_km2+MF_house+MF_pers,
        data=Table2_4))


Table_test=Table2_4%>%
  select(Visitors,area_km2,Household, Person, MF_Household, MF_Person, SF_Household, SF_Person)%>%
  na.omit()
Table_test%>%View()
#
lm1= train(Visitors~., data=Table_test, method = "lm")
```

```
rf1 <- train(Visitors~., data = Table_test, method = "rf")
class(lm1)
attributes(lm1)
lm1$finalModel
rf1$finalModel
summary(lm1$finalModel)$r.squared
lm1$results
rf1$results
fitted <- predict(lm1)

model_mars = train(Visitors~., data=Table_test, method='earth')
plot(model_mars, main="Model Accuracies with MARS")
varimp_mars <- varImp(model_mars)
plot(varimp_mars, main="Variable Importance with MARS")
#+++++++++
samp <- createDataPartition(Table_test$Visitors, p = 0.8, list = FALSE)
training <- Table_test[samp,]
testing <- Table_test[-samp,]



#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
# Set up a 10-fold cross validation
tc <- trainControl(method = "cv", number = 10)
# Include the setup in your model
lm1_cv <- train(Visitors~., data=Table_test, method = "lm",
        trControl = tc) # here
lm1_cv
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
tg <- data.frame(mtry = seq(2, 10, by =2))
rf1 <- train(Visitors~., data = Table_test, method = "rf", tuneGrid = tg)
rf1$results
#++
model_list <- list(lm = lm1, rf = rf1)
res <- resamples(model_list)
summary(res)
#
compare_models(lm1, rf1)
#++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
varImp(lm1)
plot(varImp(lm1))
```