Department of Waste Management

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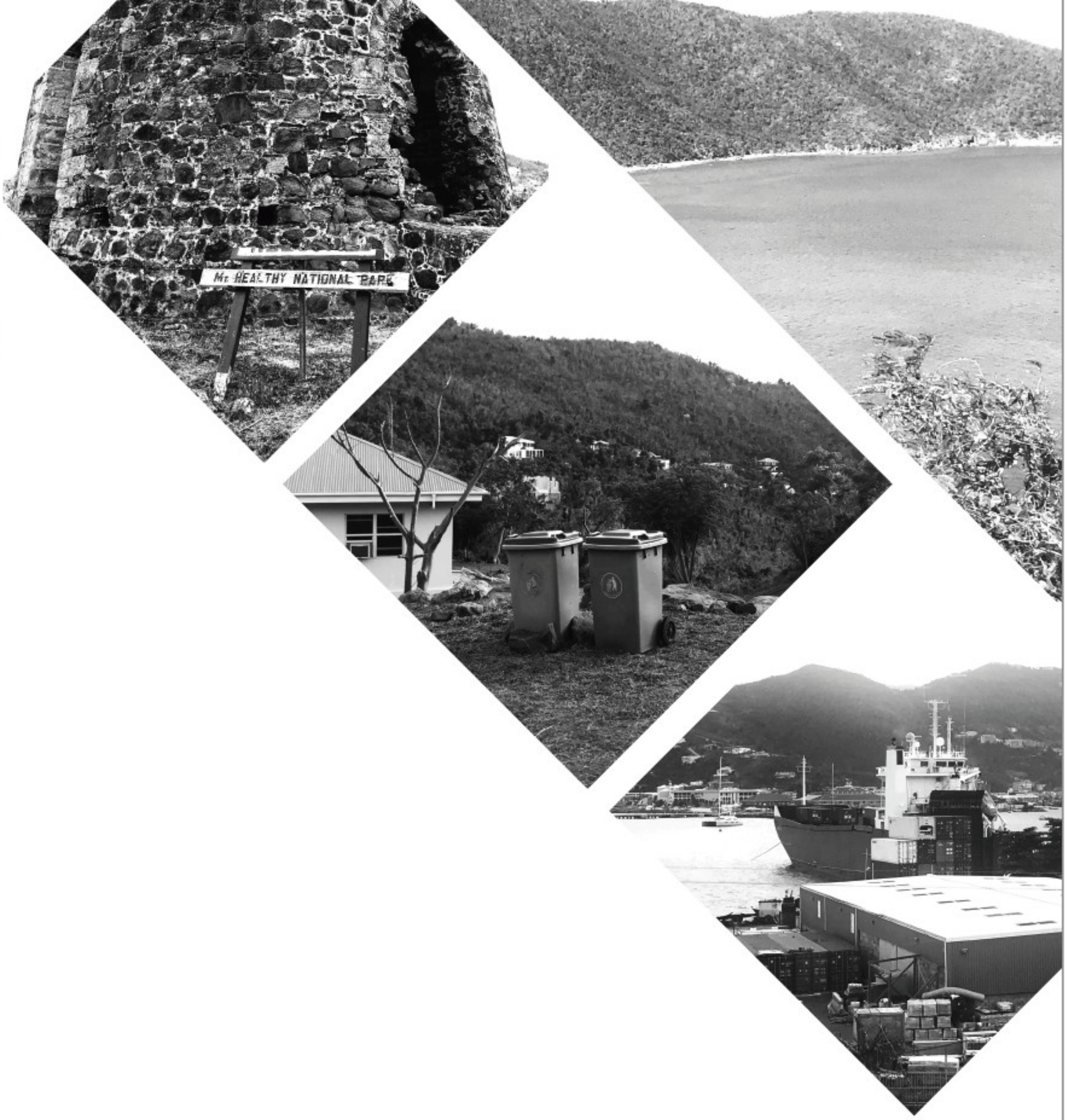

FINAL REPORT ON WASTE CHARACTERISATION

JULY 2019

Waste Management Strategy for the British Virgin Islands

RED
Agency for Resilience, Empowerment and Development

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List of Acronyms

BVIG	British Virgin Islands Government
DDM	Department of Disaster Management
DWM	Department of Waste Management
DR	District Representative
H&S	Health & Safety
IR	Inception Report
JVD	Jost Van Dyke
MCW	Ministry of Communications and Works
MHSD	Ministry of Health & Social Development
NGO	Non Governmental Organisation
TCPD	Town and Country Planning Department
PWD	Public Works Department
SWM	Solid Waste Management
USD	US Dollars
USVI	US Virgin Islands
VI	Virgin Islands
VG	Virgin Gorda

1 Introduction

1.1 Background of the Study

In the aftermath of Hurricanes Irma and Maria, The Government of the Virgin Islands is seeking to review and amend the BVI's existing Comprehensive Solid Waste Management (SWM) Strategy dated of 2013. The revision must take in consideration the impact of climate change on hurricane seasons that will bring weather which is more severe than before and that they will be more frequent hence any long term. Thus, the SWM Strategy must include aspect of Disaster Risk Reduction and emergency preparedness in terms of debris management but also aspects related to good waste management practices in order to ensure the sustainability of the environment and their health and wellbeing.

1.2 Subject of the present report

The present report covers two one-week waste characterisations, done in February and June 2019, on the islands of Tortola, Jost Van Dyke, Virgin Gorda and Anegada.

1.3 Objective of the Waste Characterisation

Waste characterisation allows us to know better the nature of waste generated in the British Virgin Islands and to establish a reference database both for policy making and for technical design of solid waste management infrastructures.

The table below summarises the different objectives of waste characterisation:

Table 1: Objectives of waste characterisation

Purpose	Use of waste characterisation results
Planning	Quantification of different waste streams
	Identification of waste collection and management approaches best suited for the waste generated in a specific location
	Identification of priority waste streams according to quantity, hazardousness, recyclability etc. criteria
Technical design	Calculation of capacities required for infrastructure and equipment to treat the different waste streams
	Determination of technical parameters for design and construction of infrastructures and equipment
Evaluation	Assessment of trends in waste generation (in comparison with previous waste characterisation studies)
	Evaluation of the success of waste policies aiming at a change in waste generation (reduction of certain waste streams, separate collection etc.)

2 METHODOLOGY

2.1 ORGANISATION AND IMPLEMENTATION OF THE WASTE CHARACTERISATION

Two waste characterisation campaigns have been implemented from 08th – 18th February 2019 and from 17th - 24th June 2019, covering waste from the islands of Tortola, Jost Van Dyke, Virgin Gorda and Anegada. The first waste characterisation campaign represents the touristic season, the second one the low season between May and October 2019. The Department of Waste Management facilitated the waste characterisation study by making available a team of 10 waste workers, who took turns at contributing to the analysis. Moreover, the NGO GreenVI as well as a student volunteer participated to the analysis of some samples. During the second campaign, less workers and no volunteers participated, the consequence of which being a smaller sample size.

For each sample, the mission team carried out at first a granulometric analysis for the purpose of getting data necessary for the evaluation of mechanical separation options. This is especially important for mixed household waste, since it is not realistic to assume that separate collection at the source would reach the required performance at short term[1], even if introduced in the British Virgin Islands by the Department of Waste Management. Sieving was done manually by wooden sieves with wire mesh. Since it was not possible to obtain sieves with the standard mesh openings of 20 mm respectively 80 mm, available mesh sizes of 2” x 4 “ and 1“[2] were chosen. The photo below shows the sieves used for granulometric analysis.

1 This assumption is based on European experiences. Even in countries where separate collection is operational since over 20 years, like Belgium or Germany, the performance is often still deficient. A recent study in Germany shows that there are still 40 – 60 % of « wrong throws » for plastic waste (source : http://www.zeit.de/wirtschaft/2018-04/muelltrennung-deutschland-verpackungsmuell-gelber-sack)

Figure 1: 1"² sieve (front) and 2" x 4" sieve (back)

Subsequently to the sieving analysis, the Consultant carried out a sorting analysis, separating the gross fraction (Wastes remaining above the 2” x 4” sieve) and the medium fraction (wastes between 1 “² and 2” x 4”) in different fractions and sub-fractions. The sorting analysis aimed at identifying the proportional weight of each waste stream, in view of quantifying the overall waste streams that might be recycled, recovered by biological treatment, that might need to be collected separately or might need to be subject to preventive measures.

The following table gives an overview over the samples taken per stratum and day. The following strata were covered:

Table 2: Sampling strata

Stratum	Samples
Residential waste	Tortola, collection zones 1 - 6
Mixed residential and commercial (restaurant) waste	Jost Van Dyke Anegada
Commercial waste	Virgin Gorda, restaurant waste Tortola, supermarket
Separate collection (residential/ restaurant)	Virgin Gorda

Table 3: Overview over samples taken during the waste characterisation campaigns

Sample size	Unit	Tortola	Jost Van Dyke	Virgin Gorda	Anegada	BVI
1st waste characterisation	kg	1084.15	155.53	118.61	173.42	1531.71
	lb	2385.13	342.17	260.94	381.52	3369.77
2nd waste characterisation	kg	669.29	140.12	0.00	0.00	809.41
	lb	1472.44	308.26	0.00	0.00	1780.70
Total	kg	1753.44	295.65	118.61	173.42	**2341.12**
	lb	3857.57	650.44	260.94	381.52	**5150.47**

2.2 Limitations and Difficulties

The summary table shows that it was, unfortunately, not possible to achieve the sample sizes of 300 kg (660 lbs) indicated in the waste characterisation methodology (Annex 1 of the Inception Report).

The main reason for this is the composition of waste, especially on Tortola. Waste is very complex, with a high percentage of lightweight plastic sub-fractions, which slows down considerably the sorting process. The organic waste content is rather low.

The most important limitation of the waste characterisation is the size, both of the overall sample and of some single samples. Usually, the approach pursued by the Consultant is to discard any sample below 100 kg (220 lbs), since measurement errors become too important if the sample is too small. This was not possible in the present characterisation, given that 6 out of 13 samples were smaller than 100 kg in the first campaign, and one in the second campaign.

The size of the overall sample is 2.341 kg (5.150 lbs). The sample size is too small to ensure a random sampling error < 10 % for the main waste streams (see also sub-chapter 3.4. on statistical analysis). Random sampling error is between 15 – 30 % for the most important waste fractions.

Strong wind affected the granulometric analysis during several days. Especially the lightweight 2D plastic fractions were sometimes partly blown away. In consequence, the proportion these fractions are probably underestimated. In general, however, we think that the weight of the plastic fractions is overestimated, due to the high percentage of impurities in discarded food containers, plastic bags and similar packaging items.

Time constraints and unavailability of workforce reduced the scope of the second characterisation campaign. Overall sample size was smaller, and it was not possible to repeat the characterisation exercise on Virgin Gorda and Anegada.

Detailed results of the waste characterisation are given in Annex 1 (separate excel file).

3 RESULTS

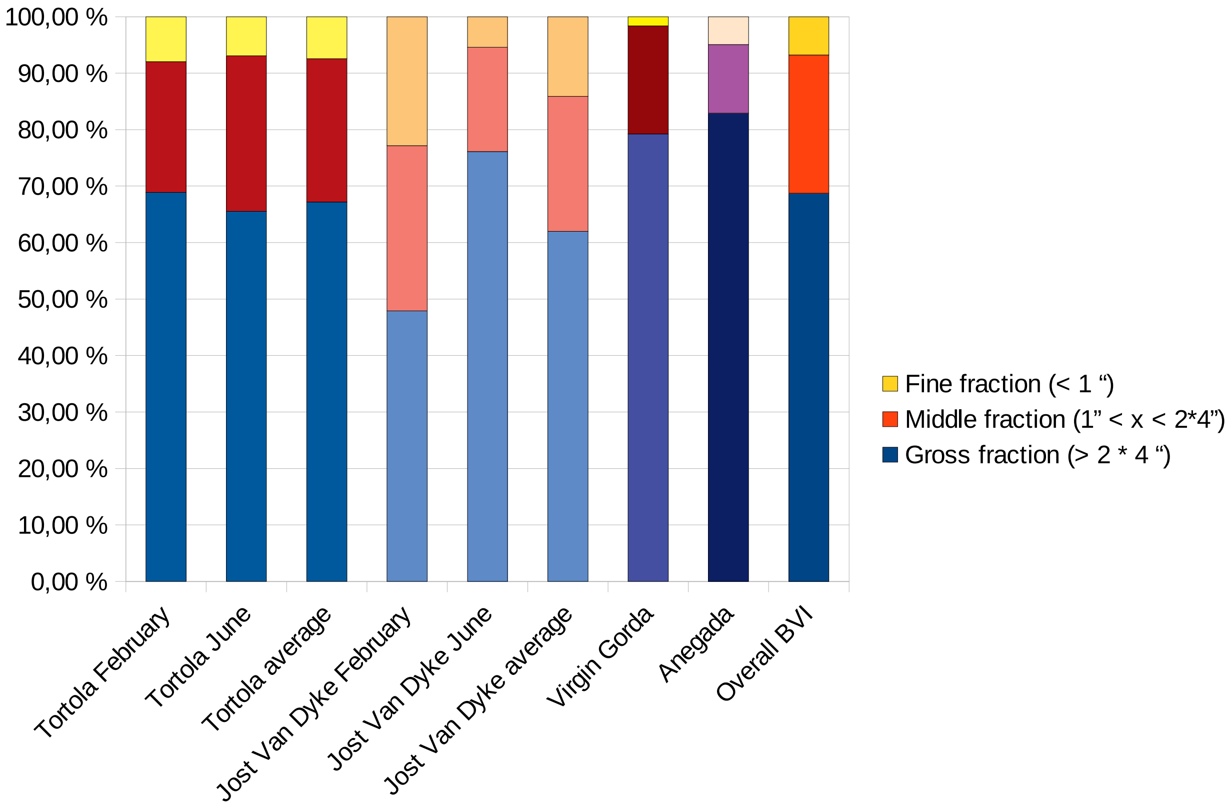
3.1 GRANULOMETRY

The distribution of the three granulometric fractions as well as their characteristics change according to the habitat stratum, i.e. the island from where waste is collected. Residential waste from Tortola has been considered a single stratum.

Table 4: Distribution of granulometric fractions on the different islands

	Tortola February	Tortola June	Tortola average	Jost Van Dyke February	Jost Van Dyke June	Jost Van Dyke average	Virgin Gorda	Anegada	Overall BVI
Gross fraction (> 2 * 4 “)	68.89	65.54	67.22	47.91	76.13	62.02	79.26	82.92	68.78
Middle fraction (1” < x < 2*4”)	23.17	27.55	25.36	29.27	18.47	23.87	19.10	12.16	24.45
Fine fraction (< 1 “)	7.94	6.92	7.43	22.82	5.40	14.11	1.65	4.93	6.78

Figure 2: Granulometric distribution of waste in the British Virgin Islands



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The table and the figure show that the gross fraction is by far the most important fraction in BVI waste, whereas the fine fraction, which consists generally mostly of organic waste, is often negligibly small. The Jost van Dyke island seems to be an exception, having a considerably more important fine fraction during the February campaign. However, visual observations showed that the fine fraction from Jost Van Dyke is not mostly organic, as it is in the purely residential areas, but that it contains large amounts of crushed bottles, since waste is collected in compactor bins at the island's transfer station. The proportion of crushed bottles was significantly lower during the June campaign, which may be explained with a lesser amount of tourists during the latter campaign.

However, in overall Tortola, Anegada and separately collected waste from Virgin Gorda, the gross fraction constitutes over 70 % of the overall waste. This is the fraction expected to contain most of the recyclable material. In the Tortola supermarket waste, no medium or fine fraction was observed.

3.2 Granulometry

Both the gross fraction (> 2" x 4") and the medium fraction (1 "² < X < 2" x 4") were subject to sorting analysis. The objective of the sorting analysis was

a) to determine the overall amount of recyclable and compostable sub-fractions

b) to assess in how far an efficient separation of recyclable and compostable material is ensured by sieving. The general assumption is that recyclable waste as well as non recyclable non biodegradable material remains above the sieve due to the bigger size of the items, and biodegradable waste falls through.

3.2.1 Overall waste composition

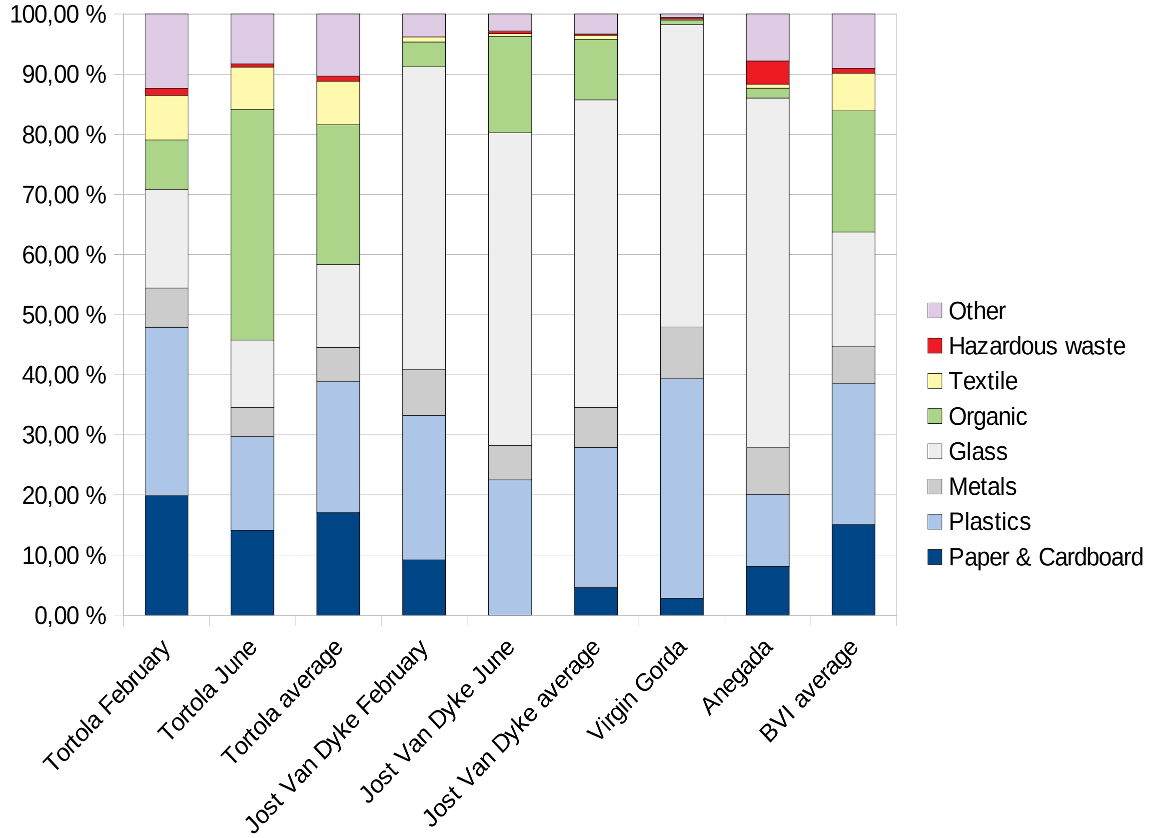
The tables and the graphic below show the overall waste composition for the residential, commercial and mixed waste samples in the British Virgin Islands. The presence of bulky waste being very haphazard given the size of samples, the proportional weight of waste (sub-) fractions has been calculated without bulk waste. Medium sized bulk waste is often delivered together with residential/ commercial waste; large size bulk waste should be delivered separately, even if many citizens do not yet comply with this requirement.

In the figures, **recyclable** waste is indicated in **fat blue**, **biodegradable** waste in **fat green** letters. Paper and cardboard are both recyclable and biodegradable; the preferred recovery option depends on the cleanness of these materials. Paper and cardboard in the fine and medium fraction has been considered under organic/ biodegradable, since it is generally torn, soiled with wet waste and no more good for recycling.

Table 5: Summary of waste composition in the British Virgin Islands

	Tortola February	Tortola June	Tortola average	Jost Van Dyke February	Jost Van Dyke June	Jost Van Dyke average	Virgin Gorda	Anegada	BVI average
Paper & Cardboard	**19.96**	**21.67**	**20.81**	**9.19**	**.97**	**5.08**	**2.81**	**8.06**	**18.34**
Plastics	**27.95**	**21.20**	**24.58**	**24.08**	**23.89**	**23.98**	**36.56**	**12.07**	**25.89**
Metals	**6.52**	**5.86**	**6.19**	**7.59**	**6.10**	**6.85**	**8.61**	**7.81**	**6.51**
Glass	**16.42**	**16.71**	**16.57**	**50.35**	**63.49**	**56.92**	**50.32**	**58.10**	**21.50**
Organic	**8.21**	**14.69**	**11.45**	**4.13**	**2.80**	**3.47**	**0.67**	**1.64**	**9.96**
Textile	7.41	9.85	8.63	.84	.56	.70	0.19	0.66	7.44
Hazardous waste	1.18	.29	.74	.00	.58	.29	0.28	3.88	0.71
Other	12.36	9.72	11.04	3.82	1.60	2.71	0.56	7.78	9.65

Figure 3: Summary of BVI waste composition



The detailed waste composition is given in the following table.

Table 6: Waste composition per stratum - without bulky waste

Fractions	Sub-fractions	Tortola February	Tortola June	Tortola average	Jost Van Dyke February	Jost Van Dyke June	Jost Van Dyke average	Virgin Gorda	Anegada	Overall BVI
	Cardboard	**9.81**	**9.62**	**9.72**	**4.14**	**0.00**	**2.07**	**1.85**	**5.92**	**8.64**
	Paper	**4.15**	**4.49**	**4.32**	**0.26**	**0.74**	**0.50**	**0.38**	**0.76**	**3.77**
Textile		5.20	7.06	6.13	0.40	0.43	0.42	0.15	2.43	5.31
Plastic	**PET**	**7.47**	**5.47**	**6.47**	**4.08**	**5.15**	**4.61**	**22.50**	**2.45**	**8.35**
	HDPE film	**3.57**	**0.94**	**2.26**	**1.34**	**1.66**	**1.50**	**0.91**	**0.60**	**2.07**
	HDPE 3D	**1.89**	**1.36**	**1.62**	**1.67**	**2.80**	**2.23**	**3.74**	**1.80**	**1.88**
	PVC	**0.25**	**0.01**	**0.13**	**0.13**	**0.00**	**0.07**	**0.00**	**0.23**	**0.11**
	LDPE clear	**3.04**	**3.75**	**3.40**	**4.65**	**5.04**	**4.84**	**1.30**	**1.93**	**3.14**
	PP film	**1.02**	**0.44**	**0.73**	**0.08**	**0.39**	**0.24**	**0.22**	**0.31**	**0.66**
	PP 3D	**2.00**	**2.35**	**2.17**	**5.45**	**6.94**	**6.19**	**3.81**	**3.77**	**2.43**
	PS	1.86	1.33	1.59	0.25	0.55	0.40	0.22	0.36	1.40
	Other	0.00	0.44	0.22	0.00	0.00	0.00	0.00	0.00	0.19
Glass	**Transparent**	**4.90**	**5.44**	**5.17**	**21.95**	**33.54**	**27.75**	**18.80**	**29.76**	**7.31**
	Coloured	**7.02**	**5.75**	**6.39**	**17.13**	**18.51**	**17.82**	**28.26**	**22.28**	**9.32**
Metal	**Fe metal**	**2.71**	**3.40**	**3.05**	**2.73**	**2.82**	**2.78**	**4.01**	**3.15**	**3.17**
	Al containers	**0.93**	**0.97**	**0.95**	**1.30**	**2.21**	**1.75**	**3.07**	**1.71**	**1.22**
	Al film	**1.11**	**0.46**	**0.78**	**0.36**	**0.66**	**0.51**	**0.76**	**3.06**	**0.80**
	Copper	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.15**	**0.00**
Hazardous waste	WEEE	0.52	0.12	0.32	0.00	0.00	0.00	0.22	3.22	0.33
	Medical waste	0.07	0.01	0.04	0.00	0.00	0.00	0.00	0.05	0.03
	Chemical waste	0.31	0.27	0.29	0.00	0.44	0.22	0.00	0.00	0.25
	Batteries/ accumulators	0.00	0.13	0.06	0.00	0.00	0.00	0.00	0.00	0.05
Organic waste		**32.04**	**38.13**	**35.09**	**31.40**	**15.28**	**23.34**	**6.35**	**2.60**	**31.15**
Wood		**0.04**	**0.20**	**0.12**	**0.00**	**0.00**	**0.00**	**0.00**	**0.34**	**0.11**
Bulky waste (Tyre, furniture, toilet seat…)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Baby diaper, pads and hygienic tissue		4.33	2.74	3.53	1.45	1.11	1.28	0.15	2.98	3.09
Shoes		0.89	1.14	1.01	0.00	0.00	0.00	0.00	0.65	0.88
Ceramic and inert waste		0.08	0.01	0.05	0.00	0.00	0.00	0.00	5.79	0.10
Complex/ composite	Packaging	2.02	2.11	2.07	0.80	0.99	0.90	1.57	1.51	1.99
	Other	0.52	0.58	0.55	0.00	0.00	0.00	0.00	0.02	0.47
Other		2.28	1.29	1.78	0.43	0.73	0.58	1.71	2.15	1.77

The assessment shows that the most important waste fractions in residential areas (Tortola) are organic waste, plastics and paper. The quality of organic waste, however, is quite poor, since a significant amount of plastic and composite waste as well as broken glass is found in the medium and fine fraction. Organic waste in the medium and fine fraction consists to an important amount of soiled paper.

Plastic waste in residential areas is often soiled with organic waste, and an important amount of the non-separated plastic sub-fractions (up to 2/3) does consist of water and sticky organic waste.

Separately collected waste at Virgin Gorda is of very good quality, near to no organic waste has been found to be mixed with the different recyclable fractions.

For the mainly touristic destinations (Anegada, Jost Van Dyke and Virgin Gorda restaurant waste), it can be observed that coloured and transparent glass constitute the most important fraction. These are mainly beer bottles, often intact. Seafood wastes are the main component of organic waste in Jost Van Dyke island.

Hazardous waste identified in the samples is mainly WEEE (waste electrical and electronic waste) and chemical waste, mostly brushes and containers contaminated with paint rests. Very few medical syringes and only one single battery were found; the syringes were very small syringes meant for injections at home (diabetes or similar); the battery was an alkali battery containing no heavy metals. Separation at the source of biohazardous waste in hospitals seems to work well.

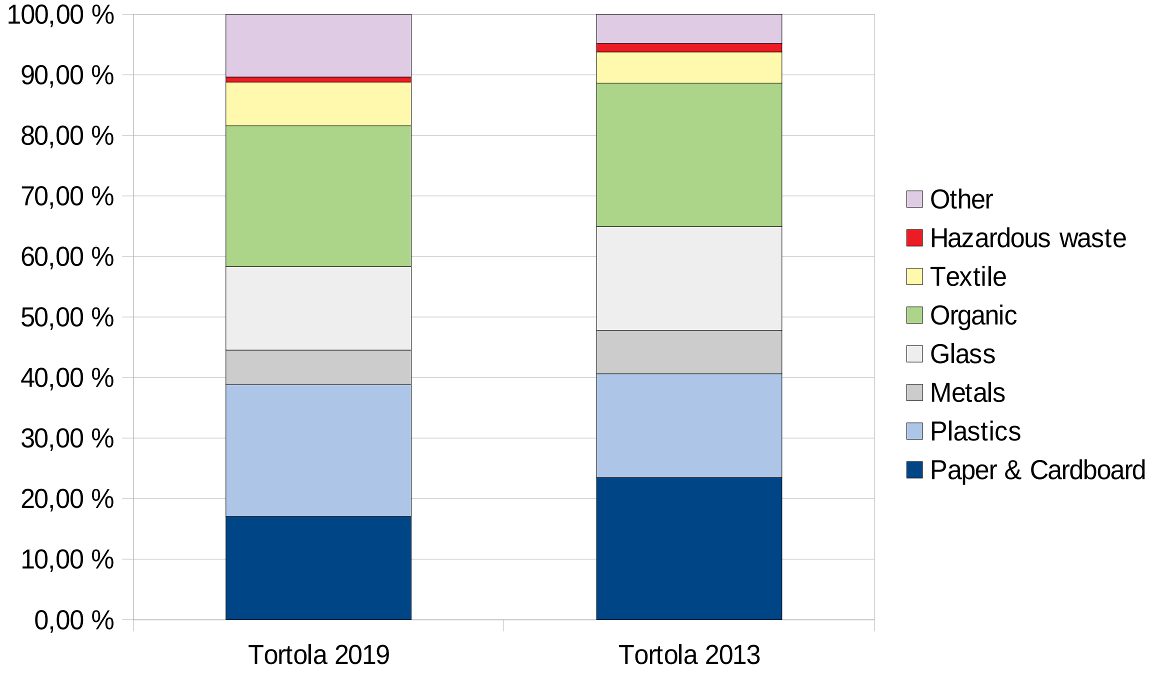
3.2.2 Development of waste composition over the years

The detailed waste composition table in the BVI waste management strategy of 2013 allows a comparison between solid waste composition in 2013 and 2019 for Tortola. Waste from the other islands was not analysed separately in 2013. The differentiation into sub-fractions being different during the 2013 assessment, only main fractions can be compared. The following table and graph show the waste composition in Tortola for 2013 and 2019.

Table 7: Waste composition in Tortola, 2013 – 2019

	Tortola 2019	Tortola 2013
Paper & Cardboard	**17.04**	**23.47**
Plastics	**21.80**	**17.14**
Metals	**5.67**	**7.19**
Glass	**13.81**	**17.14**
Organic	**23.27**	**23.69**
Textile	7.23	5.13
Hazardous waste	0.85	1.42
Other	10.33	4.81

Figure 4: Waste composition in Tortola, 2013 and 2019



The table shows an increase in organic waste, and a decrease in the generation of paper waste in Tortola. However, this is not to be considered a real increase, since no granulometric analysis was done in 2013, and all types of paper and cardboard were subsumed under this category, whereas paper and cardboard < 2” x 4” was listed under “organic” during the 2019 characterisation. This explains most probably of this apparent change.

The most noticeable development is the increase in “other” waste, which comprises items like baby diapers & hygienic pads, but also composite packaging, shoes and other complex materials.

The importance of glass waste seems to have decreased from 2013 to 2019. A decrease in the overall amount of glass consumption being very improbable, this may be an indicator for an important increase in the overall generation of the other waste fractions, which reduces the importance of the glass fraction. However, this hypothesis cannot be verified since the weighbridge register at the incinerator does not provide reliable data for the last two years.

An extrapolation has been made in order to exclude construction waste and other bulky waste measured in the 2013 characterisation from the comparative assessment.

3.2.3 Waste composition per fraction

The following table and figures show the composition of the gross fraction > 2” x 4”.

Table 8: Detailed waste composition - gross fraction

Fractions	Sub-fractions	Tortola February	Tortola June	Tortola average	Jost Van Dyke February	Jost Van Dyke June	Jost Van Dyke average	Virgin Gorda	Anegada	Overall BVI
Paper/ cardboard	**Paper**	**5.83**	**7.07**	**6.45**	**0.54**	**0.97**	**0.75**	**0.47**	**0.91**	**5.61**
	Cardboard	**14.13**	**14.64**	**14.38**	**8.65**	**0.00**	**4.32**	**2.33**	**7.14**	**12.74**
Textile		7.41	9.85	8.63	0.84	0.56	0.70	0.19	0.66	7.44
Plastic	**PET**	**10.11**	**6.94**	**8.52**	**6.73**	**6.27**	**6.50**	**27.60**	**2.96**	**10.75**
	HDPE film	**4.13**	**1.30**	**2.71**	**2.79**	**0.15**	**1.47**	**1.06**	**0.72**	**2.48**
	HDPE 3D	**2.50**	**1.78**	**2.14**	**1.69**	**3.27**	**2.48**	**3.86**	**1.32**	**2.34**
	PVC	**0.31**	**0.01**	**0.16**	**0.23**	**0.00**	**0.12**	**0.00**	**0.28**	**0.14**
	LDPE clear	**4.58**	**5.45**	**5.01**	**6.14**	**5.72**	**5.93**	**1.64**	**2.30**	**4.59**
	PP film	**1.27**	**0.53**	**0.90**	**0.18**	**0.52**	**0.35**	**0.28**	**0.37**	**0.81**
	PP 3D	**2.54**	**2.72**	**2.63**	**6.02**	**7.24**	**6.63**	**1.83**	**3.69**	**2.58**
	PS	2.52	1.84	2.18	0.30	0.72	0.51	0.28	0.43	1.92
	Other		0.63	0.32		0.00	0.00			0.27
Glass	**Transparent**	**6.84**	**8.27**	**7.55**	**27.98**	**39.18**	**33.58**	**21.96**	**35.89**	**9.86**
	Coloured	**9.58**	**8.45**	**9.01**	**22.37**	**24.32**	**23.34**	**28.37**	**22.21**	**11.64**
Metal	**Fe metal**	**3.89**	**4.28**	**4.08**	**5.48**	**3.14**	**4.31**	**3.97**	**3.28**	**4.06**
	Al containers	**1.32**	**1.14**	**1.23**	**1.82**	**2.58**	**2.20**	**3.78**	**1.51**	**1.55**
	Al film	**1.30**	**0.45**	**0.88**	**0.30**	**0.38**	**0.34**	**0.86**	**2.84**	**0.89**
	Copper	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.19**	**0.00**
Hazardous waste	WEEE	0.73	0.09	0.41	0.00	0.00	0.00	0.28	3.88	0.43
	Medical waste	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
	waste	0.45	0.19	0.32	0.00	0.58	0.29	0.00	0.00	0.28
	Batteries and accumulators	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Organic waste		**8.16**	**14.38**	**11.27**	**4.13**	**2.80**	**3.47**	**0.67**	**1.23**	**9.80**
Wood		**0.05**	**0.31**	**0.18**	**0.00**	**0.00**	**0.00**	**0.00**	**0.41**	**0.16**
Baby diaper, pads and hygienic tissue		5.50	3.24	4.37	3.04	0.89	1.96	0.19	3.60	3.83
Shoes		1.41	1.66	1.53	0.00	0.00	0.00	0.00	0.79	1.32
Ceramic and inert waste		0.13	0.00	0.06	0.00	0.00	0.00	0.00	1.04	0.06
Complex/ composite	Packaging	2.56	2.44	2.50	0.79	0.40	0.59	0.28	0.41	2.19
	Other	0.09	0.83	0.46	0.00	0.00	0.00	0.00	0.03	0.39
Other		2.69	1.56	2.12	0.00	0.31	0.15	0.09	1.92	1.85

Figure 5: Summarised composition of the gross fraction

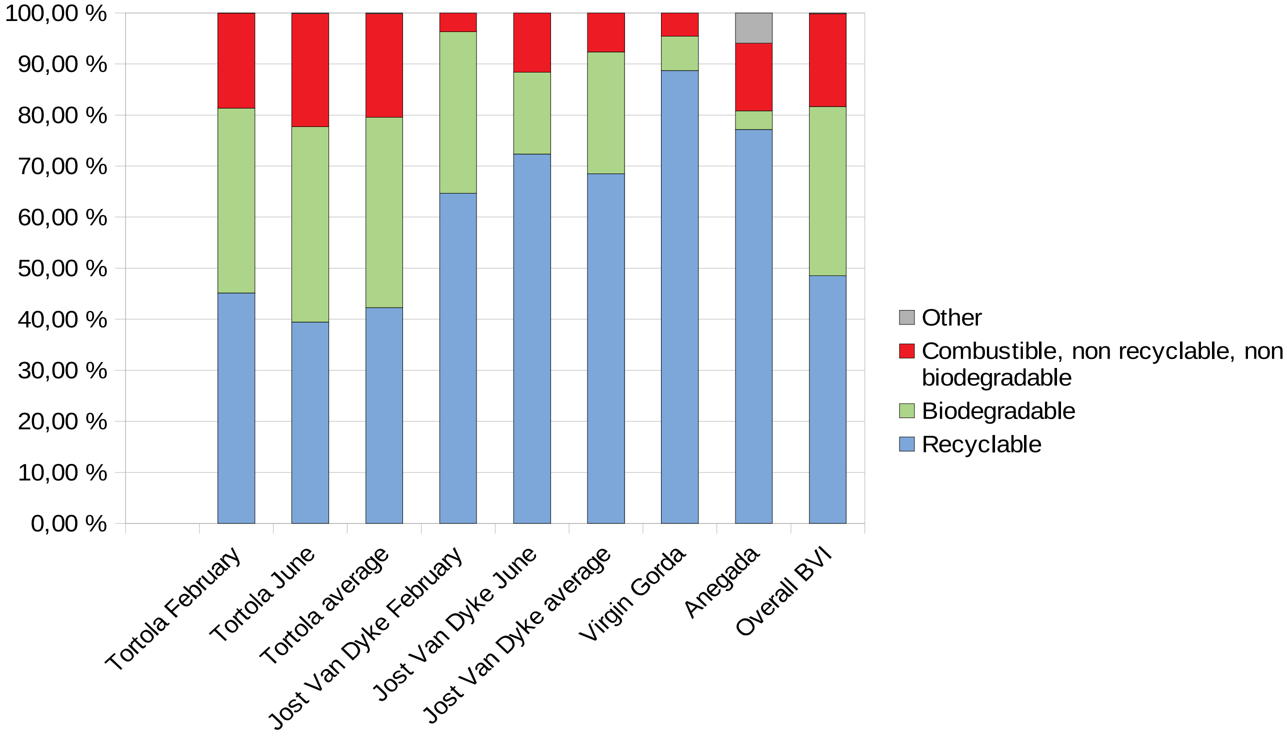
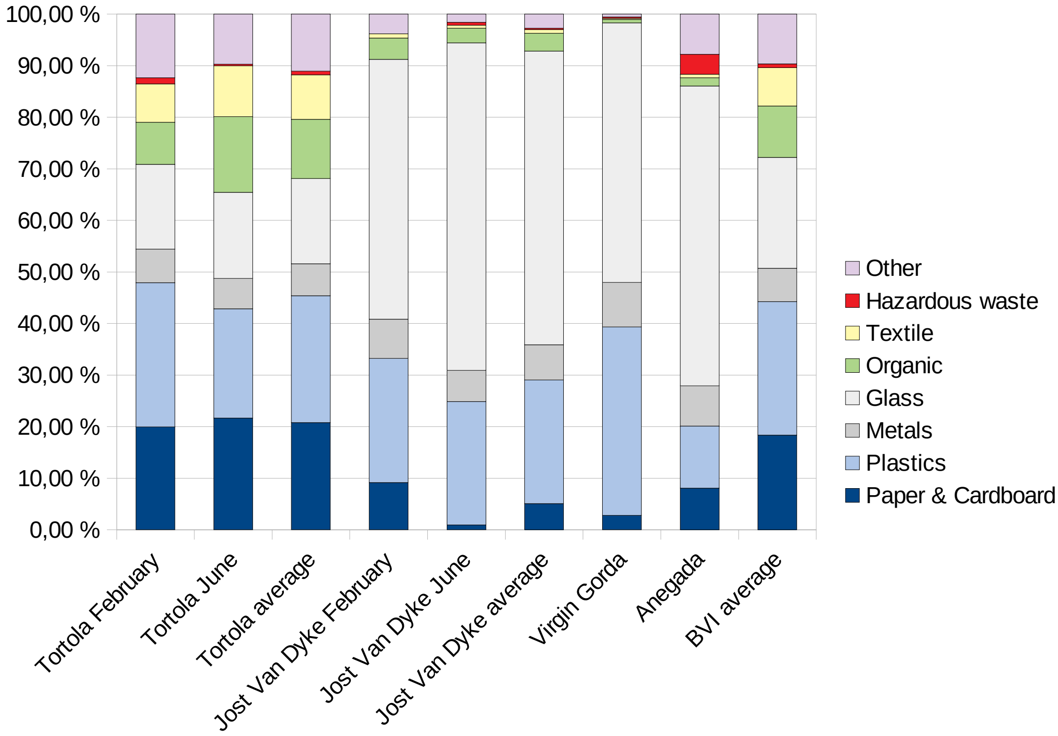


Figure 6: Composition of the gross fraction



Waste composition of the gross fraction is very similar to the composition of the overall waste produced in the British Virgin Islands, with the only difference that organic waste is nearly not present in the samples other than Tortola. The reason for this similarity is the comparatively small importance of the fine and medium fraction.

Glass is the most important fraction in all samples expect Tortola, where plastics and cardboard are the first and second biggest fraction.

The supermarket sample of the gross fraction is identical to the overall sample, since the fine and medium fraction were absent in this sample.

The table and figures below give the waste composition for the fine and medium fraction between 1 “² and 2” x 4”.

Table 9: Detailed composition of the medium fraction

Medium fraction		Tortola February	Tortola June	Tortola average	Jost Van Dyke February	Jost Van Dyke June	Jost Van Dyke average	Virgin Gorda	Anegada	Overall BVI
Paper/ cardboard	**Paper**	**0.93**	**0.00**	**0.47**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.40**
	Cardboard	**1.69**	**0.00**	**0.84**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.72**
Textile		0.92	1.49	1.20	0.00	0.00	0.00	0.00	15.50	1.19
Plastic	**PET**	**4.95**	**4.88**	**4.92**	**2.92**	**2.01**	**2.47**	**3.28**	**0.00**	**4.64**
	HDPE film	**4.74**	**0.43**	**2.59**	**0.00**	**8.39**	**4.19**	**0.40**	**0.00**	**2.31**
	HDPE 3D	**1.26**	**0.93**	**1.09**	**2.92**	**1.68**	**2.30**	**3.53**	**5.84**	**1.45**
	PVC	**0.01**	**0.00**	**0.01**	**0.07**	**0.00**	**0.04**	**0.00**	**0.00**	**0.00**
	LDPE clear	**0.85**	**1.45**	**1.15**	**5.84**	**3.69**	**4.77**	**0.00**	**0.20**	**1.04**
	PP film	**0.88**	**0.00**	**0.44**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.38**
	PP 3D	**1.89**	**4.10**	**2.99**	**8.76**	**0.00**	**4.38**	**12.35**	**5.84**	**4.17**
	PS	1.14	0.56	0.85	0.37	7.72	4.04	0.00	0.00	0.77
	Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Glass	**Transparent**	**1.70**	**0.45**	**1.07**	**29.20**	**0.00**	**14.60**	**7.31**	**0.00**	**1.96**
	Coloured	**2.69**	**2.23**	**2.46**	**21.90**	**20.13**	**21.02**	**30.24**	**31.76**	**6.32**
Metal	**Fe metal**	**0.91**	**0.00**	**0.46**	**0.37**	**0.00**	**0.18**	**4.54**	**3.56**	**0.98**
	Al containers	**0.06**	**3.40**	**1.73**	**1.46**	**0.00**	**0.73**	**0.40**	**3.81**	**1.58**
	Al film	**1.45**	**1.19**	**1.32**	**0.73**	**2.35**	**1.54**	**0.40**	**5.84**	**1.26**
	Copper	**0.00**	**0.79**	**0.40**	**0.00**	**1.34**	**0.67**	**0.00**	**0.00**	**0.35**
Hazardous waste	WEEE	0.00	0.00	0.00	0.00	2.01	1.01	0.00	0.00	0.01
	Medical waste	0.37	0.00	0.18	0.00	0.00	0.00	0.00	0.41	0.16
	waste	0.00	1.11	0.56	0.00	0.00	0.00	0.00	0.00	0.48
	Batteries and accumulators	0.00	0.61	0.31	0.00	0.00	0.00	0.00	0.00	0.26
Organic waste		**61.34**	**70.29**	**65.82**	**22.54**	**41.95**	**32.24**	**30.49**	**13.01**	**60.65**
Wood		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Baby diaper, pads and hygienic tissue		5.31	2.33	3.82	0.00	2.35	1.17	0.00	0.00	3.29
Shoes		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ceramic and inert waste		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Complex/ composite	Packaging	2.98	2.52	2.75	1.46	3.69	2.58	7.06	9.65	3.34
	Other	2.24	0.00	1.12	0.00	0.00	0.00	0.00	0.00	0.96
Other		1.68	1.24	1.46	1.46	2.68	2.07	0.00	4.57	1.32

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Figure 7: Summarised composition of the medium fraction

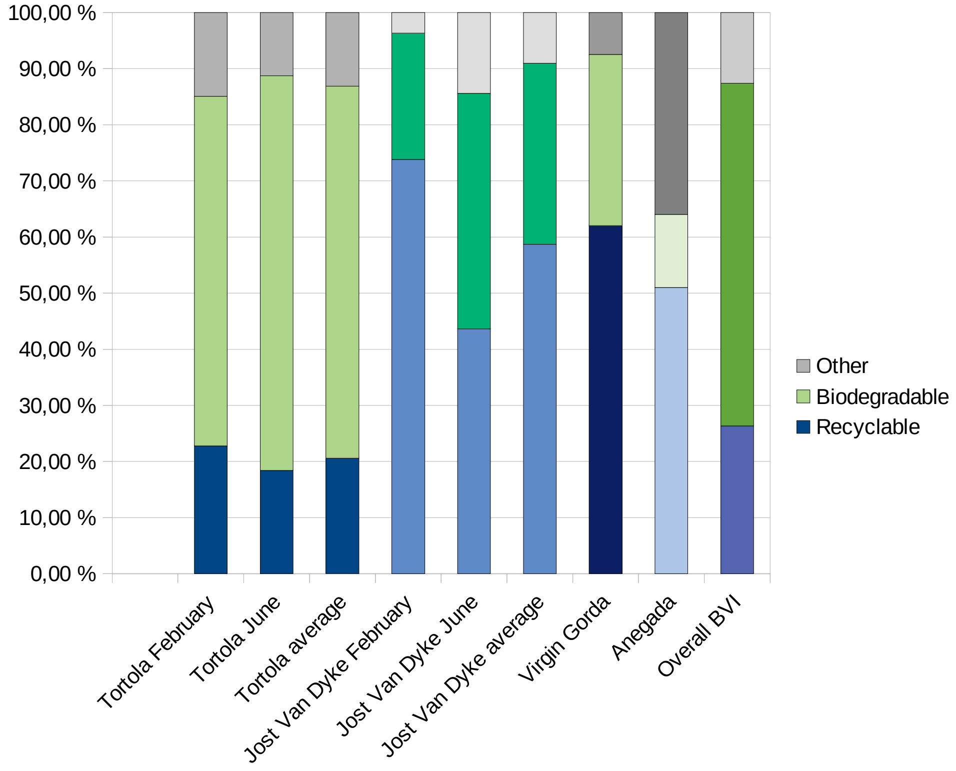
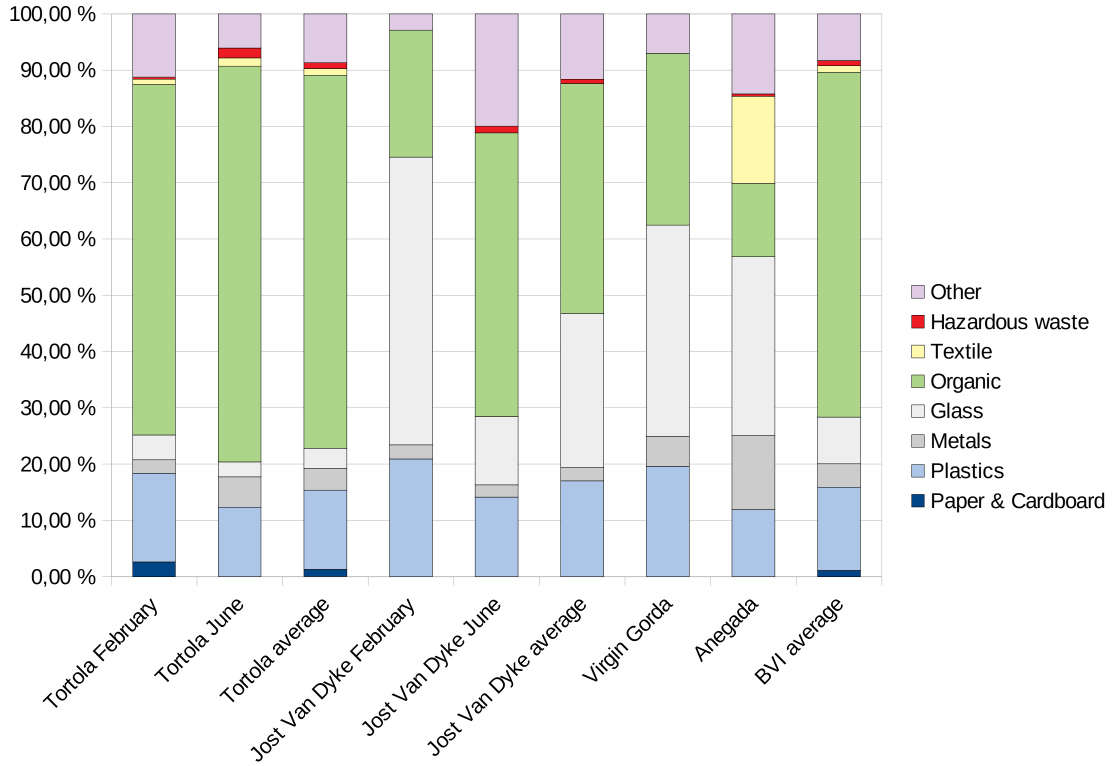


Figure 8: Composition of the medium fraction



In Tortola, 66 % of the medium fraction consist of organic waste. Soiled paper is also counted as organic waste, since small paper and cardboard pieces are difficult to sort out and not adequate for recycling.

The organic fraction is much less important in the samples taken from Jost Van Dyke and Virgin Gorda; organic waste is between 30 – 37 % in the Virgin Gorda samples, and 32 % in the Jost Van Dyke samples. It should be noted here that the medium fraction is very small in the two Virgin Gorda samples, and that 1/3 of organic waste in this fraction does not represent much in the total sample. In Jost Van Dyke, organic waste consists mostly of seafood shells, and the medium and fine fraction amounts to over 50 % of the total sample. Both in Tortola and in Jost Van Dyke, the organic fraction becomes more important during the non touristic season. This effect is more marked in Jost Van Dyke, which has a very small resident population.

Broken glass is the most important component in the medium and fine fraction of Jost Van Dyke waste. This is nearly exclusively green glass from beer bottles, which has been broken in the compactor bins. Considering that the medium + fine fraction constitute 51 % of the overall waste during the touristic season, and broken bottle glass is again 51 % of the medium fraction, we can conclude that approximately ¼ of waste coming from Jost Van Dyke consists of broken green glass. During the non touristic season, this proportion is significantly reduced.

For Anegada and the Virgin Gorda samples, broken glass and small bottles constitute also the most important element in the medium fraction. However, the medium fraction is far less important, especially in Anegada. Compactor bins being not available in these islands, crushing of bottles is less frequent.

3.3 Statistical Analysis

A statistical analysis of the reliability and representativeness of the waste characterisation campaign has been carried out for the overall sample. The results are given in the following tables.

The statistical analysis reflects the great heterogeneity of waste in the British Virgin Islands. The variation coefficient lies between 46 % and 80 % for the main fractions. In consequence, with the number of samples taken, a random sampling error of

- 15 – 20 % for Fe waste

- 20 % for HDPE 3D waste

- 20- 30 % for PET, LDPE and PS waste

- 30 % for organic waste and PP 3D

> 30 % for coloured glass, Al containers and baby diaper

has to be accepted.

Table 10: Statistical assessment per sub-fraction

Material		Variance	Standardd eviation	Variation coefficient	Confidence interval	
Fractions	Sub-fractions	kg²	kg	%	maximum	minimum
Paper & Cardboard	Cardboard	902,87	30,05	117,84	26,02	25,39
	Soiled paper	104,90	10,24	142,75	7,80	7,04
Textile		159,19	12,62	114,11	11,56	10,95
Plastic	PET	73,69	8,58	57,22	15,25	14,95
	HDPE film	24,56	4,96	91,57	5,81	5,33
	HDPE 3D	4,89	2,21	52,10	4,47	4,20
	PVC	0,58	0,76	241,42	1,37	0,09
	LDPE clear	17,22	4,15	57,27	7,50	7,19
	PP film	2,60	1,61	101,27	2,04	1,50
	PP 3D	21,98	4,69	71,04	6,91	6,53
	PS	2,82	1,68	56,94	3,20	2,90
	Other	2,59	1,61	467,86	2,40	-0,09
Glass	Transparent	790,68	28,12	117,90	24,37	23,74
	Coloured	381,28	19,53	81,52	24,31	23,88
Metal	Fe metal	10,07	3,17	46,55	7,02	6,77
	Al containers	5,03	2,24	83,16	3,06	2,62
	Al film	4,79	2,19	102,60	2,58	2,04
	Copper	0,01	0,12	460,36	2,05	-0,40
Hazardous waste	WEEE	1,70	1,30	101,21	1,73	1,19
	Medical waste	7,12	2,67	1530,18	6,89	-1,25
	Chemical waste	0,85	0,92	190,04	1,32	0,31
	Batteries and accumulators	0,24	0,49	473,30	2,18	-0,34
Organic waste	Biodegradable	887,19	29,79	69,21	43,34	42,97
	Wood	15,04	3,88	413,71	2,75	0,55
	Packed food	10,72	3,27	110,99	3,44	2,85
Baby diaper		47,70	6,91	93,64	7,79	7,29
Shoes		4,29	2,07	132,91	2,14	1,43
Ceramic		8,91	2,99	1057,51	4,93	-0,70
Complex/ composite	Packaging	59,01	7,68	206,62	4,63	3,53
	Other	46,80	6,84	360,29	3,48	1,56
Other		43,17	6,57	151,02	5,01	4,21

Table 11: Assessment of sample size

<table>
<tr><th rowspan="2">Variation coefficient</th><th colspan="6">Required and real number of sample units for a 95 % confidence level and a random sampling error of:</th></tr>
<tr><th>3%</th><th>5%</th><th>10%</th><th>15%</th><th>20%</th><th>30%</th></tr>
<tr><td>15</td><td>138</td><td>35</td><td>9</td><td>4</td><td>2</td><td>1</td></tr>
<tr><td>20</td><td>246</td><td>61</td><td>15</td><td>7</td><td>4</td><td>2</td></tr>
<tr><td>25</td><td>384</td><td>96</td><td>24</td><td>11</td><td>6</td><td>3</td></tr>
<tr><td>30</td><td>553</td><td>138</td><td>35</td><td>15</td><td>9</td><td>4</td></tr>
<tr><td>35</td><td>753</td><td>188</td><td>47</td><td>21</td><td>12</td><td>5</td></tr>
<tr><td>40</td><td>983</td><td>246</td><td>61</td><td>27</td><td>15</td><td>7</td></tr>
<tr><td rowspan="2">45</td><td rowspan="2">1.245</td><td rowspan="2">311</td><td rowspan="2">78</td><td>35</td><td>19</td><td rowspan="2">9</td></tr>
<tr><td colspan="2">22 samples</td></tr>
<tr><td rowspan="2">50</td><td rowspan="2">1.537</td><td rowspan="2">384</td><td rowspan="2">96</td><td rowspan="2">43</td><td>24</td><td>11</td></tr>
<tr><td colspan="2">22 samples</td></tr>
<tr><td rowspan="2">55</td><td rowspan="2">1.859</td><td rowspan="2">465</td><td rowspan="2">116</td><td rowspan="2">52</td><td>29</td><td>13</td></tr>
<tr><td colspan="2">22 samples</td></tr>
<tr><td>60</td><td>2.213</td><td>553</td><td>138</td><td>61</td><td>35</td><td>15</td></tr>
<tr><td>70</td><td>3.012</td><td>753</td><td>188</td><td>84</td><td>47</td><td>21</td></tr>
<tr><td>80</td><td>3.934</td><td>983</td><td>246</td><td>109</td><td>61</td><td>27</td></tr>
<tr><td>90</td><td>4.979</td><td>1.245</td><td>311</td><td>138</td><td>78</td><td>35</td></tr>
<tr><td>100</td><td>6.147</td><td>1.537</td><td>384</td><td>171</td><td>96</td><td>43</td></tr>
<tr><td>120</td><td>8.851</td><td>2.213</td><td>553</td><td>246</td><td>138</td><td>61</td></tr>
<tr><td>140</td><td>12.047</td><td>3.012</td><td>753</td><td>335</td><td>188</td><td>84</td></tr>
<tr><td>160</td><td>15.735</td><td>3.934</td><td>983</td><td>437</td><td>246</td><td>109</td></tr>
<tr><td>200</td><td>24.586</td><td>6.147</td><td>1.537</td><td>683</td><td>384</td><td>171</td></tr>
</table>

4 CONCLUSIONS

Conclusions of the waste characterisation study are listed below:

- Waste composition is, in all four islands, very complex. The medium and fine fraction, which consist mainly of organic waste in many countries, are very mixed and do **not allow a mechanical separation** of the organic (biodegradable) fraction from recyclable and other waste.

  For this reason, **separate collection is a conditio sine qua non for the introduction of efficient waste stream management, recovery and recycling** in the British Virgin Islands.

- Waste generated in the islands of Virgin Gorda, Jost Van Dyke and Anegada is much less complex than waste from Tortola. Due to the importance of touristic infrastructure, glass is the preponderant waste fraction. This situation is less marked during the low season. **Separate collection of recyclable materials from restaurants, bars and hotels is expected to** be introduced and monitored comparatively easily, and to **yield good results** in terms of quantity and quality of collected materials.

- In the island of **Jost Van Dyke, separate collection of glass waste and storage in a non compacting bin** would be necessary to allow recovery of this important waste stream. Moreover, glass being not combustible, this would alleviate greatly the charge of non combustible wastes to the incinerator.

  Similarly, separate collection of **organic waste from restaurants might allow to implement a medium size, decentralised biogas production facility** on the island.

- **Separately collected waste in Virgin Gorda is of very good quality**; the performance of the separate collection in that island is to be highlighted. Materials are separated efficiently and are clean.

- The introduction of **separate collection of recyclable materials from restaurants, bars and hotels in Tortola** would probably allow to recover an important amount of glass and metal for recycling also in this island. Given the size and the mix between residential and touristic infrastructure in Tortola, the introduction and monitoring of separate collection will be more challenging than in the smaller islands.Supermarket waste is very clean and easy to sort. **Separate collection of secondary and tertiary packaging from supermarkets** will yield an important quantity of clean recyclable materials.

- The analysis of waste from all islands underlines the **importance of the proposed ban of single-use plastics**. Polystyrene food packs and single-use mugs, plates and cutlery constitute an important waste fraction.

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