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Waste Quantity and Composition Study

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Study by LL Bolagen

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Contents

Definitions and abbreviations

AMD	Armenian dram
AUA	American University of Armenia
BAT	best available technology
CDM	Clean Development Mechanism
CDW	construction and demolition waste
CH_4	methane gas
CO_2	carbon dioxide
EEE	see WEEE
ELV	End-of-Life vehicles, scrap vehicles
EU	European Union
e-waste	See WEEE
FLW	food loss and waste
GDP	Gross Domestic Product
GHG	greenhouse gas, contributing to global warming
HCW	healthcare waste
HZW	hazardous waste
kton	1,000 ton
marz	Armenian province (with the province council *marzpetaran*)
MTAI	Ministry of Territorial Administration and Infrastructure
MSW	Municipal solid waste
PET	polyethylene terephthalate, light-weight plastic commonly used for liquid bottles
PPP	Public Private Partnership
RA	Republic of Armenia
SWM	Solid waste management
t or ton	metric ton (tonne), i.e. 1,000 kg
USD	US dollars
WB	World Bank
WCA	Waste Composition Analysis
WEEE	Waste Electrical and Electronic Equipment

Citing this report

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Project website

https://ace.aua.am/waste/wqcs

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The project was financed by the AUA Manoogian-Simone Research Fund (MSRF), which is an innovative funding opportunity aimed at building university research capacity in Armenia to advance economic growth and development of the country based on Government priorities.

This report has been developed by the Swedish consulting firm LL Miljökonsult, part of the company group LL Bolagen, which carries out waste collection services and sanitary cleaning in Stockholm, Sweden. The consulting team consisted of Ms. Karin Eberle, TL/SWM Specialist, Mr. Anders Lärkert, SWM Specialist and Ms. Ingrid Håstad SWM Specialist.

Figure 1. The WCA team, preparing for sampling and sorting at Nubarashen landfill

Executive summary

Armenia has struggled for a long time with unsustainable solid waste management practices such as uncontrolled dumpsites and inefficient waste collection, resulting in negative environmental and health impacts and poor management of resources.

Now, the new Armenian government is aiming at achieving EU-approximation within the framework of the EU-Armenia Comprehensive and Enhanced Partnership Agreement (CEPA) and to contribute to Armenia's commitment to the Sustainability Goals (SDGs) within the Agenda 2030. This includes sustainable and long-term strategic waste management, and some large infrastructure projects on sanitary landfills and capacity development are underway.

The need for more reliable data on the quality and quantity of waste in Armenia has been recognized to support the development of a policy and road map on solid waste management based on the principles of circular economy as well as information to potential investors in waste collection, recycling, and energy recovery.

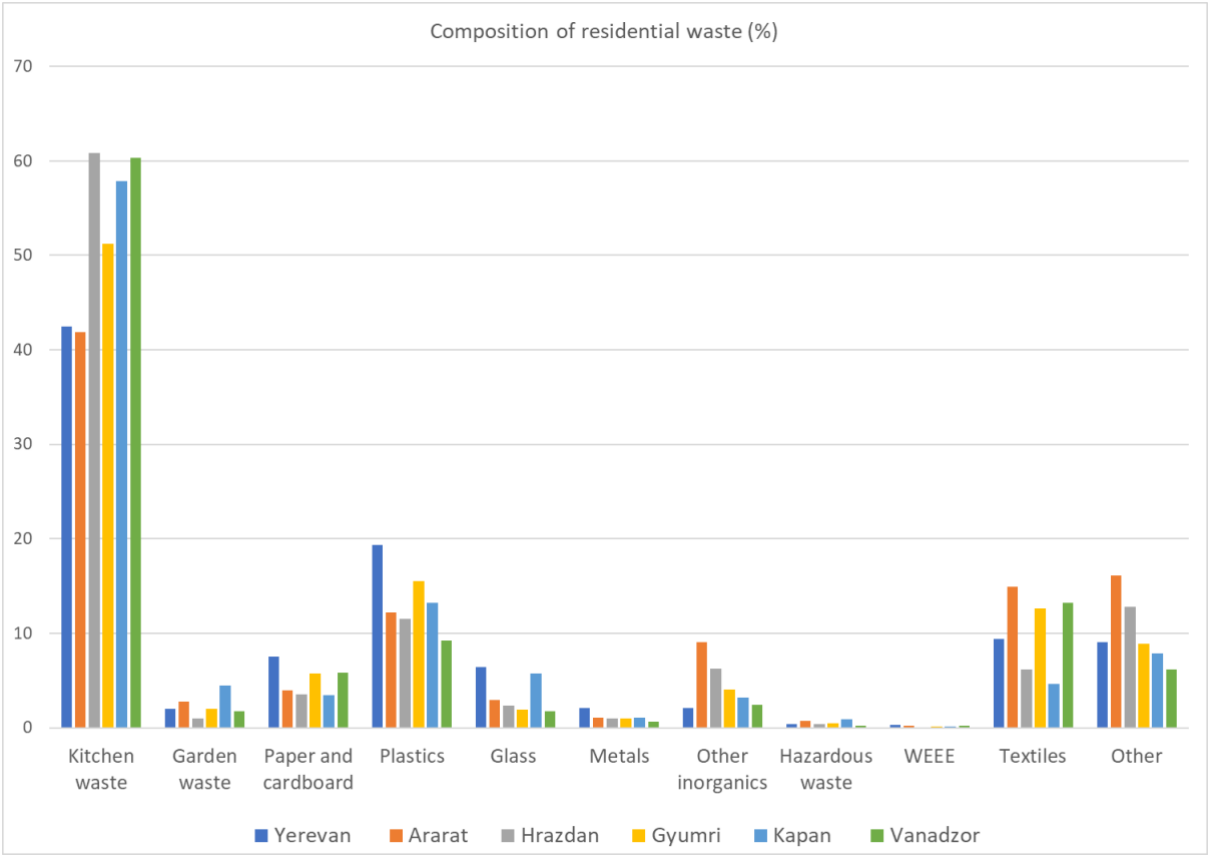
In order to support that work, this project *"Waste Quantity and Composition Study (WQCS)"* has been initiated by the American University of Armenia (AUA) Acopian Center for the Environment in partnership with the Government of Armenia. The study is funded by the AUA Manoogian-Simone Research Fund and has involved a team of three Swedish consultants working closely with the AUA and the Ministry of Territorial Administration and Infrastructure (MTAI) from May to September 2019.

- Three Waste Composition Analyses (WCA) of municipal waste have been carried out in Yerevan as well as training of a local WCA team. The team has continued to carry out 12 more WCA in Ararat, Gyumri, Hrazdan, Kapan and Vanadzor.
- Data have been collected through field visits to Armenian cities, landfills, hospitals and other sites, and interviews with stakeholders.
- Two workshops – on Hazardous waste and WEEE, and Strategic Waste Management – have been carried out. The latter included a presentation of the WCA results and preliminary findings.

The **WCA methodology** included sorting municipal solid waste into 22 waste fractions by hand from samples taken from residential and commercial areas. Every test included collecting ca 50 bins or up to 4 tons with a truck, mixing the waste and taking out 5 sub-samples amounting to a total of 500 kg. Some of the main findings and recommendations from the WCA are the following:

- Over 50% (weight) of the MSW is organic (kitchen and garden waste) and should not be landfilled to avoid spontaneous gas fires and methane emissions but tapped as a resource.
- There is basically no newspaper and the amount of paper and cardboard varies from 2-ca 10%. Plastic packaging is more dominant, especially soft plastics up to 20% in Yerevan. The material is of poor quality as it is soiled, so recycling will require segregation at source.
- The textile fraction is very high, up to 15%, as well as the presence of old furniture, toys, bags and other bulky items. It may be possible to further enhance the second hand market for these waste types.
- The inorganic fraction varies a lot but can be very high, since both sand from street cleaning and various materials from construction end up in the municipal waste bins.

The results from the WCA of residential waste in all six test cities are shown below. It can be seen, for instance, that kitchen waste is high and garden waste low, as the waste comes from apartments, and that Yerevan sticks out in terms of prevalence of packaging materials (paper/cardboard, plastics, glass and metals).



Other wastes that have been studied are bulky waste, construction and demolition waste (CDW), automotive waste, industrial waste, e-waste (WEEE), healthcare and other hazardous waste, and agricultural waste. Estimates on **quantities** for MSW and other types of waste have been given as well as methodologies for more thorough quantification, which will require much more time, possibly years and through questionnaires and extrapolation based on international experience.

Some of the estimated quantities on an annual basis are the following:

- Municipal solid waste generation: ca 739,000 tons (not to be confused with collection or disposal)
- Bulky waste: ca 246,300 tons
- Construction and demolition waste: ca 520,000 tons
- End-of-life vehicles: ca 6,000 vehicles scrapped yearly, including 25-50 tons of engine oil
- E-waste: ca 14,000 tons
- Healthcare waste: ca 500 tons
- Agricultural waste: ca 300,000 tons, predominantly wheat and dairy production

One major message in this report is that waste **statistics** is very challenging and that even within EU, where the regulatory framework is common, there are large differences in waste definitions and data collection and handling. For instance, the term “municipal solid waste” includes commercial waste in Germany but not in Sweden, and the definition and color-coding for sorting of construction waste differ between Denmark and Sweden. In Armenia, there are no weighbridges at the landfills (dumpsites) and often not even registration of vehicles or volume estimates and thus, not even the total volumes of waste can be accurately measured.

Data collection is encouraged still, but should be narrowed down to **focus more on project feasibility**, such as estimates not only on generated but available and suitable plastic or paper waste in an area, or the supply of biodegradable waste for a biogas plant.

Conclusions and recommendations have been made in a stepwise approach. Regardless of availability or accuracy of data, there are plenty of **measures** that can be taken and some immediately without major cost implications.

- Improve **collection of waste** by better maintenance of vehicles and bins, more capacity to avoid dumping of waste blocking the bins, closing of all chutes and introducing alternative methods for collection, such as large containers and particularly in the rural areas. This would make the collection faster, safer for both residents and collection staff, and cheaper.
- Arrange **separate collection of bulky waste** including construction and demolition waste to remove them from the bins for MSW. This would make the MSW collection safer and more efficient, improve the functionality and prolong the lifespan of both collection vehicles and the landfill.
- Improve general awareness on **hazardous waste** and provide separate collection systems for this kind of waste including electrical and electronic waste (WEEE). The WCA shows no or little presence of this waste in MSW, meaning that there is an informal system for reuse.
- Focus more on **implementation, monitoring and enforcement** of existing regulations than studies on future technologies to be invested in.
- **Improve landfill operations,** even though they are dumpsites. Improve the access road, set up gate control, check vehicles and register waste volumes, arrange separate disposal of various types of waste including hazardous waste, formalize or remove scavenging, train both collection and site staff in safe operation.
- **Cooperate** within marzes and with private sector, academe, NGOs and other organizations to pool resources for investment and operation of waste treatment facilities or systems but also for public awareness campaigns and exchange of information and experience.
- Promote **capacity development** of municipal staff within waste treatment technology but also management, procurement and monitoring of private contractors.
- Find **economic incentives** for businesses or public participation through, for instance, waste segregation at source or reuse, or improved management of collection and gate fees.

1. Introduction and background

The situation in Armenia concerning solid waste management has been a challenge for a long time, and time has come to plan for and develop a more sustainable system. Currently, there are issues in waste collection service delivery, illegal dumpsites, old equipment, lack of treatment alternatives, lack of sites for hazardous waste, and thus, pollution to air, soil and water bodies as well as groundwater. Lack of collection leads to improper dumping of waste, littering or burning of waste, which in turn creates health hazards. The issues are not only technical but also tied to poor enforcement or understanding of environmental regulatory framework, lack of means for investment and operation, lack of staff, and other factors.

1.1 Armenia towards sustainable SWM

The Armenian government's reform agenda is aimed at achieving EU-approximation within the framework of the EU-Armenia Comprehensive and Enhanced Partnership Agreement (CEPA) and to contribute to Armenia's commitment to the Sustainability Goals (SDGs) within the Agenda 2030.

The results of the conducted research and analyses will be one input for the Government of Armenia to develop and implement the following:

- A comprehensive solid waste governance and management policy based on the principles of circular economy.
- A road map on improving solid waste management.
- Solid waste management/recycling and disposal strategies and economic mechanisms.
- Offer necessary information to potential investors in waste collection, recycling, and energy recovery.

The new Armenian National Government is clearly focused on recycling and modern waste management to minimize the pollution but also to make use of the waste as material resource or fuel. In order to take informed and strategic decisions, the need for more reliable data on the quality and quantity of waste in Armenia has been recognized. That is the main driver for this Waste Quantity and Composition Study (WQCS) implemented by the American University of Armenia (AUA) Acopian Center for the Environment in partnership with the Government of Armenia. The study is funded by the AUA Manoogian-Simone Research Fund.

1.2 Main project objectives

This project has studied the quantity and composition of municipal solid waste, construction and demolition waste, industrial waste, electrical and electronic waste, agricultural and horticultural waste, medical waste and automotive waste with focus on municipal and hazardous waste and recommendations for improved management and treatment.

Capacity development is one important factor – that Armenia is better equipped to understand its challenges, impacts and root causes; to collect and analyse data related to waste management independently; and to plan, manage and implement manage waste management solutions, proposals from private sector and international projects. This includes strong ownership and local drive to plan for future waste management from a more strategic and long-term point-of-view. As a part of this project, several such activities have been pursued such as workshops, on-the-job-training, strategic planning, etc.

Finally, based on the findings during data collection, there are conclusions and recommendations to support decision-making in collection and treatment systems and technology from source to final treatment/disposal. This will lead not only to reduced pollution and better environment in general but also opportunities for recycling industry and investments in collaboration with private partners plus urban-rural linkages. The study indicates hotspots and issues, draws conclusions from the data

and makes recommendations on logistics, treatment options and waste management systems as well as organizational, institutional and financial issues and possible improvements.

1.3 Project methodology

The Project has been carried out in close cooperation with the Clients AUA and Ministry of Territorial Administration and Infrastructure (MTAI) by a small team of consultants with long international SWM experience including from Armenia. The general methodology has been to collect data, observe on site, draw conclusions and make short- and long-term recommendations, through the following activities:

- Study visits to landfills and closed dumpsites, waste treatment facilities, collection points at residential areas and other sites, hospitals and outpatient clinics
- Meetings/interviews with ministries, local government officials, international donors, private sector, operators including vehicle drivers, NGOs, and other pertinent stakeholders
- Studying available data, previous reports and studies
- Research for baseline data on waste quantities and composition through Waste Composition Analysis (WCA) in Yerevan and four other cities
- Analysis and reporting

Three missions have been carried out:

Mission 1 (21-29 May 2019):	Focus on fact-finding and preparations for the WCA for municipal waste, establish contacts and agree on project plan, reporting and needs for capacity development.
Mission 2 (4-14 June 2019)	Focus on carrying out of a full WCA including training of sorting team, planning of and participation in waste collection, preparing for and setting up sorting station at Nubarashen landfill and guiding the team on site. Factfinding on other types of waste, study visits and interviews.
Mission 3 (26 August- 7 September 2019)	Focus on hazardous waste including healthcare waste as well as continued factfinding on various waste fractions. Follow-up of WCA (carried out by the local WCA team in July) through field visits to Ararat, Hrazdan and Vanadzor. Two workshops were carried out: - Workshop on Hazardous Waste including WEEE and Healthcare Waste (2 September). - Workshop on Sustainable Waste Management (6 September) including presentation of preliminary WCA results.

Regarding this report, emphasis has been put on keeping it as short and to the point as possible and avoid repeating other studies' statements and conclusions, although many of them are well founded and still valid. The views expressed are solely the ones of the Consultants.

It may be worth noting that there is reference to Swedish waste management in several sections of this report, the primary reason being that Sweden is internationally renowned to be very successful in waste management including PPP solutions and a very low landfilling rate, ca 1% of the household waste. Furthermore, this study has been prepared by a team of Swedish consultants with international experience, thus with the ability to benchmark waste management performance in

several countries including Sweden. The small case boxes in the report are the consultants' own experiences and reflections for consideration in an Armenian context.

1.4 General information on the Republic of Armenia

Geography

The Republic of Armenia is situated in the western part of Asia. The country occupies 29,743 km^2 in the northeast part of the Armenian plateau – the inter-river territory between the Kur and Araks rivers between Caucasus and Nearest Asia. In the north and east it borders with Georgia and Azerbaijan, and in the west and south with Turkey and Iran. The climate is highland continental with hot summers and cold winters. Administratively, Armenia is divided into ten provinces (marzes), while the city of Yerevan has special administrative status as the country's capital.

Administrative division

The administrative division base of the Republic of Armenia (RA) is the RA Law on Administrative and Territorial Division of RA (4 December 1995). The territory of RA is divided into 10 marzes. The capital Yerevan has a status of community with 12 administrative districts.[1] At present, there are 49 cities (including Yerevan city) and 952 rural settlements.

Population

In 2019, the total population in Armenia amounts to 2,965,300 inhabitants.[2] There are 49 cities in the country and 955 villages, and although a total of 64% of the population live in urban areas, this is primarily due to the fact that Yerevan accounts for over a third of the population.

[1] The RA Law on Local Government in Yerevan city 26 December 2008

[2] Armstat, Armenia in figures 2019

Figure 2. Population density in the 10 marzes of Armenia (Armstat 2018)

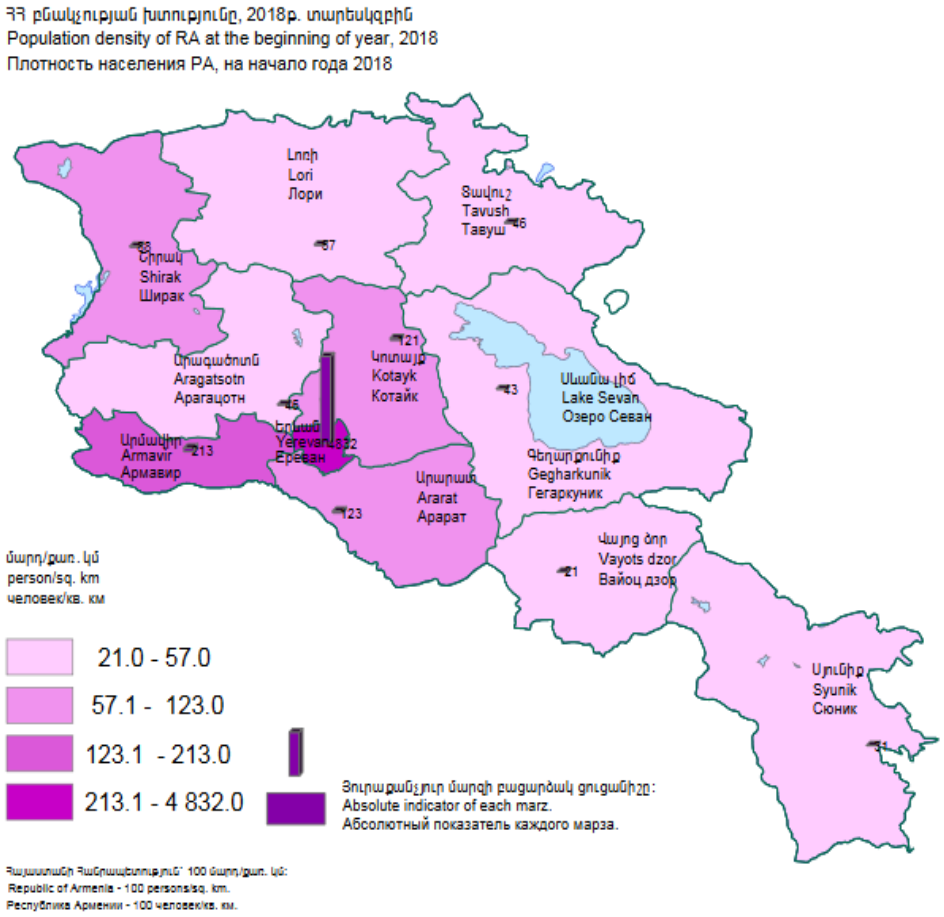


Figure 3. Population in Yerevan and the 10 marzes (Armstat, Armenia in figures, 2019) and distribution between urban and rural population

ՏԱՐԱԾՔԸ ԵՎ ԲՆԱԿՉՈՒԹՅՈՒՆԸ ԸՍՏ ՎԱՐՉԱՏԱՐԱԾՔԱՅԻՆ ԲԱԺԱՆՄԱՆ

TERRITORY AND POPULATION BY ADMINISTRATIVE AND TERRITORIAL DIVISION

Մարզերը և ք. Երևանը	Տարածքը, կմ² Territory, km²	Մշտական բնակչության թվաքանակը (2019թ. հունվարի 1-ի դրությամբ), 1 000 մարդ Number de jure population (as of January 1, 2019), 1 000 persons			Marzes and Yerevan city
		ընդամենը total	քաղաքային urban	գյուղական rural	
Հայաստանի Հանրապետություն	29 743	2 965.3	1 894.9	1 070.4	Republic of Armenia
ք. Երևան	223	1 081.8	1 081.8	-	Yerevan City
Արագածոտն	2 756	125.4	27.0	98.4	Aragatsotn
Արարատ	2 090	256.7	72.2	184.5	Ararat
Արմավիր	1 242	263.9	82.6	181.3	Armavir
Գեղարքունիք	5 349[1]	228.3	67.0	161.3	Gegharkunik
Լոռի	3 799	215.5	127.6	87.9	Lori
Կոտայք	2 086	251.6	137.4	114.2	Kotayk
Շիրակ	2 680	233.3	136.9	96.4	Shirak
Սյունիք	4 506	137.6	93.4	44.2	Syunik
Վայոց ձոր	2 308	49.0	17.3	31.7	Vayots dzor
Տավուշ	2 704	122.2	51.7	70.5	Tavush

The population has declined from 3,174,000 since the year 2004. In the same period, Yerevan city has dropped slightly from 1,095,000 to 1,082,000 while the marzes have dropped from 2,079,000 to 1,883,500.[3]

1.5 Previous studies on waste management

The AUA Acopian Center for the Environment[4] has compiled a list of studies in the sector of waste management in the following groups:

- Policy papers
- General reports on waste
- Municipal waste reports
- Agricultural waste reports
- Hazardous waste reports
- Wastewater reports

Some of the reports have been referred to in this report, and comparisons with, for instance, previous quantification or morphological studies have been made. A lot of factfinding, situation analysis and feasibility studies have been conducted and recommendations have been made. However, most of them are for one or two provinces or Yerevan only. Some projects have also made it to implementation, such as, investing in new compacting vehicles for waste collection in Yerevan in

[3] National Statistical Service of the Republic of Armenia (NSS RA)

[4] AUA, https://wrl-ace.aua.am/research-and-policy-papers/

2014 and new sanitary landfills to be constructed in 2020. The Consultant has collected new information during this project but also earlier in conjunction with the procurement of services for *"Waste collection and sanitary cleaning services including winter maintenance in Yerevan City" (2013)*

Some of the studies and project plans of interest are listed below:

- *"Report on the Evaluation of the Current Municipal SWM in Yerevan" (WB, Fichtner, 2008).* This report investigates the whole SWM system in Yerevan including the dumpsites in the vicinity and with concern to technical, institutional, and financial aspects. It also discusses waste quantities and composition. Many of the challenges described herein, such as poor sanitary conditions connected to waste chutes and use of old and inefficient vehicles are still valid.
- *"Armenia Solid Waste Management Improvement Project" (ADB, Cowi, 2013).* This report describes SWM systems in Lori, Ararat, Gyumri and Kotayk, and suggests sector development plans, institutional changes, and PPP setups. Observations on issues in waste collection and disposal are similar to the Fichtner study.
- *"Feasibility Study for Solid Waste Management Improvement in Shirak" (ADB, Cowi, 2015).* This study focuses on the Shirak marz, existing system and amounts and proposed development, improved operation of collection and landfills, financial setups, tariff increase and more.
- *"Feasibility Study on Integrated Solid Waste Management System, Vanadzor, Armenia" (I&U, ATMS, ERM, 2014).* The report investigates the feasibility of development of three Waste Management Zones (WMZ) to adopt waste management systems that reflect European standards. It emphasizes the need for decentralization and pragmatic approaches for stepwise modernization, for instance, if one or more landfills should be constructed to serve the different cities within the marz and different collection systems (containers etc.). It is suggested that one municipality (here Vanadzor) takes the lead to form a municipal company and that other municipalities contribute following their financial and organizational capacity.
- *"Solid waste management in Armenian cities – the experience of the USAID-funded Armenia Local Government Program – Phase 3 (LGP3), USAID, 2010).* This relatively short report pinpoints some interesting things regarding for instance the ratio between public and private SWM companies, service delivery, willingness to pay and payment ratio, and financial sustainability.
- Republic acts and other relevant legislation
  - *"Landfill design and exploitation manual "(Minister of Urban Development of RA, Order #321-A, 29 December 2009).* Here, requirements for location, design, operation, and closure of landfills can be found. From the study visits made within this report's scope, it can be noted that few of these requirements are followed. For instance, the dumpsites are not fenced, there is no compactor or bulldozer for levelling the waste, and hazardous waste is disposed of mixed with other wastes.
  - *"Development Strategy of the Republic of Armenia for 2017-2036 on Municipal Solid Waste Management System" (Government Decree #49, December 8, 2016)*
  - *"The Strategic Implementation Action Plan by the Protocol Decision No. 13 of the Government of the Republic of Armenia" (March 30, 2017)*
- Inventory of all dumpsites in Armenia, carried out by the Ministry of Territorial Administration and Infrastructure
- Planned project "*Yerevan Solid Waste Project*, for the construction of a regional waste landfill in Nubarashen district to serve Yerevan, Aragatsotn and Armavir provinces

- Planned project *"Kotayk and Gegharkunik Solid Waste Management Project",* supported by EBRD

There are also a number of studies specifically on hazardous waste in Armenia, but most of them are focusing on obsolete chemicals and contaminated sites not considered relevant for this study. Some of the studies include:

- *Updated National Implementation Plan for the Stockholm Convention on Persistent Organic Pollutants (POPs), 2017*. The report comprises a very ambitious action plan for the implementation of the Stockholm Convention Protocol. Many of the actions proposed would be beneficial to the environment, like e.g. upgrade the current conditions at the landfills, but the number of actions seem unrealistic.
- UNDP-GEF Full-size Project: *"Elimination of obsolete pesticide stockpiles and addressing POPs contaminated sites within a Sound Chemicals Management Framework in Armenia"* Consulting Assignment: Detailed Design, Technical Definition of Works and Supporting Assessments/Studies required for the Removal of POPs Pesticides and Recovery of Associated Contaminated Soil along with Site Cleanup, Stabilization, Containment, and Monitoring applied to the Nubarashen POPs Burial Site (Yerevan, Armenia).
- Several other studies on obsolete chemicals and contaminated sites.

1.6 Waste statistics – a big challenge

Collection of waste statistics is one of the most difficult and challenging areas within data collection. Subsequently, comparing waste statistics between similar waste activities and different countries is also very problematic. Even within EU, this constantly emerges as a challenge and not seldom with a national political twist, despite having EU waste regulations in place as well as European associations, such as EURIC (European Recycling Industries' Confederation), FEAD (European Federation of Waste Management and Environment), Municipal Waste Europe, CEWEP (Confederation of European Waste-to-Energy Plants), ERPA, European Recovered Paper Association, ECN (European Compost Network).[5]

Some of the challenges connected to statistics related to collection are listed below.

- Data on collected waste amounts are not the same as generated amounts, since municipal waste collection services are often not extended fully. Waste may be collected informally or disposed of, buried or burnt at source.
- If there is no weighing of the waste in the truck or at the disposal site, the reported amount will not be accurate since volumes varies depending on, for instance, compaction rate and number of transfers.
- A contractor for collection or operator of a landfill site may lack in reporting, and even in case there is a monitoring agency with adequate time and resources for enforcement, it is hard to control and prove possible mismanagement. To understand and assess if the reported data on generated waste amounts reported are correct require deep familiarity with the type of operations by the inspecting authorities.
- The collector's capacity and knowledge about various types of waste and their standardization or classification may also be lacking and unintentionally, waste types are falsely documented or mixed. One example is infectious waste generated in hospitals and healthcare establishments. The notion of what is considered infectious, for instance the rate

[55] Swedish Recycling Industries' Association

of blood staining on cotton swabs to be classified as infectious, varies greatly among countries.[6] Hence, the amount of infectious waste may vary significantly between countries and healthcare establishments. Another example is construction and demolition waste. Even though there is a standardized system within the EU, it has been recognized that classification varies between countries; thus, it is difficult to compare notes. Moreover, some countries are including organic waste from commercial activities in household waste, some collect separate data.

For certain wastes, quantification could theoretically be carried out by using customs data on products import/retail and export. To start with, this approach ignores any private import or unofficial trade. Through informed estimates on products' expected lifetime, the generated amount of waste could be calculated. However, to understand and assess the amount of waste generated based on products that have been retailed during a year, is very difficult especially for products/goods with longevity.

- One example would be electronic devices that subsequently become e-waste. The number of electronic devices being discarded as waste varies greatly within a country and between countries, depending on, for instance, the standard of living, markets for used items, used products exported, obsolete e-waste in storage, etc.
- To monitor and control the export of used e-waste has been proved to be difficult in many countries and stealing of such wastes, especially discarded laptops, is common.[7] There have been cases of e-waste being exported to developing countries for "reuse", waste that in practice is obsolete and where the real reason for export is to avoid the costly waste management in Sweden. The size of this problem is unknown; the customs inspects only a few percent of shipping containers for import and export.
- To assess the amount of waste oil being generated in various activities such as car repair shops, based on import statistics on motor oil would be completely pointless. Oil is used in commercial as well as private activities, which means that not all motor oil will be used by car repair shops and that some of the oil is used during the engine combustion process.

For some waste streams, there are standards for calculations of the waste amounts generated per year, for instance for e-waste, but it should be noted that the work involved in such estimates is very time-consuming and the outcome still somewhat questionable. In this report, many of the methods suggested are focusing on reasonable approaches based on the consultants' collected extensive experience.

2. Municipal waste

2.1 Definition

EU[8] defines municipal waste as "*household waste and waste similar in nature and composition to household waste"*, further explaining it:

"The bulk of the waste stream originates from households, though similar wastes from sources such as commerce, offices, public institutions and selected municipal services are also included. It also includes bulky waste but excludes waste from municipal sewage networks and municipal construction and demolition waste."

[6] Project on healthcare waste for Baxter, USA (Sweco International AB, 2010)

[7] LL Bolagen, Recycling Center for e-waste, 2019

[8] EUROPEAN COMMISSION EUROSTAT Directorate E: Sectoral and regional statistics Unit E-2

In most countries world-wide, the local government is responsible for collection of municipal waste primarily for sanitary reasons and that is the case also in Armenia from the *"Law on Local Self Government"*. However, the exact implementation of these definitions in practical work varies slightly between different EU countries. In some places, particularly businesses and restaurants handle or arrange for treatment or removal of the "municipal" waste themselves.

In Armenia, it is the *"Law on Waste (adopted 24.11.2004)"* that defines waste in Article 4 *"Industrial waste and household refuse (hereafter referred to as "waste") remains of materials, raw materials, output, products and production derived from industrial activities and consumption, as well as goods (products) that lost their initial consumer attributes"*.

2.2 Existing situation and previous estimates

Collection

According to the Armenian Law on Local Self Government, waste collection and disposal service is one of the mandatory functions of local governments. Service delivery is generally high in cities and peri-urban areas but less prevailing in rural areas.

In most areas in Armenia, the local governments engage contractors for waste collection and disposal. Waste is usually collected in metal or plastic bins grouped in stations or along curbsides. In some areas, there are no bins so people bring the waste to the truck in bags or bins/small containers on the collection day. The system is called "the signal system" as the drivers give signal with the horn when entering different areas. With time, people learn when collection is due.

Restaurants are also using the bins for municipal waste and they pay a tariff to the municipality based on the restaurants' floor area.

Based on findings during this assignment and in Yerevan for the past 5 years the consultants note that the present collection is of substandard in several respects and needs improvement in terms of efficiency, sanitation, service delivery, occupational health and safety. Typical problem areas are the following:

- Large bins of 1100 L are commonly used and the lid is often open or broken, and the large openings invite any kind of waste, ranging from furniture and kitchenware, to large heaps of garden waste and construction waste.
- The absence of separate collection systems for bulky waste leaves the bins for household waste as the only option for residents to get rid of the large items.
- Tough handling of the truck-mounted bin lifts leads to damaged bin wheels, which in turn makes it impossible to roll the bins to the collection truck. It is time-consuming, inefficient and dangerous for the staff and people around.
- Concrete, gravel and other construction and demolition waste make the bins very heavy which puts pressure on the bin structure and especially the wheels.
- Since the bin stations or pick-up points are under-dimensioned, garbage bags and bulky waste items are left around the bins, effectively blocking the bins so that it again is very hard to bring them to the truck.
- The presence of construction waste, reinforced concrete, metal rods, wires etc. leads to damage to the compacting mechanism in the trucks. This is dangerous while loading, but also expensive in the long run since the compaction unit is either faulty resulting in reduced load on the truck or has to be repaired.
- The waste chutes and bunkers are a sanitary disaster because they are poorly maintained, open to rats and other animals and contain all kinds of waste that are hazardous to people in general and children in particular. Emptying a bunker or a storage area in a basement below

a chute is a tedious and unhealthy task, and an extremely costly way of collecting waste as both staff and the vehicle spend too much time per collection point.

- Another worrying trend is that after introducing the new compacting, high-capacity trucks in Yerevan in 2014 (capacity ca 11 m^3 compacted waste, which corresponds to ca 60-70 m^3 non-compacted waste), there are now areas that are again being serviced by the old, open trucks with capacity of only some 5-7 m^3. This seems to have happened because of difficulties for the current contractor to serve all areas with their own vehicles in accordance with the contract with the Municipality and thus, they have engaged sub-contractors for part of the operations.

Figure 4. Waste collection in Yerevan in 2013 (l) and in 2019 (r)

Tariffs

With the described collection method, it is impossible to charge each building or family for actual waste produced. Therefore, the tariffs are set as a fee per person per month. Today's most common monthly rate is 200 AMD per person, but the maximum rate allowed by law is 400 AMD per person and month. Alternatively, the maximum monthly tariff can be 25 AMD per m^2 of a residential building or apartment.[9] Restaurants pay a tariff based on service area in m^2.

According to representatives from municipalities[10], the willingness to pay the tariffs is low among the general public and the local authorities have to spend considerable time and resources to collect the fee. It is also a fact that the fees are not sufficient to pay for the services. In one visited municipality (namely, Vanadzor) the negative balance was stated to be 30%, which has to be covered by the municipal budget.

Recent estimate of the waste tariff collection rate in the Kotayk and Gegharkunik region is over 60%.[11] Previous surveys[12] in 25 cities showed that 75-80% of apartment building residents paid for service but only 60% of private houses residents. The willingness-to-pay was directly linked to the service delivery rather than social conditions.

[9] Ministry of Territorial Administration and Infrastructure: Procurement document for consulting services for Project Implementation; Support for Kotayk and Gegharkunik SWM project: Terms of Reference, section 1.5, page 60.

[10] Referring to the cities visited as part of this project (Yerevan, Hrazdan, Ararat, Vanadzor)

[11] ITB Kotayk and Gegharkunik Solid Waste Management Project (2019)

[12] USAID Armenia Local Government Program (2005-2010)

Estimates of waste quantities based on previous research

So far, there are no figures in actual weight for the quantities of the household waste taken to landfills because of the lack of weigh-bridges. This fact makes quantity calculations very challenging and unreliable as they have to be based on estimates instead of on recorded quantities.

In the Armstat report *"Environment and natural resources in RA for 2018"*, quantities of municipal solid waste disposed of at landfills for Yerevan city and the ten marzes have been listed. Based on this report and population per marz in 2018,[13] waste quantities in kg per person and day have been calculated according to the table below.

Figure 5. Estimated waste quantities per marz and the city of Yerevan (2018)

Marz	Population 1000 p	Waste quantity 1000 tons/a	Waste quantity kg/p, a
Yerevan city	1,081.8	310.2	286.7
Aragatsotn	125.4	3.6	28.7
Ararat	256.7	15.3	59.6
Armavir	263.9	15.4	58.4
Gegharkunik	228.3	17.7	77.3
Lori	215.5	16.9	78.4
Kotayk	251.6	33.8	134.3
Shirak	233.3	21.6	92.6
Syunik	137.6	14.1	102.5
Vayots Dzor	49.0	9.4	191.8
Tavush	122.2	11.9	97.3
Total	2,965.3	469.9	158.5

These data are reported by urban municipalities to the Statistical Committee on an annual basis. The figures are estimates based on how many trucks of certain size have entered the landfills or dumpsites; however, it is unclear if the municipalities calculate this in the same way, if there is a common methodology, and if the estimates cover all transports to the landfill taking into account that few of them have on-site gate staff. It is also not clear how and if rural communities bring their waste to these or other sites, and if the data collection distinguishes between household, commercial, and industrial waste.

Comparing the above with data from 2015, it can be concluded that these figures vary too much to be reliable. For instance, the reported waste quantity for Aragatsotn was more than five times higher in 2015 (22,000 tons) and twice as much in Tavush (22,400 tons). One may assume that municipalities with a predominantly rural population would have less (collected) waste per capita due to lacking waste collection services and consumer patterns, but the correlation here is not entirely clear as, for instance, Ararat has more than twice the quantity per capita compared to Aragatsotn.

A factor which affects the above calculation is the coverage of waste collection. If, for example, 20% of the population lack collection it would mean that the actual waste volume per capita would be 20% higher than calculated. It is a fact that the collection coverage is lower for the population living

[13] Armstat, Armenia in figures 2018

in the outskirts of the cities and in the countryside, but there is no reliable information of how much this corresponds to. The coverage between the years 2006 and 2010 increased by between 11 and 30% for various areas, but the current coverage figures cannot be found.[14] The coverage has most likely continued to rise, so the actual figure outside Yerevan is assessed to be 70%. In Yerevan, the coverage is estimated to be 100%.

As the standard of living and the business activity vary a lot between Yerevan city and the rest of the country, it is relevant to work with different figures for Yerevan and other cities. Using this approach, the figures derived from the above table show the following waste quantities:

Figure 6. Waste quantities in Yerevan and marzes (2018)

City/marz	Waste quantity kg/p,a	Collection coverage %	Adjusted waste quantity kg/p,a
Yerevan city	287	100	287
Marzes	85	70	121
Total country			196

These estimates may be compared with data from neighboring countries and countries with similar conditions although it should be noted that waste statistics in general is very unreliable for a number of reasons. One example is the current revision of national legislation in EU countries to adjust to the amendments in the EU Directive 2008/98/EC on waste, which includes changes in waste definitions to improve the coherence between different nations' data (see also section 1.6 Waste statistics – a big challenge). The following table shows data on waste quantities from some selected countries.

Figure 7. Municipal waste generation in selected countries

Country	Waste quantity kg/p,d	Waste quantity kg/p,a	Reference
Romania	0.73	266	Eurostat; Municipal waste by waste management operations, 2019
Turkey	0.94	345	*Waste Atlas*. University of Leeds and ISWA. Retrieved 6 April 2015.
Azerbaijan	0.81	295	The State Statistical Committee of the Republic of Azerbaijan 2018
Georgia	0.62	225	The EU Neighbors Portal 2018
Uzbekistan	0.74	270	State Committee of the republic of Uzbekistan on Statistics (SCS) 2016
Armenia	0.54	196	

As can be seen, the average waste amount in Armenia - 196 kg per person and year - is low in comparison with all the countries shown in the table. There are some factors which could explain part of the difference. One reason is that countries have different definitions for their waste streams. As mentioned earlier, even between the EU countries it is difficult to compare waste quantities because of differences in waste definition and methodology for data collection. Another reason is

[14] USAID 2010-08-26 Sustainable SWM

errors in the statistics collection which is quite common, since waste in general is a very heterogenic material and the number of samples cannot be statistically fully satisfactory for practical reasons. Nevertheless, it gives a rough idea on where Armenia is and possibly where it is going in comparison with countries that have had strong economic development.

The National strategic plan from 2012[15] estimates higher values for Armenia, namely 274 kg per person and year for Yerevan, and 219 kg per person and year for cities bigger than 100,000 population and 146 kg per person and year for all other rural communities.

For Yerevan, a consulting study[16] from 2008 estimates the waste quantity in Yerevan to be 240-260 kg per person and year. Another consulting study estimates the volumes to be 241 kg per person and year in bigger cities, 208 in medium-to small cities and 147 in rural communities for year 2020.[17]

Based on the above, the Consultants recommend the following figures as basis for design of collection and disposal in the year 2019:

Yerevan city	300 kg/p,a
Marzes, average	220 kg/p,a

Using the above figures, the waste generation in Yerevan and the marzes can be calculated as follows in the below table.

Figure 8. Summary of estimated municipal waste generation for the year 2019

City/marz	Population	Waste quantity kg/p,a	Waste quantity t/a
Yerevan city	1,081,800	300	324,540
Aragatsotn	125,400	220	27,588
Ararat	256,700	220	56,474
Armavir	263,900	220	58,058
Gegharkunik	228,300	220	50,226
Lori	215,500	220	47,410
Kotayk	251,600	220	55,352
Shirak	233,300	220	51,326
Syunik	137,600	220	30,272
Vayots Dzor	49,000	220	10,780
Tavush	122,200	220	26,884
Total	2,965,300	249	738,910

[15] *) Strategic Development Plan, Road Map and Long Term Investment Plan for the SWM Sector in Armenia, Interim Report. Asian Development Bank (ADB) and COWI, July 2013.

[16] Final Report December 2008: Report on the Evaluation of the Current Municipal SWM in Yerevan (Fichtner)

[17] Feasibility Study, Integrated Solid Waste Management System, Vanadzor (I&U, ATMS, ERM)

Future waste generation

For design purposes, it is necessary to assess the annual increase of the waste production, with due consideration to recycling and other effects. Also, the estimated population growth must be established.

In the absence of reliable statistics, experience from other countries and general assessments may be used to arrive to a plausible value of the future waste generation. Two main factors for the predictions are:

- the economic development in the country
- the level of waste minimization and recycling

Yet another important indicator is the coverage of the collection systems that may help assess the amounts of waste that is in fact available for treatment. At present the coverage rate is deemed almost 100% in Yerevan but lower in the rest of the country. As described earlier the consultants estimate the coverage outside Yerevan to ca 70%. With the present standard of collection, it is highly probable that 100% coverage in the outskirts will not come true until after 5-10 years.

Some previous studies[18] estimate that the municipal waste volume going to disposal in Yerevan will increase by 50% in the next 20 years, starting from 2008. This corresponds to an annual growth of about 2%.

There are some initiatives, plans and ideas on recycling schemes in Yerevan and other cities. However, taking the current standard of the collection and disposal system into account, as observed and reported in SWM studies referred to in this report, and realizing that the challenges at, for instance, Nubarashen landfill were exactly the same 15-20 years ago, it is not assumed that things will change very quickly, that recycling will have been implemented on large scale or have a great impact on waste statistics in the next 7-10 years. The import ban from large buyers of recovered waste, such as China, should also be considered, since the global market keeps changing (see more under Recommendations). Thus, it is estimated that the municipal waste volume will keep going up with about 2% per year for the next 10 years. This would, based on previous estimates, lead to the following estimated waste volumes for 2019 - Yerevan City 300 kg per person and year and for marzes 220 kg per person and year on average.

Population increase

Historically, the population in Armenia has grown as shown in the following table.[19]

[18] "Report on the Evaluation of the Current MSWM in Yerevan" (Fichtner report (2008) and "Armenia SWM Improvement Report" (COWI, 2013)

[19] Worldometer. The population data differs somewhat from the figures in Armstat, however it is the approximate relative difference that is of interest.

Figure 9. The population in Armenia per year from 1955 to 2019.

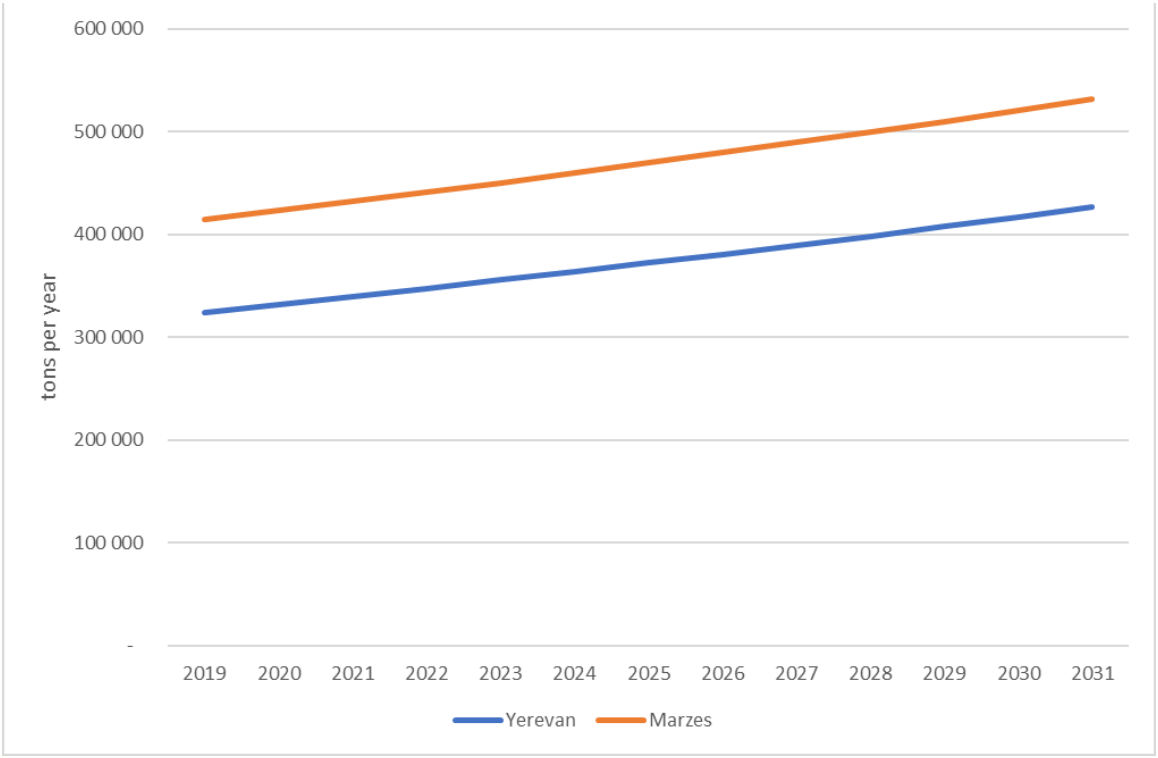
Year	Population	Change per year
2019	**2,957,731**	0.20%
2018	**2,951,745**	0.24%
2017	**2,944,791**	0.29%
2016	**2,936,143**	0.36%
2015	**2,925,553**	0.33%
2010	**2,877,319**	-0.71%
2005	**2,981,269**	-0.58%
2000	**3,069,591**	-0.94%
1995	**3,217,348**	-1.88%
1990	**3,538,171**	1.18%
1985	**3,335,940**	1.48%
1980	**3,099,754**	1.82%
1975	**2,832,759**	2.33%
1970	**2,525,068**	2.69%
1965	**2,211,319**	3.36%
1960	**1,874,121**	3.69%
1955	**1,563,507**	2.93%

The last 10 years the population growth rate has dropped to about 0.2-0.4% per year, with the two last year's marking 0.2%. With the new government in place, the population is expected to increase although not very fast following the previously shown trend. Most likely the growth will be higher in Yerevan than in the countryside as urbanization is a clear and increasing trend in Armenia as elsewhere in the world. In the figures below, the estimated municipal waste generation increase and total volumes for Yerevan and marzes can be found.

Figure 10. Estimate of municipal waste generation increase

City/marz	MSW quantity (2019) kg/p,a	Annual waste increase %	Annual population increase %
Yerevan	300	2	0.3
Marzes	220	2	0.1

Figure 11. Projected municipal waste generation for Yerevan and marzes until year 2031



2.3 Guidelines and methodology for quantification of MSW

To make values for quantities of MSW useful, one must arrive at a figure which is tied to the population, usually the unit kg per person and year (kg/p,a) or per day (kg/p,d). Thus, the methodology is to start by selecting an area where the population is known and measure the waste generated in the same area. The measurement of the waste amount must be done by weighing, normally by weighing the trucks transporting the waste. Thus, weighbridges are required. This is a problem in Armenia where no landfills have such weighbridges. However, movable weighbridges may be rented in Yerevan and possibly elsewhere, alternatively other companies' or institutions' weighbridges may be used, such as the one used for customs.

Here, two alternative methodologies for waste quantification are proposed.

1. **Weighing waste trucks**

   There are reliable figures for the population of a whole city or village in Armenia. Thus, to weigh all the MSW collected in the city during a specific time period will give a correct value of the waste per inhabitant per time unit. To get representative values the tests should extend over periods long enough to cover the seasonable variations. Alternatively, a series of shorter tests during different periods of the year can be done. If there is no waste collection in certain remote areas, the population of such areas should be excluded from the calculations.

   If there are population figures for parts of a city, the test can be done for such areas. However, the test will not give as representative values as for the whole city. Influx of tourists or other seasonal changes in number of people staying in the area must be taken into account.

2. **Weighing separate bins**

   If no weighbridges are available, tests can be carried out by weighing separate waste bins using a movable scale. Such scales with a capacity up to 100-200 kg are available at reasonable prices. As it is normally not possible to weigh all bins in a city, a selection of bins should be made. It is important to pick bins all over the collection area to get figures which are representative for the

whole city. The method requires that the population serviced by the selected bins is known. With the curbside system, though, the exact population connected to each bin will be difficult to know for certain and people (and businesses) may also use different bins from time to time. Consequently, the tests have to be done as a project outside of the normal collection service, in a well-defined area where these factors are known. A separate truck and crew will be required, since the weighing of each bin will be time consuming and slow down the collection service considerably.

2.4 Guidelines and methodology for municipal waste composition analysis (WCA)

Many countries carry out waste composition analyses (WCA) on particularly municipal waste for the purpose of better planning and designing waste collection systems or treatment plants, for instance. It can also be used to investigate how much hazardous or packaging waste is left in the MSW stream, and thus, how effective the legislation or separate collection systems, if in place, actually are.

The methodology that has been used in Armenia during this project is based on the Swedish manual for waste composition analysis, Report U2013:11, which is not a legally binding document in Sweden, but a result of the collective work of the Swedish Waste Management Association which represents all the Swedish municipalities and has been used for more than 4,000 tests. The methodology is to a large extent in compliance with the EU document "Methodology for the Analysis of Solid Waste (SWA-Tool)" of 2004, which is also a guide only and not an EU Directive.

A more comprehensive description of the manual is included as Appendix 1.

A proper waste composition analysis requires good preparation, a detailed plan for the work and reliable, well trained staff to carry out both sampling and the manual sorting of waste samples. Improper methodology and careless or inconsistent work will give unreliable results.

The work must be planned and supervised by an experienced expert. The actual sorting work may be carried out by local staff after having undergone ½-1 day of training. The important parameters are:

- Definition of the fractions to be sorted out
- Taking out representative samples of waste
- Careful sorting, following the exact fractions that have been pre-defined
- Proper handling and weighing of the sorted-out fractions
- Presentation of the results in a clear and logical way

For practical purposes, it is convenient if a site for sorting can be arranged at or close to a landfill, but other places can naturally be used. It should not be located too close to dwellings (minimum 500 m)

The guide is primarily aimed at manual sorting of municipal waste. The methodology consists of the following main steps, which have also been taken in this project's WCA:[20]

1. Planning
2. Preparatory studies
3. Sampling
4. Preparation of samples for manual sorting
5. Manual sorting
6. Analysis

[20] All photos below are taken by the consultants as part of this WCA and show key activities and staff involved.

Planning and preparation

- Decide the purpose of the sorting project through stakeholder meetings
- Start to plan practical work early, preferably some months ahead.
- Prepare a detailed time schedule and a budget for the project
- Preparations such as vaccinations, procurement of protective clothing and gear
- Training of the sorting staff

Preparatory study

- Collect and document relevant facts about the analysis area
- Decide what quantities of waste, for instance, how many cubic meters, truck loads or bins to be collected
- Decide stratification[21] criteria with regard to the desired results
- Plan representative routes within each sub-area which have the desired waste types[22]

Collection of "mother" sample

- The mother sample should be about 45 m^3 or 45-60 bins (1100 L), corresponding to 0,5-1 truck load
- Plan routes in detail and work closely with collection staff
- Avoid too much compaction in the collection truck and make sure that bulky items are removed
- Weigh the truck full and empty (if tare weight is not known)
- Record relevant facts about the route (No. of households, collection frequency, etc.)
- Protect the collected mother sample from external impacts, e.g. rain, wind, animals etc., if it must be stored for a day or two
- Make sure the sorting area is ready including that the tipping area is paved and clean, or covered by a sturdy tarpaulin.
- Make sure that staff is ready with equipment and protective clothing

[21] Subdivision of the in-homogenous parent population into more homogenous sub-populations, e.g. high-rise areas, villa areas, commercial areas, called strata

[22] For details on stratification and preparing the waste collection, see Appendix 1

Taking out sub-samples

- Mix the mother sample carefully with a wheel loader with least possible crushing of the waste, possibly after cutting some bags open
- Put the waste in a long string or in a square
- Take the sub-samples randomly along the string, or choose every second square when using the quartering method
- Take out about 500 kg, preferably as 5 sub-samples, each of about 100 kg
- Take out any obviously misplaced bulky item, such as furniture, household machines, computers, etc. found after emptying the truck/ bins
- Place the sub-samples in plastic bins with lids or plastic bags to protect them from external impact
- Mark the bins/bags clearly with water resistant paint
- Manual sorting should commence within 1 day (summer) or max 2 days (winter) after collection

Manual sorting

- Check that the sorting staff equipped in accordance with specified lists
- Start the manual sorting
- Take photos of the work and the fractions for reporting and backtracking
- Weigh all fractions after the sorting is finished
- Fill in the weights in the data sheets

Analysis

- Assemble all documentation including purpose, methodology, background about the areas and the waste, results and photos
- Calculate the results of the sorting operation
- Make corrections for moisture and dirt
- Make comparison with other results of sorting analyses, if any
- Discuss possible sources of errors
- Write a report with the above including important observations and conclusions

Closure of the sorting project

- Save excess materials like bags, containers, paper rolls, etc. for future tests
- Clean plant and all equipment carefully with cleaning agents and water
- Clean floors and tipping area with water and brushes
- Make sure no waste or other debris is left on the site

An illustrated summary of the various steps in the process can be found in Appendix 1.7.

2.5 Approach and methodology of WCA in Armenia

In this project, sampling and analyses were carried out in six cities – Yerevan, Vanadzor, Hrazdan, Ararat, Kapan and Gyumri.

In order to have comparable results, it was decided to choose only residential waste in the first test, preferably from chutes where there is less influx from commercial waste. In the second test, curbside bins were sampled, so primarily waste from low-rise buildings, villas and some commercial waste. In the third test, areas with high density of commercial activities and restaurants were targeted.

The staff conducting the waste composition analysis underwent both in-class and field "learning by doing" training carried out by the Consultant. The three tests in Yerevan were carried out under supervision of the Consultant while the others by the local team only. Before sampling and sorting started, a small workshop was held with the local team discussing the methodology and practical arrangements, risks and data management plus final decision on stratification and collection routes in Yerevan in detail.

Choice of fractions should be made in each test depending on the ultimate goal of the analysis. In places where only the main fractions - organic waste, paper, plastics and inert material – are of interest, it is enough to have five to six fractions. Where more extended collection is done, the goal is normally to establish the basis for sorting out more materials; hence the number of chosen fractions will be higher. The number of fractions chosen for Armenia is in accordance with the EU recommendations, which is high and includes in principle all fractions of interest for an advanced collection service, which was also good from an educational point-of-view. The nine main groups and 22 sub-fractions are shown in the table below.

Figure 12. The main groups of waste types and the 22 waste fractions for WCA

	Organic	Kitchen waste Garden waste Other biodegradable (e.g. bones, animal remains, feces)
	Paper and cardboard	Newspaper and print Corrugated cardboard Paper packaging Other paper (e.g. postcards, books with hard cover, tickets)
	Plastics	Soft plastics packaging Styrofoam Dense (hard) plastic packaging Other plastics (e.g. toys, disposable cutlery, tooth brushes)
	Glass	Glass packaging Other glass (e.g. drinking glasses, mirror glass)
	Metals	Metal packaging Other metals (e-g-frying pans, cutlery, screws)
	Other inorganics	All other inorganics (e.g. cat sand, ceramics, stones, gravel)
	Hazardous	All hazardous waste (e.g. syringes and other sharp objects, medicine, paints and solvents, oils, pesticides)
	Mixed WEEE	All electric items, battery or high voltage
	Other	Wood Textiles Diapers, sanitary napkins, etc. Other, not applicable elsewhere (e.g. shoes, rugs, bags, rubber)

Tests in Yerevan

The research team, in consultation with representatives from the Ministry of Territorial Administration and Infrastructure, decided to carry out three tests in Yerevan, based on a stratification strategy with three distinguished areas defined:

- Test 1: Sub-area 1: High-rise residential areas with waste chutes
- Test 2: Sub-area 2: Villas and low-rise residential area, curbside bin collection
- Test 3: Sub-area 3: Commercial areas with high restaurant density

The tests were carried out both day and night during the period 7-12 June 2019. After nightly sampling, the sorting at Nubarashen was carried out early in the morning, thus minimizing the time for storage of the waste.

- For **collection** of the mother samples (three samples of ca 4-5 tons respectively), a heavy waste truck (22 m^3 capacity) with crew was provided by the Municipality of Yerevan. The truck was weighed at a weigh-bridge owned by a private company in the vicinity of Nubarashen landfill.
- For **mixing** of the mother sample, a front loader (JCB) was hired.
- The **sorting area** was arranged at the Nubarashen landfill by the Municipality of Yerevan. It was levelled out with a relatively hard surface area although not paved, so a tarpaulin was used as base.
- **Sorting equipment** was procured according to the list in Appendix 1.6 including protective clothing for the sorting staff. The equipment was stored in a big van for mobility.

The WCA was initially planned to start with urban households in multi-story residential buildings in Yerevan, but the first tests were carried out at night and the residential areas had to wait until the third sampling. In the table below, the three tests are described.

Figure 13. Stratification for WCA in Yerevan

Test 1	Test 2	Test 3
High-rise residential areas with chutes	**Villas and low-rise residential area, curbside bin collection**	**Commercial areas with high restaurant density**
About 50 bins mostly of size 1100 L were collected in 5 districts with high-rise buildings and waste chutes.	About 50 bins of size 1100 L were collected in 5 districts with low-rise buildings and curb-side collection.	About 50 bins of size 1100 L were collected in 5 districts with commercial areas with high density of restaurants.

Tests outside Yerevan

The tests outside Yerevan were carried out by the local WCA team accompanied by an AUA representative during the period June 17 to July 20, 2019. In three of the cities, it turned out to be difficult to pinpoint commercial waste, so eventually 12 out of the planned 15 tests were actually carried out.

The Swedish experts reviewed the results later to identify any gaps. The five cities were selected together with AUA and MTAI based on the following factors to have a mix of various conditions:

- Population
- Geographical size
- Tourism influx
- Development, industry, etc.

The selected cities were **Vanadzor**, **Hrazdan**, **Ararat**, **Kapan** and **Gyumri**. In each city, the following three sub-areas were tested:

- sub-areas with focus on urban households
- sub-areas with focus on urban mixed household/commerce
- sub-areas with focus on peri-urban households, villas in the outskirts

In practice, it turned out to be hard to find, for instance, commercial waste in Ararat, and the sub-categories were not as clear-cut as in Yerevan in the smaller cities.

Figure 14. Stratification for WCA in other cities

City	Test 1	Test 2	Test 3
Ararat	Low-rise/Residential	Villas	
Hrazdan	Residential, high-rise chutes	Villas	Hrazdan/Tsakhadzor commercial
Gyumri	Residential, multi-apartment	Low-rise, commercial	Villas
Kapan	Residential + commercial	Villas	
Vanadzor	Residential, highrise chutes	Lowrise, villas + commercial	

The work was reported to follow the plan, and the only problem met was a storm with heavy winds that destroyed some equipment and delayed the time schedule.

No quantification could be done in any of the cities within the limited scope of this project because it requires the accurate population data connected to the selected bins which could not be calculated. Even if figures would be available, they are very uncertain particularly for the villa areas and commercial areas, because people are probably not using the same bins all the time and the waste emanating from businesses cannot really be tied to a certain population.

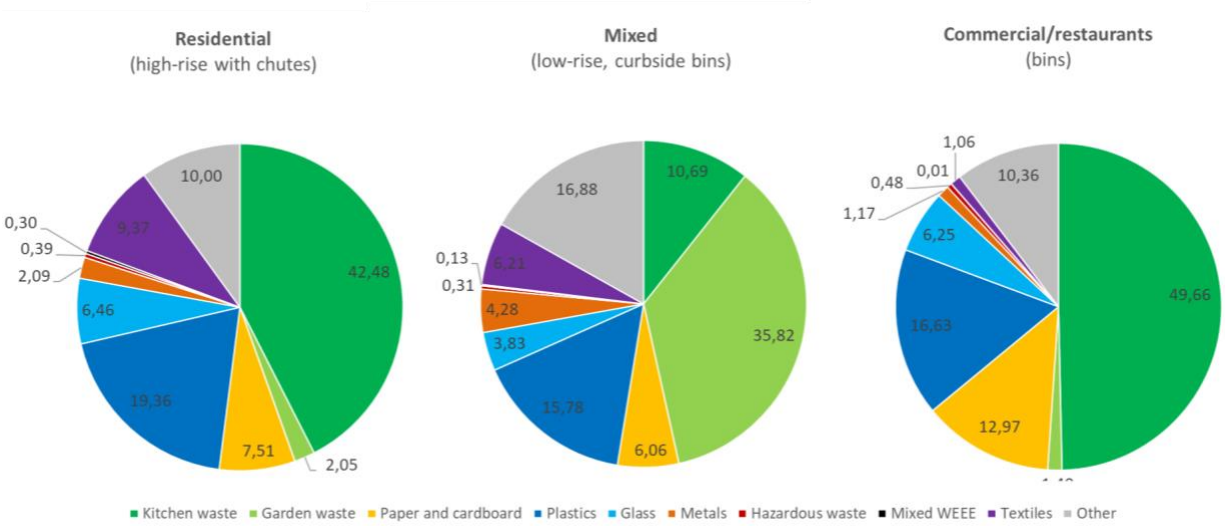
2.6 Analysis of the test results in Yerevan and other cities

The results of the individual tests 1-3 in Yerevan are presented in Appendices 2. including weight in kg for each fraction, standard deviation and percentages.

In the below graphs, the main waste fraction groups are shown for clarity for the three tests in Yerevan. These groups are:

- kitchen waste
- garden waste
- paper and cardboard
- plastics
- glass
- metals
- hazardous waste
- mixed WEEE
- textiles
- others, such as inorganic waste like gypsum, rocks, bones, etc.

Figure 15. Waste composition by weight in Yerevan per fraction



The general picture of the test results is that the sub-samples are relatively consistent with each other despite the relatively small statistical basis, and that most values are within a normal and expected range, based on the Consultant's experience. Here are some of the observations from the tests and main findings:

- During collection as well as sampling, it was observed that there is a lot of **bulky waste** including construction and demolition waste in an international comparison with e.g. Sweden or other countries with separate collection of such waste. In most places, that kind of waste was also littered and heaped around the bins, effectively blocking collection operation. In sampling, it was difficult to get homogenous results and some of this waste had to be removed not to affect the result too much.
- The waste was **relatively dry**, but very dirty and contaminated with clay, sand and particles which reduces the material value as well as fuel value of the material.
- Whole animal **carcasses** (sheep, chicken) could be found as well as sacks with feathers from ducks or chicken. For sanitary reasons including spreading of disease, this kind of waste should never enter the municipal waste collection stream.
- There are clear and expected differences between residential, curbside (mixed) and commercial waste, for instance more packaging and food waste in commercial waste, and more garden waste in curbside (villa) bins.
- Some of the results stand out with a bit unusual values, particularly for test No. 2. In this area with a mix of low-rise buildings and villas and some commerce, the kitchen waste amount is unusually low (ca 10%) while the **garden waste figure is very high** (36%). Since the sampling was made in five districts with several kilometers distance in between, it is not likely that the test happened to find an area with abnormal conditions. From this result as well as observations on site, it is conceivable that the large and publicly accessible curbside bins invite also large items including garden waste from public areas. This is further supported by the high amount of inert material in this test; most of it being sand and gravel which supposedly derives from street cleaning.

  The garden waste, and consequently the total amount of organic waste, is expected to decrease if the test would be carried out during the winter season. For multistory buildings in Yerevan, there was little garden waste, so it will be less impacted by the season.

- The **soft plastic** fractions are quite high in all test areas. The plastic fractions are dirty, as are the paper fractions, which adds to the weight.
- **Hazardous waste** fraction and WEEE (electrical appliances, batteries, etc.) fractions can only be found in small volumes, which is odd considering the absence of separate collection systems for these fractions. This is however typical for other tests in similar areas and cities, according to the Consultant's experience. It is a bit disturbing as it could indicate that the hazardous waste is disposed of elsewhere; for example, liquid hazardous waste as oils, solutions, paint, etc. may be emptied in the sewage network system or at dumpsites.
- The amount of **textile** (6-9%) was very high in residential areas, both in waste from chutes and in curbside bins, clearly coming from households.

In the photos below, there are some examples of sorted fractions – paper, cardboard and other waste (notably very dirty), the sorting table scattered with garden waste debris and soils and below two plastic fractions with crushed and torn bottles, and finally the small amount of hazardous waste found in a 100 kg sub-sample.

Figure 16-Examples of sorted waste fractions in the WCA in Yerevan and the sorting table (upper right)

A more detailed report on the WCA in Yerevan can be found in Appendix 5 and the results from Yerevan in detail in Appendix 2.

Comparison with previous waste composition analyses

During the years 1990 to 2006, five waste composition analyses have been carried out for the city of Yerevan, see the figure below. Now, these data can be compared with the WCA carried out in this project as well as a multi-country analysis in an EU project (Armenia plus Croatia, F.Y.R.O.M., Ukraine) from 2019. All analysis results are summarized below. The tests used slightly different fractions; thus, not all individual figures are directly comparable.

Figure 17. Consolidated data on MSW composition by weight (%) in Yerevan[23]

Test number	Date of analysis	Paper and cardboard	Food waste	Wood and leaves	Textile	Rubber and leather	Polymer materials	Bones	Ferrous metal	Non-ferrous metals	Glass	Stones and ceramics	Soil	Notes
1	1990	11.6	40.9	6.7	2.8	2	2	1.8	1.9	1.2	5.4	7.6	16.1	RA[24] 1990
2	After 1990	18	30	2	2	1	2	1.5	0.2	0.1	4	11.2	28	RA
3	2000	13.3	24.2	7.9	2.8	2	19.4	2.2	0	0	5.4	6.7	16.1	Shimizu 2000
4	2006	11.5	46.1	2.1	2	3.1	9.8	1.9	2.8	2.2	8.7	5.4	4.3	Shimizu 2006
5	2006	25-45	18-35	N/A	10	N/A	N/A	N/A	5			?	N/A	UNDP[25] 2006
6	2015	7.0	57.0		2.7	0.2	11.4	N/A	3.2	0.2	3.2	N/A	5.8	Enviroplan[26]
7	2019	8.9	34.3	13.1	5.6	N/A	17.3	N/A	2.5		5.5	4.3		LL-Bolagen[27] 2019

The variation between the tests is high in certain cases, so it is not wise to draw too far-reaching conclusions. For instance, the paper and cardboard fraction (test no 5) is extremely high and contradicts all other tests.

[23] Line 1-5: Fichtner Report on the Evaluation of the Current Municipal SWM in Yerevan 2008 . Line 6 and 7 added by LL Bolagen 2019

[24] The study was conducted in 1990 by a specialized organization based on methodologies developed by Panfilov Academy of Communal Economy. Source: Report on MSW for 2005, NSS of RA

[25] "Strengthening of Integrated Waste Management in Armenia", UNDP in 2006

[26] "Qualitative Analysis of MSW in Armenia, Croatia, Cyprus, F.Y.R.O.M. and Ukraine. Methodology and Results", Enviroplan, 2015.

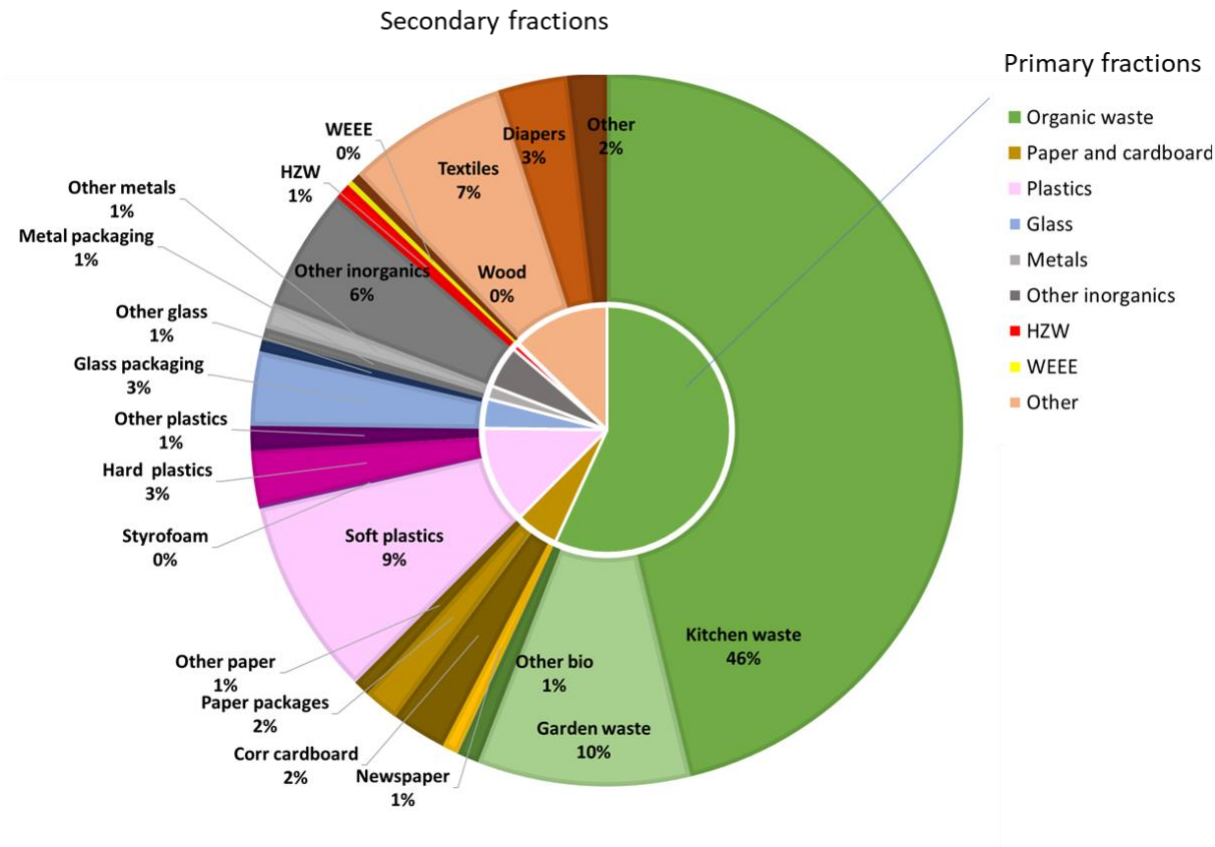
[27] "Waste Quantity and Composition Study". LL Bolagen AB, 2019

Some of the WCA results and findings are presented in the below figures together with the results from Yerevan. Detailed results for the tests outside Yerevan can be found in Appendix 3 and a summary of all tests in Appendix 4.

The waste was sorted into 22 fractions in the WCA, and after analysis of all cities, it turned out that there were certain fractions dominating each main group – for instance, “Soft plastic packaging” in “Plastics”, “Glass packaging” in “Glass” and “Textile” in “Other waste”. Thus, in the subsequent graphs, the main waste groups plus kitchen waste and textiles will be used for clarity.

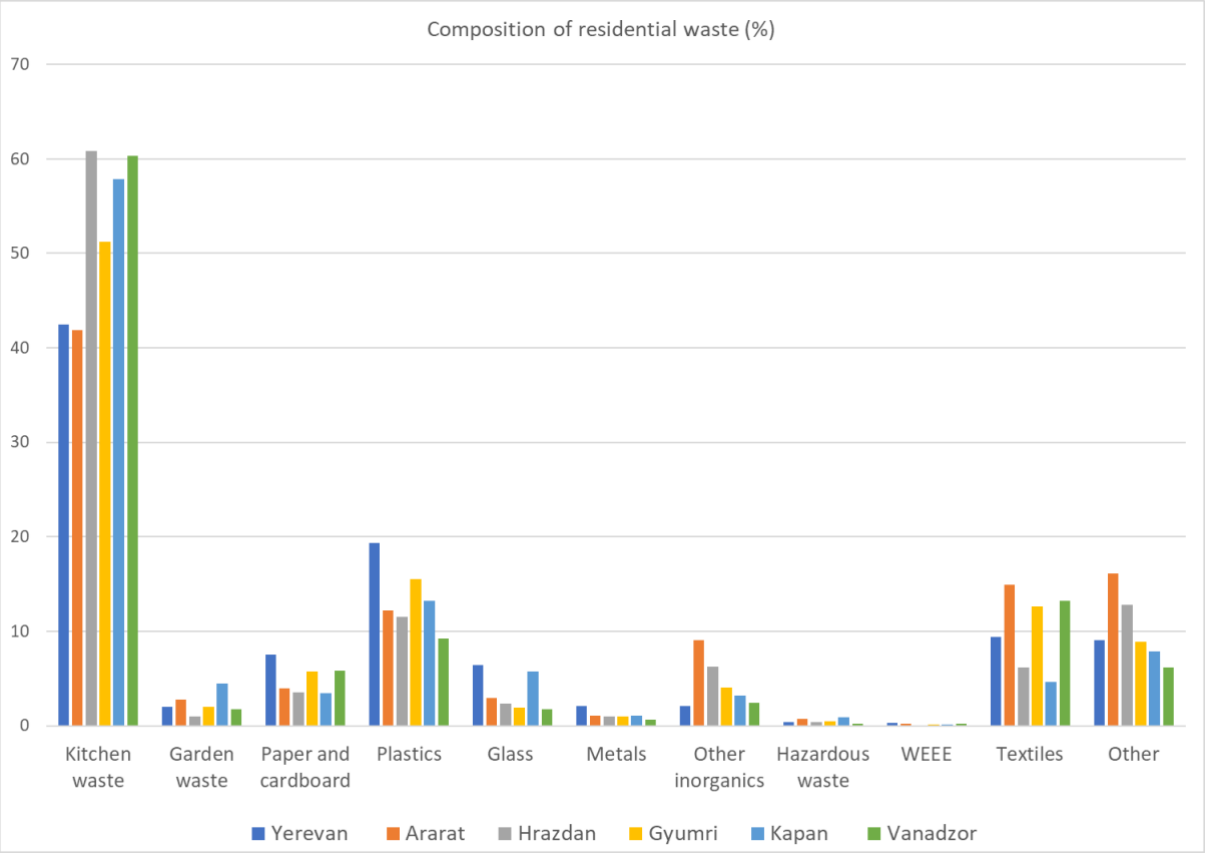
In the figure below, the average share of all fractions can be found. In the inner circle, there are the primary fractions (main waste type groups) and in the outer circle, there are detailed, secondary fractions. For the figures of 0%, the quantity was hardly measurable.

Figure 18. Average shares of each primary (inner circle) and secondary fraction (outer circle) in all six test cities



A comparison of the waste collected from **high-density residential areas**, predominantly multistory buildings with or without chutes, is made in the below graph for all six test cities.

Figure 19. Comparison of WCA results per main fractions from household waste[28] in the six test cities



Some observations in the results from **residential areas** are the following:

- Kitchen waste is generally high, but varies between 42 and 60%.
- Garden waste share is very low, which is logical since this is waste from apartments with chutes.
- Packaging material such as paper, plastics and glass is very similar in all cities, except for Yerevan where it is significantly higher. Glass packaging in Kapan sticks out at almost the same level as in Yerevan.
- Other inorganics, for instance sand from street sweeping, is quite unpredictable, three times higher in Ararat as in Yerevan and Vanadzor in this case.
- Textiles varies a lot and is somewhat high, from 4 to 15%.
- The "Others" fraction is relatively high which may be due to some heavy items, such as wet rugs, shoes, bags and rubber items, but also the high weight of diapers and wooden items. Even though some large items, such as furniture and large coats were removed prior to sorting, this fraction is likely to vary depending on certain activities in residential areas, such as renovation, or transition with inflow of young families with toddlers.

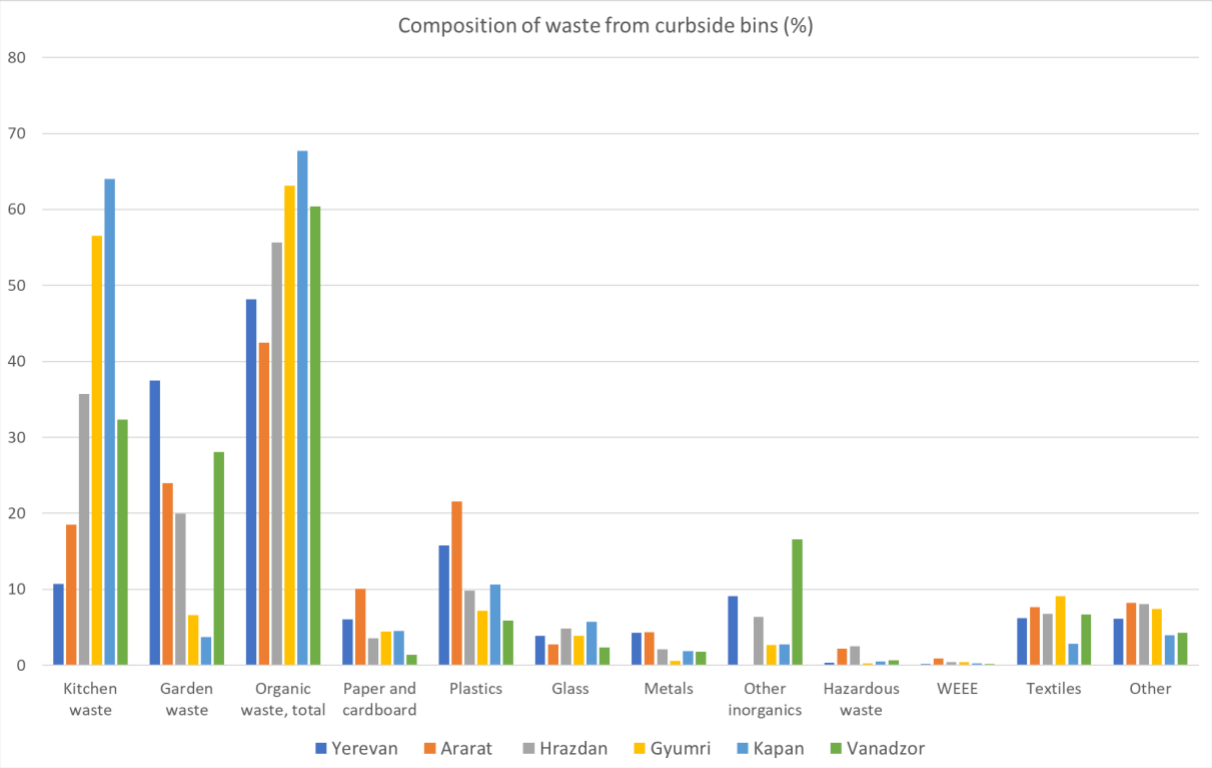
The rationale for having the above results separate is to be better prepared for future calculations and international comparison if focusing on household waste only. Since the curbside bins placed in areas with low-rise buildings contain waste from both private households and commercial activities,

[28] Waste collected from chutes or bins in residential areas with high density and multi-story buildings.

it is hard to distinguish between the two and thus also to use this for future strategies on, for instance, fee collection or separation collection of certain waste fractions from businesses.

However, a comparison of **mixed waste** from curbside bins in all six cities has been made, see figure below.

Figure 20. Comparison of WCA results per main fractions from waste in curbside bins in the six test cities

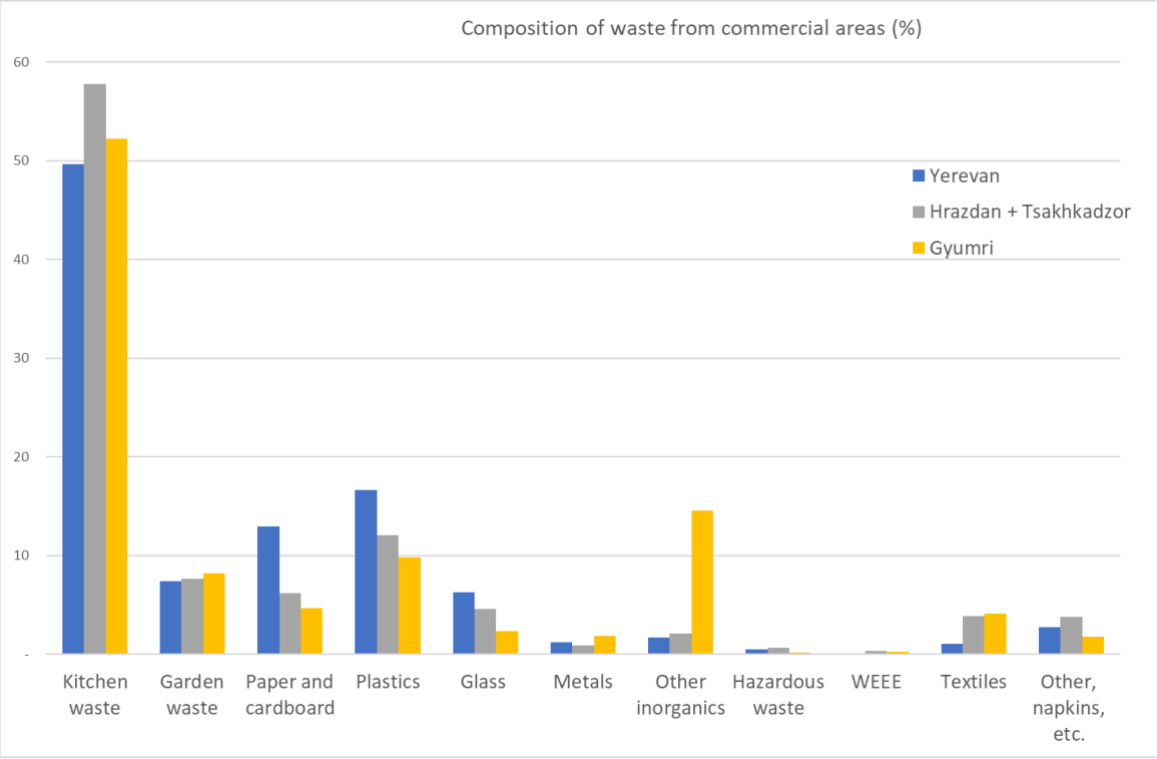


Some observations in the results from curbside bins with mixed waste are the following:

- For several cities, the amount of kitchen waste as well as garden waste is either very low or very high. The total organic content per city is however more even. This supports the previous observation that it is difficult to separate these two fractions in sorting. Ararat has the lowest organic content, possibly due to the waste being used as animal feed.
- Packaging of paper, plastic and glass is very consistent in all cities except Yerevan which has higher volumes. However, Ararat also sticks out with even higher amounts of paper and plastic packaging, which cannot really be explained. The test in Ararat was hampered with odd results in inorganic waste volume, which has been removed and thus affected the overall results from Ararat.
- Other inorganics, possibly ash, stones or gravel in Vanadzor amount to over 15%.
- Textiles are very consistent in all cities except Kapan with a smaller amount.

In three of the test cities – Yerevan, Gyumri and Hrazdan/Tsaghkadzor – waste from predominantly **commercial areas** may be compared (see figure below).

Figure 21. Comparison of WCA results per main fractions in commercial areas in three cities[29]



It can be noted that:

- Kitchen (restaurant) waste is high in all three cities (over 50%).
- Garden waste is very low (below 10%).
- Packaging of paper, plastic and glass is higher in Yerevan.
- Metals and hazardous waste including WEEE are found in very small quantities, in commercial areas as well as in the other tests from residential areas.
- Textiles in all three cities are much lower than in the previous comparison of residential waste.
- Again, the inorganic content is very high in the Gyumri test for some reason, possibly street sweeping or misplaced construction waste.

Finally, it should be noted that the above observations and findings are based on a few tests only. To gradually build up more accuracy, the WCA must be repeated. It is recommended to make another test shortly, probably in February, to also add parameters like colder weather conditions (more humidity) and less organic waste (from gardens and harvesting).

Most importantly, though, is to make the data collection more specific when certain data is of interest, say amount of organic waste for possible investment in biological waste technology such as a biogas reactor or composting plant. The calculated generated amount of organic waste, still, is not automatically accessible for collection and may not be suitable for the treatment in question either.

[29] Waste collected in areas with predominantly commercial activities and restaurants. In the three remaining test cities, the commercial waste was mixed with household waste to a larger extent.

3. Bulky waste

3.1 Definition of bulky waste

Bulky waste is household waste which is too large or too heavy to be accepted by the regular waste collection. Bulky waste items include discarded furniture (couches, recliners, tables), large appliances, plumbing fixtures (bathtubs, toilets, sinks), grass mowers, etc. In many countries, Sweden for example, also smaller appliances and tools are included in the definition.

In the Law of the Republic of Armenia "on waste disposal and sanitary cleaning" (2011) the bulky waste is defined as:

Article 3, Garbage: *"c. large-scale waste, generated or consumed by legal entities or individual entrepreneurs as a result of human activities, which, due to their physical properties (including size, volume or weight), cannot be collected, stored or transported for domestic waste by commonly used technical means."*

3.2 Existing situation and data

There is no organized collection of bulky items in Armenia. Therefore, inhabitants use the bins for municipal waste, which adds to the continuous overfill. The waste that does not fit into the bins is simply dumped on the ground next to them or on empty lots. It is likely that some residents ask contractors to take bulky items like furniture, kitchen appliances, etc. to the landfill or bring them there themselves. The company Davars, which is contracted by Yerevan municipality to collect construction and demolition waste (CDW), also collects bulky waste as an extra service.

Like in any other country, there is an informal market where people sell the old items like furniture to friends or through internet sites. This reduces the waste going to dumpsites or landfills and is part of an increasing circular economy.

As a result of the non-existent regulated collection, there is no information about quantities or where the bulky items are disposed. Like for other waste streams in Armenia, it is necessary to use numbers from other countries to get an idea of the volumes. As the volume of bulky items has a direct relation to the standard of living, it can be safely assumed that the volume per person is considerably higher in Yerevan than in the rest of the country.

In Sweden, like in the rest of Europe, the volume of collected bulky waste has increased steadily during the last decades. Today, it amounts to about 1/3 of the total MSW quantity (170 kg per person and year out of totally 477). In Armenia, the volume is very hard to assess since the collection is mixed and the level of reuse, second hand markets etc. is unknown. The economic conditions on average indicate lesser generation, but this implies to all kinds of waste. Thus, the ratio between bulky waste and MSW is assumed to be the same. Based on an MSW collection of 220-300 kg per person and year in Armenia in general, the bulky waste is assessed to about 70-100 kg per person and year, the higher figure for Yerevan.

Since the bulky waste constitutes a problem for the efficient collection of normal MSW, it is important to arrange separate collection of the bulky items. Some alternative methods are presented in the recommendation section.

3.3 Guidelines and methodology for bulky waste inventory

Determination of the quantities and composition of the bulky waste must be done in the same way as for municipal residential waste: to take out representative samples of the waste, sort it manually and weigh the various fractions. As the bulky waste contains bigger and heavier pieces the sorting process will require more space and some equipment to handle the heavy pieces. Also, the samples must be larger than when sorting MSW.

However, as there is no official collection and no reception places for bulky waste it is not possible to take out samples for the testing. It would take very special methods to collect representative samples as registration of the waste owner is more or less impossible.

Before organized collection of bulky waste is arranged, the only reasonable way to get some approximation of quantities is to inspect a number of sites for municipal waste bins and make visual estimates of number of bulky items, the frequency of them and the approximate weights. By assessing the approximate population near the studied container sites an approximate volume per inhabitant can be calculated. Again, the estimated quantities will be very approximate.

If and when separate collection of bulky waste is arranged, or when recycling stations as described later in this report are set up, it will be possible to obtain better data on population and waste quantities which can be used to calculate more reliable statistics of quantities for bulky waste.

4. Construction and demolition waste

4.1 Definitions

The Law 237-N of the RA 23.06 2011 defines construction and demolition waste as "*waste generated during urban development, construction repair, building reconstruction and demolition*".

The European Commission' defines and comments construction and demolition waste (CDW) as follows:

"Construction and demolition waste arises from activities such as the construction of buildings and civil infrastructure, total or partial demolition of buildings and civil infrastructure, road planning and maintenance.

Different definitions are applied throughout the EU, which makes cross-country comparisons cumbersome. In some countries, even inert materials and soil from land leveling are regarded as construction and demolition waste." In this study, the EU Commission's definition is used.

4.2 Existing situation and data

The largest part by weight of the CDW is heavy material, such as concrete, bricks, stones, steel and wood. Also excavated soil and gravel may end up as waste. Semi-light fractions are primarily dense plastic of PVC and HDPE which are used in pipes, sheets, etc. The most voluminous materials are cardboard and polyethylene plastics which are used in packages, as protection material, etc.

The municipalities have no legal responsibility for collection or disposal of CDW or other industrial waste. However, they can give violation citations to those who are caught disposing CDW or industrial waste illegally.

In the municipalities of Ararat and Hrazdan, which the consultants visited, the construction waste is collected by the private sector but disposed of at the municipal landfills. It is highly likely that the same situation exists in many cities outside Yerevan. In Yerevan, the municipality has contracted a private firm, Davars Co., to collect construction waste. The contract does not include bulky household waste, but the company's manager informed the consultants that they collect also bulky waste as an extra service. This implies that the bulky waste volume at present is very low. The company uses three open trucks to collect the waste and dispose it at two registered dumpsites. Before, the company took the waste to the Spandaryan landfill in the Ajapnyak district of Yerevan, but this landfill was closed in 2018.

No official statistics or other information about the quantities of CDW is available in Armenia, nor of its origin or disposal. Therefore, an assessment of existing volumes must be based on international experiences, adopted to local conditions.

It is evident that the majority of ordinary CDW arises from construction and demolition of buildings, both residential and commercial, while civil infrastructure works such as roads, bridges, pipelines, etc. mostly produce soil, excess masses of gravel and rock etc., which are normally not handled by the waste management system.

The CDW volumes have a direct relation to the construction activity in the country, the majority of which takes place in the greater Yerevan area. The building activities in other cities in the country are small in comparison to Yerevan, but will naturally produce waste of similar type.

The waste composition in CDW varies between construction and demolition. Construction waste contains mostly wood, metals (steel and aluminum), cardboard, paper, and polyethylene plastics while demolition waste is dominated by stone bricks, concrete, wood and, in newer buildings, steel bars and gypsum sheets. CDW from construction sites is collected and disposed of by the building contractor or by private haulers hired by the builder. Organized recycling of construction waste is non-existent, although according to local verbal information some steel or plastics is collected and sold by the private market.

An assessment of the generated CDW can be made using international statistics, see the table below.

Figure 22. Comparison of CDW amounts in different countries

Year	**Country**	**Population** million	**CDW** million ton/a	**CDW** ton/p, a	**References**
2008	Hungary	10	5	0.5	Eurostat 2016
2014	Germany	83	84	1.0	Eurostat 2016
2016	Sweden	10	10	1.0	Swedish EPA 2017
2016	UK	66	66	1.0	Government Statistical Service 2019
2017	Greece	10	4	0.4	Article in Fresenius Environmental Bulletin Sept 2017
2018	Albania	2.8	1.9	0.7	Strategic Environmental Assessment, Consulting study Prof Böhm und partners 2018
2018	Georgia	3	0.3	0.1	Total waste 0.3 t/p/a, CDW assessed to 0.1. EU in action 2018
2018	Ukraine	42	4.2-8.4	0.1-0.2	Bilfinger study. Waste management in Ukraine, Oct 5, 2018

Based on this material, a qualified assessment can be made. Armenia is made up of two areas with different situations: the greater Yerevan area and the rest of the country. In Yerevan, the construction activity is quite high and should be on the same level as southeast Europe, Ukraine and Georgia. The estimated volume is set to 0.3 ton per person and year. For the areas outside Yerevan, the figure 0.1 ton per person and year is estimated. With these assessments, the CDW volume in Armenia would be as follows in the below table:

Figure 23. CDW generation in tons in Armenia

City/area	Population	CDW generation (tons per year)
Yerevan	1.1 million	330,000
Outside Yerevan	1.8 million	180,000
Total CDW volume in Armenia		510,000

4.3 Guidelines and methodology for waste inventory of CDW

Like for the municipal waste, the CDW inventory should include determination of quantities/volumes and the composition of the CDW. At present none of this is measured. As most CDW is produced in Yerevan it is recommended to make the first inventory there. The consultants recommend that the inventory could be performed in the following steps:

1) Information about the number of on-going construction sites should be sought from the relevant authority. It would also be useful if the size in m^2 or Euro of each site was made available.
2) A number of construction sites should be selected, visited and studied in terms of data on
    a) The type of building (residential, office, other commerce, industrial, other)
    b) The size of the building in number of m^2 floor area and/or total construction cost
    c) The main construction material (stone, steel, concrete, bricks, wood, other)
    d) The amount of disposed waste
    e) The assessed composition of the waste (if containers are used, visual inspection could suffice)
    f) The name of the contractor in charge of the waste disposal
    g) The disposal site for the waste
3) If acceptable results of the items in points 1 and 2 above are obtained from a sufficient number of construction sites, a rough estimate of the total CDW quantity in Yerevan can be made. Also, some idea of the composition may be obtained.

For more accurate results, a more comprehensive procedure must be used as described below. The process requires a sizeable amount of funding, covering supervision, labor and equipment.

Quantification

For more exact determination of the CDW quantities some portion of the waste must be weighed. This can be arranged by selecting a number of construction sites and agree with the contractor to let the trucks transporting the waste pass a weighbridge before dumping it on the landfill. There are such weighbridges available in Yerevan, one even close to the Nubarashen landfill. Unless the truck's tare weight (the net load of the truck) is known, the truck must be weighed before and after the waste is unloaded. Construction sites should be selected where information of area, etc., as mentioned above, is known.

The weighing must continue during a period long enough to give representative samples of the CDW. It is desirable to get sampling of as many construction stages as possible. It is better to pick fewer construction sites and extend the sampling over a longer period, rather than more sites and shorter periods. The general rule is that more samples and longer periods give more representative results.

Provided the important influx parameters are available, the results of the process should give a value for tons of CDW per construction area or tons of CDW per investment capital. This value can be used to calculate the total quantity of CDW if and when the annual construction volume is known.

Waste composition

More detailed determination of the composition of the CDW must be done in the same manner as for municipal residential waste: to take out representative samples of the waste, sort it manually (with help of equipment) and weigh the various fractions. Since the CDW contains larger and heavier items, the sorting process will be different:

- The mother sample and the sub-samples must be considerable bigger, in the range 2-4 times more than for MSW (10-20 tons and 1-2 tons respectively), depending on the composition of the waste.
- The sorting must be done on the ground, so a surfaced area (or well compacted sand/earth area) is essential.
- Heavy sorting equipment will be required to handle the waste. The minimum requirement is to have a backhoe tractor ("JCB") equipped with a bucket and a grip.
- The scale used must handle weights of minimum 1 ton.

The waste composition analysis is preferably carried out during the period when weighing of the waste is done. However, to get representative samples it is necessary to mix waste from different construction sites. Therefore, special collection routes should be designed where waste from several sites is collected in the same load. Alternatively, smaller volumes can be collected from various sites and mixed at the sorting site.

As understood from the above description, proper analyses of CDW will be both time- and cost-consuming. It is doubtful whether the results are worth the efforts. It is not of utmost important to get exact data of the waste quantities and composition. Typical values from international statistics may well be sufficient for planning purposes. For future assessments and planning work in Armenia, it is recommended to look closer at the ongoing work on improvement of CDW sorting and management in Europe and the goal to achieve a minimum of 70% (by weight) reuse, recycling and other material recovery (including backfilling) of non-hazardous CDW by 2020.[30] One approach is to target major construction sites for closer investigation and make a pre-demolition audit[31] to see which fractions can be sorted out and which can be practically reused/recycled/upgraded depending on available treatment and market demands.

5. Automotive waste

5.1 Definition of automotive waste

Automotive waste is usually defined as waste origin from vehicles repair shops.[32] Examples of waste types are:

- Waste oil and brake fluid
- Oil filters

[30] The EU Waste Framework Directive (Directive 2008/98/EC) requires the Member States of the European Union to take the necessary measures to achieve this reduction by 2020.

[31] http://norden.diva-portal.org/smash/get/diva2:1294662/FULLTEXT01.pdf

[32] https://www.cpp.edu/ehs/portals/environmental/automotive-waste.shtml

- Asbestos brake pads
- Lead/acid-batteries
- Lamps
- Cooling agents

Automotive waste may also comprise of "End of life vehicles" (ELV), cars that no longer are used or unfit to be driven safely. The definition in the European legislation refers to vehicles with a maximum weight of 3,500 kg. There are almost the same kinds of hazardous waste types from ELVs as in repair shops. From ELVs, three is also non-hazardous waste generated such as ASR (automotive shredded residues, also known as car-fluff) if the cars are crushed. ASR consists of glass, fibre, rubber, liquids, plastics and dirt.

5.2 Existing situation and data

End-of-Life Vehicles

The Directive on End-of Life Vehicle 2000/53/EC is the first EU waste directive with which the European Commission introduced the concept of Extended Producer Responsibility (EPR). In order to measure the actual performance of the countries, targets have been defined with the ELV Directive. The EU Member States and EFTA countries are obliged to ensure that economic operators - authorities, treatment operators and producers - as part of their shared responsibility meet certain minimum targets. The directive allows for keeping track of waste amounts if the directive is both properly adopted and implemented in the national legislation and enforced. In Sweden, scrap yards must be certified in order to operate and each operator must report yearly to the authorities, including waste amounts. The system is quite advanced, and the operators are in general compliant with the regulations since there is a risk of losing the licence.

In Armenia, there are no publicly available data on the number of ELVs, handling of car carcasses and spare parts is primarily handled by small and sometimes informal businesses. Thus, it is hard to get an overview of active sites, data on waste and current handling. One site close to Yerevan handling passenger car carcasses (without engines or wheels) was observed during the consultants' site visits. The same type of handling of the hazardous waste from scrapping cars as in repair shops is assumed. It is likely that all facilities dismantling cars are using and selling spare parts.

In the countries within the EU, an increase of 43% in the number of ELVs was observed in 2009 compared with 2008 followed by a decrease in 2011.[33] From 2012 onwards, the number of ELVs per 1,000 inhabitants remains the same. In e.g. Romania, the number of ELVs per 1,000 inhabitants were about 2 in 2016. It is fair estimate to assume the same numbers in Armenia, since an attempt to estimate the number of vehicles scrapped yearly proves very difficult. Looking at the yearly number of cars imported would only give a number but not the age of the cars, most cars imported are used since new cars are very expensive due to custom duties. In 2019,[34] there has been a significant raise in importing used cars from abroad due to raised customs duties by the end of the year 2019. According to the Green City Action Plan for Yerevan,[35] the vehicle fleet is generally older than 16 years and often poorly maintained. The number of cars that are no longer used or unfit to drive yearly depends on many parameters such as age of the fleet, financial situation of the population, the willingness of driving old and worn-out cars, number and age of cars imported, etc. Hence, it is in this stage good enough to assume the same figures as for Romania.

[33] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=End-of-life_vehicle_statistics&oldid=211962

[34] https://hetq.am/en (Investigative journalists)

[35] Green City Action Plan for Yerevan, 2017

This means that it is a fair estimate to assume that about 6,000 vehicles are scrapped yearly in Armenia. One single car has about 4-8 litres of motor oil and one battery: which means about 25–50 tons of waste oil is generated and 6,000 batteries. The oil is probably utilized as fuel and the batteries either dumped or recycled.

Car repair shops

A general experience in most countries, it is difficult to keep track of waste amounts generated in car repair shops. No official data is available on the number of Armenian car repair shops and it is difficult to get information from operators of car shops. Most of the waste oil is probably used as fuel in furnaces while it is likely that other fluids such as cooling liquids and acid from batteries are emptied on the ground or in storm water/sewage drains.

Every generator of waste (i.e. enterprises and commercial businesses) are supposed to keep records of their waste generated and must report to the Inspectorate for Nature Protection and Mineral Resources. The data is not public and must be requested formally. Such request has not been made in the present project for many reasons; for instance, the work involved to first access and compile the data would be very time-consuming and the outcome still questionable. According to government officials, not all facilities are reporting their data and the data reported is not validated either. It is important to note that it is very difficult to obtain correct volumes/amounts of waste generated due to lack of knowledge with the operators about for instance reporting obligations but also with respect to categorizing and classification of the waste.

5.3 Guidelines and methodology for waste inventory

There are no official standards for compiling waste amounts from car repair shops and scrap yards. For instance, the approach in Sweden varies among regions and local authorities. Car repair shops are considered as small waste generators and the focus lies on informing about proper operational standards including waste management rather than mapping waste amounts for statistical purposes. Scrap yards are, as described above, obliged to be licensed to operate along with the requirements under the producer responsibility scheme. If there is no such system in place, which is the case in Armenia, it is recommended to focus on proper operational procedures including waste management rather than documentation of waste amounts. The methodology here is based on the Swedish approach.

In order to understand and estimate the waste amounts from car repair shops and from scrap yards, the first task is to map the number of car shops and scrap yards.

- A good start would be to request information from the Inspectorate to get a first impression of the number of enterprises that are listed as car repair shops and scrap yards, if any.
- The work that has been initiated by the American University should continue, visits to a few representative repair shops to map the waste generated. An area in Yerevan and in the cities, where WCA of municipal waste have been conducted, can be visited and, based on the numbers of shops in those areas, a total number may be extrapolated. This number can be compared to the car shops reporting to the Inspectorate.
- Visits to some scrap yards, where dismantling and crushing is taking place if any, to investigate the waste generated and to understand if there is any recycling of spare parts. The same approach as for car repair shops may be used.
- When some car repair shops and scrap yards have been identified and the amount of waste generated have been estimated, the amounts may be extrapolated for the assumed numbers of repair shops and scrap yards.
- In the long run, all facilities generating hazardous waste such as car repair shops and scrap yards should report waste amounts to the Inspectorate.

- As discussed above, instead of allocating a lot of resources to map the waste amounts from car repair shops and scrap yards, the focus should lie on introduction of appropriate operational routines and waste management procedures.

6. Industrial waste

6.1 Definition

Industrial waste is the waste generated during industrial activities which includes any material that is rendered useless during a manufacturing process such as that of factories, industries, mills, and mining operations. Industrial waste may be solid, liquid or gaseous.

6.2 Existing situation and data

The industrial sector is small in Armenia, accounting for ca 30% of the GDP.[36] The main industrial sectors in Armenia are mining, jewellery, agriculture and textile. There are also other significant industries such as agro-industry, software manufacturers and drug/pharmaceutical manufacturers. The present project does not include mining waste and tailings.

According to the Armstat report "Environment and natural resources in RA for 2017", chapter 10, the total amount of industrial waste was almost 60 million tons (recorded 59 622 444.3); 15.8 tons per capita. The data is summarized from the information collected by the Inspectorate. The amount of industrial waste reported seems very high, provided that the industrial activity is quite meagre in Armenia, which suggests that also mining waste and tailings are included in these figures. [37] The volumes recorded are not validated and not to be viewed as accurate but more an indication of volumes.

As a comparison, the total waste amounts in Sweden were almost 32 million tons in 2017, not including mining waste and tailings. Since the population in Sweden is almost 10 million people; the amount per capita is about 3.2 tons. The amount of mining waste and tailings was more than 100 million tons, which means that the amount per capita would be more than 13 tons if mining waste was included in the figures.

Based on experience, it is very difficult to estimate the amount of waste based on industrial activities, the waste generation varies due to several parameters; type and efficiency of the technical processes, internal recycling of waste, reporting procedures, classification of different waste fractions, etc. As discussed in chapter 1.6, the operator has the best knowledge about waste amounts generated in a factory. To understand and assess the waste amounts as an outsider/inspector, the level of familiarity with a certain industrial process must be extremely high, which is not the case in general.

The following table is an excerpt from chapter 10 in the same report and indicates the level of hazardousness of the industrial waste. The data suggests that the main portion of the industrial waste is non-hazardous. This is also true for countries like Sweden. The figures in the table are official, however it would require more research to further investigate the validity of the data with expected meager outcome. Hence, the table and data should be used as an indication of hazardous waste volumes rather than actual reliable data.

[36] Armstat, www.armstat.am/file/article/armenia_2019_6.pdf

[37] The conclusion is made based on the consultants' experience from Sweden and many other countries.

Figure 24. Data from Environment and natural resources in RA for 2017, chapter 10:

Արտադրական թափոնների քանակական շարժն ըստ վտանգավորության դասերի, 2017թ.

Quantitative movement of industrial waste by hazardous classes, 2017

տոննա
tons

	Առաջացել են թափոններ տարվա ընթացքում Waste generated during the year	Տրվել են թափոններ այլ կազմակերպություններին Waste transmitted to other organizations	Ստացվել են թափոններ այլ կազմակերպություններից Waste received from other organizations	Վնասազերծվել և ոչնչացվել են կազմակերպության կողմից Treated and destructed by organizations	Օգտագործվել են թափոններ կազմակերպության կողմից Waste used by organizations	Տեղափոխվել են տեղադրման վայրեր կազմակերպության միջոցներով Transported to landfills by means of organizations
1-ին դասի 1-class	5.1	2.3	1.8	-	-	2.5
2-րդ դասի 2-nd class	30.7	14.4	3.7	3.7	0.1	0.8
3-րդ դասի 3-rd class	2 087.6	223.5	266.4	267.9	1 097.4	622.2
4-րդ դասի 4-th class	41 790.3	22 138.9	707.3	311.2	539.4	17 188.8
Ոչ վտանգավոր Not hazardous	59 578 530.6	39 374.3	2 108.9	78.0	268 142.7	56 598 498.6
Ընդամենը ՀՀ Total RA	**59 622 444.3**	**61 753.4**	**3 088.1**	**660.8**	**269 779.6**	**56 616 312.9**

The numbers in the table above suggests that the quantities reported are generated amounts, but mixing of the different hazardous classes is probably taking place during transportation and treatment. Some of the drug/pharmaceutical waste is treated by the companies treating the hazardous fraction of healthcare waste. Most of the industrial waste is probably landfilled, either in municipal sites or in sites landfilling construction and demolition waste or in sites for mining waste and tailings.

6.3 Guidelines and methodology for waste inventory

There is no particular standard for inventory of industrial waste. The selected method may include consulting branch associations, work with questionnaires, inspections etc. depending on resources and available information. In Sweden, the reporting of industrial waste generated is made through the companies' annual environmental reporting, at least for industrial activities of a certain size. Sometimes branch associations compile such data and sometimes the environmental regional authorities compile data that is reported to the national government. Based on long-term experience from Sweden, a good start would be to request information from the Inspectorate to get a first idea of the number of industrial enterprises that are listed. According to the World Atlas, the Armenian Chamber of Commerce and Industry plays a vital role in supporting and regulating the industries. Hence, this might also be a feasible body to consult. To validate that all enterprises of a certain size are listed and reporting to the Inspectorate, local authorities may provide valuable input if enterprises are missing in the Inspectorate list. Local authorities may have experience from inspections of local industrial enterprises and would hence have knowledge about operations and waste generation. After this, questionnaires may be sent out, with subsequent follow-up. A number of enterprises are selected and visited to validate the data reported in the questionnaire. Follow-up of some enterprises can be made by phone. Such an approach has been proven successful in Sweden, especially for smaller enterprises. However, focus is not on actual waste amounts but rather on good practices and routines for proper waste management. Follow-ups and control of reported waste amounts are usually made during inspections of industrial facilities.

7. Electric and electronic waste (E-waste or WEEE)

7.1 Definitions

E-waste or WEEE is electrical or electronic equipment that has come to the end of its "user life" and covers a range of equipment; items that use electricity, usually connected via a plug or battery, are included in this category. Examples are mobile phones, kitchen or other household appliances, computers, TVs, etc. Light bulbs and fluorescent lights should also be considered as WEEE as well as small batteries, although such waste is covered by separate legislation within EU. Naturally, e-waste is also part of other waste such as household waste, bulky waste, demolition waste, industrial waste, etc.

7.2 Existing situation and data

Today, there is no separate collection of e-waste in Armenia or any official data regarding e-waste generation. There are no specific requirements in the Armenian Waste law[38] regarding e-waste. E-waste ends up in other waste streams including municipal waste collected primarily via bins or chutes. There are some indications that informal collection takes place, but the fate of the collected items is unknown.

In 2016, the total amount of collected e-waste varied considerably across EU Member States, ranging from 1.6 kg per inhabitant in Romania to 16.5 kg per inhabitant in Sweden. The considerable variation in the collected amounts reflects differences in EEE consumption levels as well as the different performance levels of existing waste collection schemes. According to the *Global E-waste monitor 2018*,[39] Armenia has an average generation of e-waste of 4.7 kg/capita. With a population of about 3 million people, the total amount would be about 14,000 tons per year. Theoretically, volumes could be estimated from customs data on import and export of electrical products; however, this is a very unreliable method since assumptions must be made for so many aspects – private import and export, informal second-hand market, very varying lifespans of e-products from less than a year for some smartphones and for people who can afford to many years even for old TV sets and kitchen stoves.

Worldwide, only 20% of the e-waste is being collected separately and managed properly.[40] In countries where there is no national e-waste legislation in place, e-waste is likely treated as other or general waste. This is either landfilled or recycled, along with other metal or plastic wastes. There is the high risk that the hazardous elements are not taken care of properly, or by the informal sector and recycled without properly protecting the workers, while emitting the toxins contained in e-waste.

7.3 Guidelines and methodology for WEEE inventory

The method that the *Global E-waste monitor* has used to estimate the amount of e-waste generated is defined in a statistical measuring framework on e-waste as described by the Partnership of Measuring ICT for Development.[41] The method seems very comprehensive but also time consuming and maybe not be completely accurate, although good enough. One obvious challenge in data

[38] The RA Law on Waste (Adopted on November 24, 2004)

[39] The Global E-waste Monitor 2017 is a collaborative effort of the United Nations University (UNU) represented through its Vice-Rectorate in Europe hosted Sustainable Cycles (SCYCLE) Programme, the International Telecommunication Union (ITU), and the International Solid Waste Association (ISWA).

[40] http://collections.unu.edu/eserv/UNU:6341/Global-E-waste_Monitor_2017__electronic_single_pages_.pdf

[41] C. P. Baldé, R. Kuehr, K. Blumenthal, S. F. Gill, J. Huisman, M. Kern, P. Micheli and E. Magpantay (2015). E-waste statistics: Guidelines on classifications, reporting and indicators. Bonn, Germany, United Nations University, IAS - SCYCLE.

collection is that the lifespan of electrical items in countries with high standard of living is shorter while it is the opposite in countries with lower incomes. Furthermore, which is a problem also in Sweden, electrical items are being exported to other countries and it is difficult to keep track of such transboundary movements. The overall assessment here is that the figures presented in the *Global E-waste monitor* are adequate for this study.

The waste composition analyses on municipal waste that were performed during this project identified almost no e-waste. It is possible that there is an informal market for upgrade and repair of e-waste.

8. Healthcare waste

8.1 Definitions

Healthcare waste includes all types of waste generated within healthcare units and hospitals. Also, waste generated associated with home caring is included. The main part of the waste generated in a hospital is non-hazardous like household waste. The hazardous waste constitutes radioactive, infectious and chemical substances including obsolete pharmaceuticals.[42] Pathological waste is also considered hazardous.

8.2 Existing situation and data

The compiled official data on total amounts of healthcare waste generated in Armenia is missing; however, some information can be obtained. The amount of hazardous waste generated by healthcare activities is usually about 15% of the total waste generated.[43] Generation varies between 0.2-0.5 kg hazardous waste per hospital bed and day depending on the welfare status of the country. High-income countries generate higher amounts. However, the hazardous waste is often mixed with the non-hazardous waste, which results in higher quantities of hazardous waste (due to the mixing rule). According to the findings in this study in Armenia, the low rate of waste generation per bed in the hospitals visited suggests that there might be hazardous waste sorted as non-hazardous.

Hospitals are supposed to be inspected once a year by the Ministry of Health (MoH), but according to some of the hospital staff, there is no cooperation between the MoH and the Inspectorate. Cooperation would for instance be useful to follow up on the sorting regime to validate waste amounts.

According to Armenian legislation, all healthcare units must have a contract with licenced treatment companies. Currently, there are two licenced companies that collect and treat the hazardous waste generated in hospitals and healthcare outpatient units. The companies collect waste from some of the hospitals several times a week. Without having studied their daily operation and from a pure logistical point-of-view, it seems challenging for only two companies to extend collection services to all healthcare related operations with such a high frequency and considering that only in-house collection vehicles that can be used. However, it has not been feasible within this project to investigate if all hospitals and healthcare units have such contracts and verify the total waste amounts treated.

[42] WHO, https://www.who.int/news-room/fact-sheets/detail/health-care-waste

[43] Safe management of wastes from health-care activities, Second edition. World Health Organization 2014.

Treatment facilities for healthcare waste

The project experts visited Ecoprotect LLC, one of the two currently licensed medical waste collection/disposal companies. The waste admitted to the facility is stored and then incinerated in a rotating kiln. The facility seems to be operating properly and the staff expressed great knowledge and level of awareness. Mercury batteries and equipment are collected and stored on-site separately, not to contaminate the waste. This is good procedure since mercury is very difficult to capture in the flue gases from incineration.

The capacity of the Ecoprotect kiln is 250 kg/h and it operates 24 h during weekdays if there is enough waste to be treated. The total amount of waste incinerated would hence be maximum about 1,500 tons per year. The total amount incinerated is not only healthcare waste; also waste from the cosmetic industry and pharmaceutical companies is accepted and treated on-site.

The facility has a permit and certain parameters are monitored in the stack by the Inspectorate. The facility operates on a licence and the emissions allowed have been established in the permit process According to the staff, the permit is complied with. The facility also accepts waste from other types of operation such as pharmaceutical companies, pharmacies, make-up manufacturers, etc.

The treatment facility of the other company, Ecologica, has not been visited due to lack of time and possibilities to arrange for such a visit during the consultancy visit.

Calculations of healthcare waste amounts

There are about 100 hospitals in Armenia. A number of hospitals and outpatient clinics have been visited by the consultants. All units visited had adequate separation of the infectious waste and sharps; collected separately by one of the designated companies. The sorting procedures seemed very efficient and the level of awareness among the staff in all units was very high.

The information gathered shows that the amounts of hazardous waste generated in the hospitals is about 50 kg per month in Ararat (50 beds, about 30–45% occupation rate). In the Ararat hospital, about 500 surgeries are performed yearly. The daily generation of hazardous waste in Ararat would be about 0.03 kg per bed if counted as full occupancy of the beds. The records of the hazardous waste collected is adequate, but the amount of general waste collected weekly is not known.

The Medical Center of Yerevan comprise various specialty services, the hospital has 250 beds (of which 18 are designated for intensive care). The total amount of hazardous healthcare waste collected by Ecoprotect is on average 550 kg per month, corresponding to 0.07 kg per bed and day.

The low waste generation rate may depend on several aspects like occupancy rate; that other types of hazardous waste is not included in the figures or that very small amounts of the generated waste is considered infectious/hazardous (sorted as non-hazardous waste) or that disposables are not commonly used.

In order to estimate the total amount of hazardous waste from the healthcare sector, the following approach has been made:

- An assumption is made that about 400 kg of hazardous waste is generated per month and per hospital. This is probably an overrate with the current sorting regime; however, including waste also from smaller clinics, it is a fair estimate.
- The total amount of hazardous healthcare waste from one hospital would hence be 4.8 tons per year.
- An estimate of the total amount of generated healthcare waste per year in Armenia, would then be almost 500 tons, assuming 100 hospitals in total. It is possible that the capacity is sufficient for treatment of the hazardous waste components in generated healthcare waste, but if the logistic challenges are overcome is not clear.

8.3 Guidelines and methodology for waste inventory

There is no standard methodology for collection of waste data from hospitals and healthcare units. For instance, the WHO used survey questionnaires[44] to selected hospitals to estimate and assess the waste amounts generated and handled.

Since data collection is quite time consuming, the common method in Sweden is to select several typical institutions and use the data from the environmental reports and then extrapolate. It is also possible to collect data from the waste incineration plants through the Swedish Waste Management Association; many incineration facilities have permits to treat healthcare waste.

In Armenia, since many hospitals and other healthcare units do have a contract with either one of the collection companies, the first step would be to get a list of the clients to these companies and to compile data on treated waste amounts. The next step would be to investigate the reporting to the Inspectorate, to match the amounts being collected and the amounts reported to the Inspectorate. Then it is important to establish if there are other existing healthcare units that are neither reporting nor have a contract with any of the collection/treatment companies. The Ministry of Health should have records of listed licenced healthcare units, since they are inspecting such units on as regular basis.

After obtaining lists of healthcare units in Armenia, questionnaires may be sent out to the missing establishments missing a contract with any of the licenced companies.

Figure 25. Visit to a hospital in Hrazdan (l), examples of waste containers (r)

9. Other hazardous waste

9.1 Definition

Hazardous waste is such waste that poses a potentially higher risk to life and health by than non-hazardous waste, in itself or in contact with air or water, carrying properties such as being corrosive, toxic, radioactive, flammable, or the like.

9.2 Existing situation and data

In Armenia, there is a lack of reliable data on hazardous waste generation and it is also difficult to know how many and what kind of enterprises that are reporting to the Inspectorate. Four percent (4%) of the total waste generated in EU 2016 was considered hazardous waste. Almost all EU states

[44] Status of health-care waste management in selected countries of the Western Pacific Region, 2008-2013.

had an average of less than 10% hazardous waste of the total generation, except Bulgaria and Estonia with 11% and 40%, respectively (for Estonia due to energy production from oil shale).[45] Since the reporting of waste amounts is difficult and not streamlined although there are established routines, the accuracy of the data from some countries can be questioned. However, even though the amount of hazardous waste in comparison to non-hazardous waste is low with respect to tonnage, the impact from hazardous waste may be as great due to its properties posing risks to the health and the environment, especially if the waste is just landfilled or dumped.

9.3 Guidelines and methodology for waste inventory

In order to collect data regarding hazardous waste generation from different types of activities and operations, a systematic approach is necessary. There is not one single established method to investigate waste streams from industrial facilities. The approach suggested for Armenia below is based on experience from several similar international projects (for instance carrying out an inventory of PCB oil in Cyprus) but also from Sweden when starting to develop waste management plans for the municipalities.[46]

1. Collect information from the Inspectorate and possibly the Armenian Chamber of Commerce and Industry regarding different branches/enterprises etc.
2. Group similar activities and select a number from each group that will be approached, interviewed and maybe visited. It is possible to work with questionnaires; however, based on experience, the questionnaires must be followed up by a personal contact, preferably verbally.
3. Based on the information from the selected operations, assumptions and extrapolations can be made.

10. Agricultural and horticultural waste

10.1 Definition of agricultural waste

There are different ways of defining agricultural waste or waste being generated in farms, the types depend somewhat on the type of operations. Agricultural waste comprises different types waste such as:

1. Losses during the entire chain from production to consumption of e.g. cereals, roots, oilseeds, fruits, vegetables, meat, fish, seafood, milk and eggs;
2. Manure from animals during meat or milk production;
3. Packaging materials (e.g., plastic containers) for used pesticides, herbicides, and fertilizers;
4. Obsolete pesticides, herbicides, and fertilizers;
5. Expired pharmaceuticals used for animals;
6. Animal carcasses;
7. Waste oil from machinery and vehicles.

[45] EU Waste Statistics, https://ec.europa.eu/eurostat/statistics-explained/index.php/Waste_statistics#Hazardous_waste_generation

[46] Sweden has had mandatory municipal solid waste management planning since the 1990'ies. The plans must include also waste that is not under municipal jurisdiction, for instance industrial waste.

10.2 Existing situation and data

An FAO report on Food losses and waste in Armenia[47] was published in 2013. The information was gathered through different sources, not only existing reports and studies but also through interviews with farmers, wholesalers, etc. and is to date, the most comprehensive and recent information found during this study.

The FAO report states that main agri-food chains with economic importance for the country are wheat, potatoes, tomatoes, apples and milk. The waste amounts and losses throughout the supply chain of these produce were the following in Armenia in the year 2009:

Figure 26. Estimated waste amounts and losses of five produce (entire food chain) in 2009

Produce	**Estimated amount of waste** (tons)
Wheat	127,600
Potatoes	64,300
Tomatoes	27,900
Apples	9,500
Milk and dairy products	56,900
Total	About 300,000

There are several reports on historic obsolete chemical storage, for instance the inventory carried out by the Ministry of Agriculture in 2014 in which 150 tons of expired pesticides were found in all parts of Armenia.

There are no records of the fourth and fifth categories of waste referenced above, i.e. waste that is currently being generated. However, it is a fair assumption that since most of the farms are small with low financial income, the use of chemicals and animal drugs is low, which is very beneficial for the environment and for the quality of the food produced.

The amounts of waste from animals, such as manure and carcasses, have not been assessed due to lack of time to investigate on site or identify usable data.

10.3 Guidelines and methodology for agricultural waste inventory

Since most of the waste generated in farms is assumed to be utilized in-house as forage and fertilizer, the focus on waste amounts should be on safe management of animal carcasses. In Georgia, for instance, anthrax deaths among livestock has been identified as a problem, especially the management of the carcasses. To enhance capacity and introduction of better routines for risk mitigation, there has been a cooperation between the Georgian Ministry of Agriculture and the Swedish Board of Agriculture.

The methodology that was used in the FAO study considered the entire food chain. If only the waste from the farms is of interest, the report still gives a good idea of the agricultural waste part from farms since an average low-income country, food loss and waste (FLW) in Armenia is much higher at the beginning of the supply chain (agricultural production stage) than at the end (in distribution or consumption steps). This is maybe not true for areas with higher incomes such as Yerevan.

[47] FAO, www.fao.org/3/a-au842e.pdf

The methodology proposed for inventories of agricultural and animal waste is based on the methods applies in the FAO study.

- First the official data from the Statistical Committee of the Republic of Armenia (Armstat) on farms and agricultural production units should be compiled and assessed.
- A number of farms in different regions are selected and interviews with farmers can be made to assess the validity of the data.
- Extrapolation of the collected data from interviews with farmers is made to compare the data from Armstat.
- The issue of handling of animal carcasses should be addressed as well when interviewing the farmers. Cooperation with the Georgian Ministry of Agriculture could be considered long-term to address the anthrax problem.

11. Landfills and dumpsites

11.1 Definitions

Generally speaking, there are two types of waste disposal sites – landfills and dumpsites. Landfills are planned sites with environmental permits in place, engineered for function and maximum capacity and to create minimal environmental and health impacts. Dumpsites, on the other hand, are simple disposal sites with no or little management, and they are often illegal or at least not complying with landfill regulations in terms of design, operation, gate control and fencing, etc. Below these two broad types of disposal sites are defined further.

Landfills

A landfill, or sanitary landfill, is a facility built for receiving and storing waste under controlled, sanitary conditions which will not have any negative effect on the environment or the surrounding areas. New landfills must be constructed according to the applicable laws and regulations and have all permits required. In the European Union, the Landfill Directive[48] regulates waste management of landfills. It was implemented by its Member States by 16 July 2001. Existing landfills have to be re-constructed according the Landfill Directive to be allowed for continued operation.

According to the EU Landfill Directive, there are three types of landfills:

- landfills for hazardous waste
- landfills for non-hazardous waste
- landfills for inert waste (gravel, stones, clean soil, etc.).

Dumpsites

Dumpsites are places that have not been properly selected or designed in accordance with environmental legislation and where waste is being indiscriminately disposed of, totally or partly without control or management. Usually, there is no operational staff at the grounds and installations to direct the tipping, and thus, the tipping wound (the active face) is large and waste spread around.

In Armenia, like in many countries, all of the landfills used for municipal waste, although approved by the local authorities, are in effect dumpsites, as they do not have any of the minimum requirements

[48] Formally the Council Directive 1999/31/EC of 26 April 1999; https://en.wikipedia.org/wiki/Directive_(European_Union)

that constitute landfills, such as gate control, weighbridge, fence, compaction, regular cover of the waste, leachate control, methane gas extraction, etc. Even at the country's largest landfill, Nubarashen in Yerevan, there is no weighbridge and incoming vehicles are not registered or monitored, and thus, the types and volumes of deposited waste can only be approximately estimated.

However, to avoid confusion with terminology, the word "landfill" will be used subsequently for the dumpsites visited as part of this project.

On-going projects

The need for sanitary landfills has long been recognized in Armenia and work has started do a full inventory of dumpsites and embark on large infrastructure projects with donor support for construction of modern landfills.

In 2017, in the project *"Clean Armenia"*, the Ministry of Territorial Administration inventoried 2,031 dumpsites in Armenia. Since then, about 1,700 of them have been closed and there are now 45 urban landfills and approximately 429 rural landfills in Armenia.[49] As part of the project, committees and working groups were set up in all marzes and a community officer responsible for waste collection has been appointed in each marz. There have been nationwide cleanups in for instance touristic areas and improved quality of services and contract management.

Following the National Waste Strategy of 2015, developed by the Armenian state and Yerevan Municipality, there is a plan to set up five regional landfills in Armenia including one for Yerevan.[50] The latter project is being tendered in 2019, funded by the EBRD. It comprises construction of a new sanitary landfill close to the old Nubarashen landfill and 10 years' operational responsibility before the landfill is turned over to the Municipality. The *"Yerevan Solid Waste Project"* cost is 26.0 million EUR of which the loan component is 16.0 million EUR, half of it from the European Investment Bank (EIB) and the other half from EBRD).[51] The new landfill site will serve the city of Yerevan, as well as to urban and rural communities of Aragatsotn and Armavir provinces/marzes. The program also envisions to produce 1.8-2.0 MW of energy.

Another EU funded landfill project, the *"Kotayk and Gegharkunik Solid Waste Management Project"* involving the marzes of Kotayk and Gegharkunik is presently being tendered to be implemented in 2020. It is planned to build EU standards compliant sanitary landfill and introduce an effective waste management system. The total budget is 11.0 million EUR of which 5.5 million is grants from the European Neighborhood Investment Facility (NIF) and the Eastern European Energy Efficiency and Environmental Partnership Program (E5P). The loan will be paid by the communities.

Within the framework of the project, is planned to build a new sanitary landfill (including infrastructures, buildings and structures) in Hrazdan community to provide solid waste collection and disposal services for 12 urban and rural communities of two marzes, as well as:

- construction of 2 waste transfer stations in Abovyan and Martuni
- procurement of waste containers/boxes and trucks, and
- procurement of special equipment for landfill operation, installation of new waste collection points.

[49] Armenian Environmental Network, https://www.armenia-environment.org/proj-page-waste-management

[50] Details can be found in The Armenia Solid Waste Project Environmental and Social Due Diligence – Environmental and Social Impact Assessment www.eib.org/attachments/registers/60142333.pdf

[51] https://www.ebrd.com/cs/Satellite?c=Content&cid=1395270938482&d=Mobile&pagename=EBRD%2FContent%2FContentLayout

11.2 Field visits undertaken

Nubarashen landfill in Yerevan

This site has been visited at several occasions by the team members since 2013 and daily during the WCA carried out in this project.

The distance to the landfill is about 12 km from the city. The landfill was started in 1960 and is supposed to receive only municipal household waste from the city of Yerevan. It is operated by a private contractor. According to a consulting study from 2008,[52] the remaining area would be sufficient for another 5-10 years which would then suffice until the planned new landfill would be ready for operation, as planned. In the pictures below, the current tipping area with official and other vehicles can be seen (left), and sludge trucks emptying sewage sludge at the upper part, closed to the entrance (right).

Figure 27. Tipping area at Nubarashen Landfill (l) and septic sludge trucks emptying the latrine nearby (r)

The landfill has neither gate control nor weighbridge and there seem to be no records of the received volume or even types of waste available. From mere observation of the deposited waste at Nubarashen and other landfills, any kind of waste can be disposed of here, mixed and in all areas of the site. A report from 2018[53] gives the quantity 310,100 tons transported to the landfill.

The access road is asphalted and of good standard, which is contrary to other visited landfills in Armenia, where the roads are hardly trafficable. However, the roads within the total landfill area are in poorer standard and more importantly, the unstructured and uncontrolled tipping of waste risk blocking and destroying them. A lot of informal recyclers, a.k.a. scavengers, arrive to the site in the morning and work all day to collect recyclables, primarily plastics that can be sold at an acceptable price. There are also numerous stray dogs and birds at the site, feeding from the food waste and contributing to spreading of disease and unhygienic conditions. At the time of one visit, a heavy tractor with a blade/shovel moved the dumped waste to the tipping area, but no compactor was visible.

Nubarashen landfill is the only one in Armenia where landfill gas extraction for CDM has been installed.[54] The project *"Nubarashen Landfill Gas Capture and Power Generation Project in Yerevan"* was initiated by the Japanese company Shimizu Corp. in 2005 with an estimated CO_2-eq. reduction of 2.16 million tons. The installation only covers a minor part of the whole area, though. It is not clear

[52] Final Report December 2008: Report on the Evaluation of the Current Municipal SWM in Yerevan, Fichtner

[53] https://www.armstat.am/file/article/eco_book_2018_10.pdf

[54] https://cdm.unfccc.int/Projects/DB/JQA1116316762.57/view?cp=1

whether the gas pump station is still active. In any case, there is no utilization of the gas apart from flaring (thus converting it from the strong greenhouse gas methane to less potent carbon dioxide).

Construction waste landfill Spandaryan in Yerevan (closed)

The dumpsite is located in Ajapnyak district along Tichina street at the former gravel stone mine operated by the Spandaryan industrial unit. By the Yerevan city Mayor's June 30, 2016 N 2391-A decree, a 10 ha area of the mentioned mine was allocated for landfilling of construction and demolition waste (CDW) and a permit to operate the dumpsite for CDW has been given to Davars LLC. However, starting from 2005, the area seems to have been used to dump both CDW and municipal solid waste as indicated by fires and smoke visible on satellite images. In 2018, some parliamentarians initiated the blockage of the access to the dumpsite. The closure of the dumpsite has led to uncontrolled illegal dumping of CDW in several locations around the city of Yerevan.

Through on-site observations, it can be noted that the landfill extends over a large area and contains municipal waste, textiles, CDW waste but also certain amounts of industrial waste of all types, such as electrical waste, etc.

Municipal landfill, Ararat

The landfill[55] is located quite close to the city, approximately 2.5 km, with an access road in very poor condition. According to the information given by the local municipal representative, the contractor cannot invest in modern waste trucks because of the extremely bad road. The landfill is a typical dumpsite, open without fencing and where different kinds of waste turn up and is being disposed of without any plan.

Apart from the dumpsite, there is a new, fenced area with a sorting plant[56] for municipal waste. At the entrance, there are two buildings for gate fee/control and staff. The trucks that enter are supposed to proceed up to a platform and dump the municipal waste in a feed hopper from which the material is further led into a small building. Transported by a conveyor belt of about 4 m length, the waste should be sorted by staff taking out recyclables and possibly hazardous waste as well to put in separate bins. The residue would then be further transported out of the building into a deep concrete bunker. It seems that the idea was to let the remainder biodegrade there to produce a compost, since there is no or limited possibilities to ever get the waste out of the bunker again. The pit is open, thus completely exposed to rainfall without any drainage layer or outlet.

The small plant was not in operation as it had not functioned as planned. It is obvious that such a design is an expensive and cumbersome way of sorting out small volumes of recyclables and ending up with a pit with an extremely short lifespan, where nothing but a completely useless mixed waste fraction will be left.

[55] Host: Mr. Artyom Balayan, Head of Communal Services at Ararat Municipality

[56] EU funded project

Figure 28. The sorting plant and "compost pit" at Ararat

Municipal landfill, Hrazdan

The landfill[57] is located about 6 km outside Hrazdan city. The access road is short, about 500 m, and of bad quality. A lot of waste has been dumped along the road.

The landfill is about 30 years old and 7 m deep. There were no staff to manage the site and no weighbridge or any other control of incoming vehicles. The waste had no cover and thus, plastics and paper were blown away by the wind. There were informal recyclers on site, collecting PET plastics, and a van had arrived to collect it. The plastics could allegedly be sold for about 200 USD per ton and they would collect about 30-40 kg per day in total.

Incoming quantity was assessed at 8-10 tons per day while the municipal office had mentioned about 20-25 tons per day. As the population of Hrazdan is about 40,000, the lower figure is more likely to be correct.

Figure 29. The landfill in Hrazdan (l) and metal bins in Dilijan (r)

Landfills in Vanadzor

The municipal landfill[58] was not visited due to very poor road conditions and long distances. The road quality is apparently so bad that waste collection trucks sometimes overturn. The landfill is located in a natural ravine at quite high elevation above the city. Even from a distance, smoke from spontaneous dump fires could be seen, and this was apparently the usual state of the site. The yearly volume of waste to the municipal landfill is estimated at 25,000 tons per year which is realistic as Vanadzor is about double the size of Hrazdan.

A positive initiative in Vanadzor city is that separate collection of PET bottles is arranged at about 35 collection points. The total number of collection points is 160. The PET is sold for 180 USD per ton.

[57] Host: Mr. Vagharshak Poghosyan, Head of Communal Services at Hrazdan Municipality.

[58] Host: Mr. Karen Paravyan, Head of Communal Services at Vanadzor Municipality

The construction waste landfill is located close to the city and was inspected on site. It is located beside a ravine with depth of about 10-15 m. The trucks tip the waste on the brinks of the ravine and the municipality uses a heavy tractor to push the waste down the ravine once or twice a year. This could be acceptable if only construction waste was disposed of; however, the consultants observed both paint containers and electrical waste in the garbage. Engine oil, on the other hand, is collected by special companies that sell it for reuse or burning.

11.3 Assessment of the existing situation

As understood from the descriptions of the site visits above, the existing state of the municipal landfills is sub-standard and should be rectified urgently. Without gate control and proper operation of the site, the waste is not registered and spread all over the landfill area without compaction or cover.

The landfills contain not only large amounts of combustible material but also chemicals, oil and methane gas that can self-ignite; the risk of long and deeply rooted fires is great. Hence, smoking should be strictly forbidden within the premises and only allowed in a designated zone at or close to the gate.

Another challenge at the dumpsites in general is that light material, mainly light plastics and paper, is spread by the wind and pollute the surroundings. The reasons are that the dumped waste is not covered with soil and that there are no fences to catch some of the flying materials. Plastic bottles and some plastic film are collected at the landfills by the informal sector, which reduces the plastic volume to some extent, but apart from that not much can be done to prevent the littering.

Based on the observations from study visits in this and other projects, there will be increasing cost implications to reduce the impacts and disturbances from the existing landfills both on short term and long term landfill remediation.

12. Business models

12.1 General

Municipal waste collection from households is the responsibility of the local government by law in most countries. However, the municipalities do not have to carry out the services with their own means. In most cases, they sign contracts with private companies to carry out all or some of the services. Earlier, mostly only collection was sub-contracted, but it is becoming common to have private firms contracted also for operation of landfills, incinerators and sorting facilities. In many cases, this is done on a turn-key basis, involving also construction. Waste from industrial activities and sometimes also from commercial activities may not be included in the municipal responsibility and monopoly.[59] Sometimes, it is a requirement within their business permit to report waste types and volumes to the municipality or environmental authority although in practice, these data are hard to verify. Waste collection is usually dominated by private companies. Some business models for waste management operations are described in the following sections. These types of models are also used for water and sewerage utilities.

[59] In the EU DIRECTIVE (EU) 2018/851 of 30 May 2018 amending Directive 2008/98/EC on waste, the term “municipal waste” is introduced to replace “household waste” and other terms to facilitate uniform data collection. In Sweden and other countries, however, there is a distinction between what is referred to as “municipal waste” and municipal ownership of the waste, which is primarily referring to waste from households.

12.2 Municipal companies

In Sweden and other European countries, a very common business model for waste management and other utilities is municipal limited companies, wholly owned by the municipalities and with a board of directors usually being local politicians. It gives some economic advantages, deductible VAT among other things, and a company can be run in a more professional mode than a municipal organization; other employment contracts with more flexible rules can be used, etc. The described business model was also introduced in Armenia during the period 2005-2010 and was adopted by many municipalities.[60]

12.3 Municipal jointly owned companies

Another model also commonly used in Europe and to a certain extent in Armenia is that two or several municipalities form alliances to carry out major solid waste projects, typically for major investment projects such as landfills, incinerators, etc. A new limited company is then started, jointly owned by the municipalities involved in the project, usually geographically close to each other. Such joint stock companies often take over collection of the waste in all the municipalities as this offers economies of scale. However, it doesn't mean that the municipal company carries out the collection with own staff; usually private contractors are used also in this case.

It is of course possible to arrange the cooperation without forming a company and formalize the mode of operation in an operation contract between the municipalities. The difference is that in the absence of a jointly owned company, the ownership of the facility must lie directly with one or several of the municipalities in this case.

12.4 Public-Private-Partnership (PPP)

Public-private partnership (PPP) is usually defined as a long-term contract between a private party and a government agency for providing a public asset or service, in which the private party bears significant risk and management responsibility (World Bank, 2012). It relies on the recognition that public and private sectors each have certain advantages relative to each other in performing specific tasks. The responsibilities of the private sector could entail finance, design, construction, operation, management and maintenance of primarily infrastructural projects such as waste management facilities.

The PPP business model was introduced during the last part of the 20th century in Europe and USA. Many communities hesitated to start large infrastructural projects on their own and wanted to join forces with the private sector to profit from their economic strength and knowledge of complex projects. The model was most favored in the UK. The possible success of PPP setups varies and depends highly on the commitment and stability of the private party, the financing model, and the ability of the public party to be actively involved. One successful project in Sweden is the fast train connecting the airport Arlanda with Stockholm city, but a poor example is the new, highly specialized hospital in Stockholm that has overrun both timeframes and budget repeatedly.

The challenges are often the difficulty for the public sector to prepare adequate contracts and also to follow up and monitor the work in a professional way.

PPPs typically do not include service contracts or turnkey construction contracts, which are categorized as public procurement projects. However, contrary to this, projects in many countries which are announced as PPP-projects, are in reality normal service contract where for example a

[60] USAID 2010-08-26 Sustainable SWM

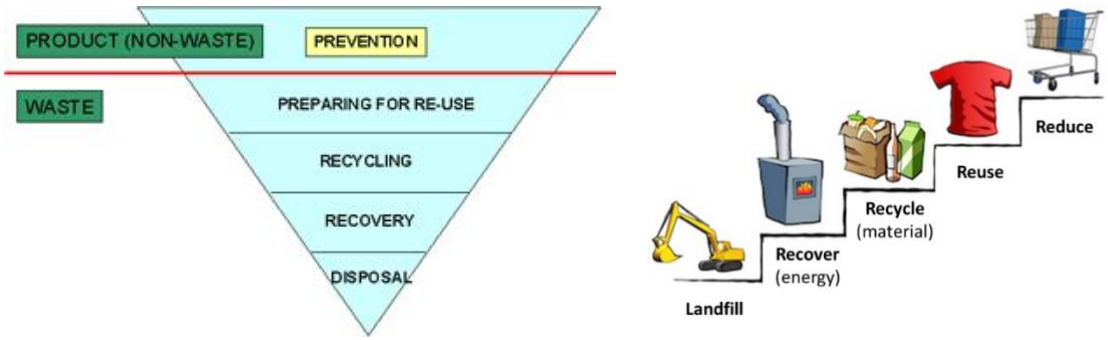
municipality engages a contractor to carry out a waste collection contract involving both purchase of equipment and operation of the contract.

13. Recommendations and action plan for improvement of waste management

13.1 Introduction

Based on the findings in this study, primarily the waste composition analysis (WCA), site visits and interviews with stakeholders, a number of recommendations and actions on short and long term can be proposed. Thus, below are some discussions, examples and to-the-point actions in phases to inspire to future work. It should be mentioned that some of the guiding principles in all of these sections emanate from the EU Directive 2008/98/EC on waste (Waste Framework Directive).[61] Some basic concepts here are “polluters pay principle” and “extended producer responsibility", which basically dictate that any entity that risk polluting the environment directly or indirectly from waste generated from its business or activities must take responsibility and pay for its safe handling. All EU member countries must adopt the so called waste hierarchy in their respective legal framework, where waste minimization is prioritized and then reuse, recycling, energy recovery and landfilling by that order. For Armenia, the bulk of the waste is still with the least preferred option and here are recommendations to start climbing the stairs towards a more sustainable system.

Figure 30. EU waste hierarchy presented in two ways



13.2 Municipal waste collection

Phase 1

The recommendations herein are mostly directed towards the waste collection contractor. However, the municipality, having the overall responsibility of the waste management, should act in cooperation with the contractor to ensure that improvements are achieved. The recommendations also involve higher costs which may be outside the current contract.

- Collection management should be improved through, for instance;
    - training of staff how to operate the equipment properly and thus prolong the life and function of those investments;

[61] https://ec.europa.eu/environment/waste/framework/

- provision of protective gear/clothes;
- improved maintenance of bins and vehicles.

- All rear-loading waste trucks should be equipped with automatic bin lift systems which ensure that the bins are lowered slowly to avoid damage to the wheels. This can most likely be added to existing lifts.
- All the bin sites should be inspected and checked:
  - Damaged bins should be repaired or replaced immediately. This is obviously a question on work environment but also a financial issue since it is very costly to have a large truck waiting for inefficient unloading of bins that have to be dragged instead of wheeled.
  - Overfilled collection points should be further investigated for reasons why this situation arises – there could be too few sites or bins in relation to the waste volume, bulky/ construction waste being disposed of, too low collection frequency, or other reasons.
  - A plan for improvements and measures to be taken plus cost estimates if any for such problematic sites should be made.
- Information and guidelines on waste management should be developed and disseminated. This could be coordinated with a general campaign for public awareness regarding waste, recycling and other environmental issues (see the section on Capacity development below).

Phase 2

A project to deal with the unacceptable conditions for emptying the waste chute bunkers of the high-rise apartment houses should be introduced. The waste chutes pose both health and environmental hazards and are part of an old-fashioned and generally inefficient way of waste collection. The individuals' preference to be able to throw the waste at each apartment floor cannot be dictating the terms in the long run. When changing this culture, there will be complaints for a period of time,[62] but that risk can be mitigated through information and education as well as possible financial incentives, such as reduced collection fees.

- Initiate a project on improvements in buildings with waste chutes:
  - Close the chutes and replace them with bin stations near the respective building.
  - Improve the system by arranging acceptable collection by placing bins under the chutes to be emptied in a normal way. This alternative requires that all chute rooms are being managed by house janitors or similar service.
  - Chute rooms which are located higher than street level or are in other ways un-accessible for wheeled bins, must be closed for work environment reasons.
- Arrange systems for separate collection of bulky waste as this waste stream constitutes a major problem for the present household waste collection as described earlier (see more recommendations in the section on bulky waste below).
- Arrange for full-scale systems for separate collection of small batteries and WEEE.

[62] Consultants' experience from Sweden and Germany.

- Start planning for separate collection of recyclables and garden waste in the main cities of Armenia. The fractions to be collected are packaging of paper, plastics, glass and metals, newsprint and hazardous waste from the households.

Phase 3

- Develop and enforce policy tools and enforcement, e.g. serious fines for littering or dumping bulky waste in bins, etc.
- Plan and build recycling centers where people can bring bulky waste, hazardous waste, garden waste, etc. by using private cars with trailer or other means. In Yerevan two centers or more would be needed, while one center will suffice in other cities.
- Implement a first stage of separate collection of recyclables, primarily packaging and garden waste.
- Implement a collection system for collection of hazardous waste, including e-waste from the households.
- Find high-capacity alternatives to the current system with only 1100 L bins and with adjustments in collection frequency. According to the current private contractor Sanitek for waste collection in Yerevan, 60-70% of the bins are collected twice daily and the rest once per day. This may be needed during the hot summer months and for organic waste, but it must be regarded internationally as a very high frequency. Clearly, it could be cut to once per day or three times a week if only alternative, high-capacity containers or other waste collection systems were considered.

Some examples of alternative collection systems are shown in the figures below.

Figure 31. Large tipping containers being emptied (l) and mixed collection of different-colored bags[63]

[63] Pictures from Moderna Återvinningslösningar AB and OptiBag

Figure 32. High-capacity containers (l) and one system for emptying them(r)

13.3 Reuse and recycling

One aim with the WCA has been be to investigate the potential for recycling, hence possible investment in material recycling in Armenia.

This project's WCA shows the following:

- The amount of cardboard and paper packaging is varying a lot between households and commercial areas, amounting to on average 3-5% of the total weight. In Yerevan's commercial waste flow, the total amount is considerably higher, 13% including "Other paper".
- Newspaper in the waste is very limited, less than 1% except for Yerevan (2%).
- Metals are also very limited leading to the assumption that there is separate collection somehow.
- Plastic waste (except styrofoam) is a large amount, over 10%.
- Much of the recyclable materials, such as plastic and cardboard packaging and newspapers, are severely contaminated with dirt and sand, significantly reducing their value.

The recycling is currently limited and non-structured[64] and the value of materials is lower than it could have been if segregation at source would be applied.

It should be noted that the international market for trade with recyclable waste has changed since China and other Asian countries have imposed an import ban on some waste fractions. The market price on waste paper, for instance, has dropped 300% in 2 years only.[65] This has led to large volumes of particularly plastic waste being stored for years, awaiting better market prices, and that countries have been forced to invest in their own recycling industry or simply bring the waste to landfills.

In many countries, the installation of sorting facilities with conveyor belts is being promoted by public and private entities. One of the largest plants started up in Motala, Sweden, this year with a capacity of 120,000 tons per year, which is basically all plastic packaging in Sweden. It is very vital to note that only plastic packaging sorted at source is accepted, because this is the most common misunderstanding and mistake made at other locations – to expect a high-value output from a poor input e.g. mixed household waste with a high organic content, which the case below shows.

[64] Report on the Evaluation of the Current SWM in Yerevan (Ficthner, 2008)

[65] EURIC www.euractiv.com/section/circular-economy/news/eu-paper-recyclers-in-crisis-as-china-waste-import-ban-bites/

Figure 33. Case of a project on waste sorting (Russia 2013).

CASE

A KfW funded project in St Petersburg involved design and construction of a new waste collection system including transfer stations and a sorting plant for recyclables. Mixed household waste was unloaded from compacting trucks into a shaft leading to a conveyor belt. Manual sorters picked e.g. cardboard and paper, glass, metals and hard and soft plastics. The estimated amount of recyclables was around 30%; however, the actual rate was around 12% and some of that material was so contaminated with food scraps that it yielded a low market price. The conclusion was that it was simply impossible to get enough revenues to finance the sorting plant investment.

Plastic recycling itself is far from easy since different types of plastics are mixed and contain fillers, additive, coloring etc. that reduces the chance of recycling. In Sweden, which has a relatively good track record still, the collected amount is ca 40% but only half or less of that amount is actually recycled. Thus, as much as 80% of the plastic packaging waste is still used as fuel in power plants. However, there is a market for certain streams, such as PET bottles in Armenia, which should be tapped more efficiently than through informal scavenging at the dumps

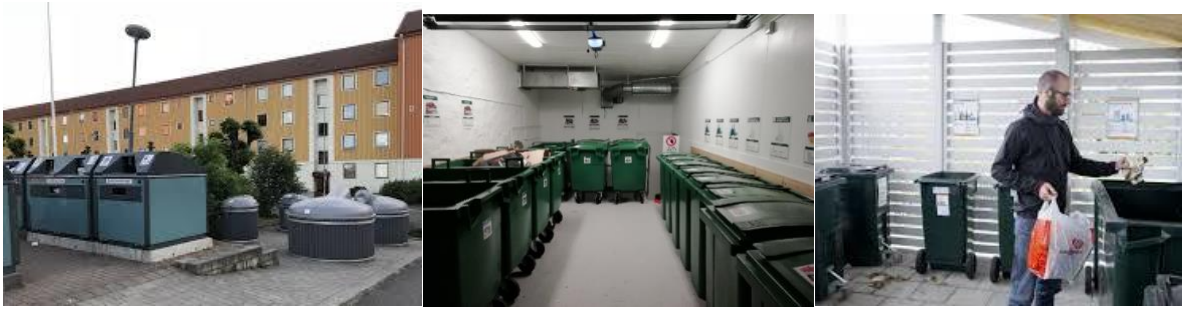
Recycling of paper and cardboard is usually easier with the exception of liquid packaging board which apart from the cellulose may consist of thin layers of plastic and aluminum. There is a market for newspaper, paper and cardboard in Armenia.

Metals are already taken out from the waste stream, which is normal for any waste with good quality properties in second-use and with a high market value. The same thing goes for laptops, cellphones and other WEEE that can be dismantled for valuable metals including gold.

Glass should also be collected separately, if not for the recycling/reuse potential then for the work environment issues with regards to both bin weight and risk for cuts.

All of this could be done at household level, simply having different bins for different types of waste. The bins can be placed indoor if the space is adequate and can be reached by collection staff, or outdoor. Below are some examples of waste collection points for residential areas.

Figure 34. Containers for packaging waste, food waste and combustible waste (l), in- and outdoor spaces for segregation of packaging waste and other fractions for residential areas (r)



The market for reuse should be investigated, since a lot of bulky waste was found in and around the bins. Even in countries with cheap, domestic textile production, the market for second-hand clothes may be large, so this could be further explored. Below (see figure) a popular reuse concept in Stockholm, Sweden where a mobile unit both receives and a gives away second-hand furniture, toys, clothes, kitchen appliances etc.

Figure 35. A mobile station for reuse of clothes, furniture and other household items[66]

For bulky waste, as mentioned earlier under the "Waste collection" section, there can be recycling centers where individuals and companies bring the waste free of charge for sorting and recycling, as shown in the figure below.

Figure 36. Recycling center in Stockholm for sorting of bulky waste (l) and recycling station for bringing packaging waste (r)

Phase 1

- Map out all active organizations, institutions, companies, and other stakeholders involved in recycling, the types and volumes of collected materials, system for collection, their primary interest, financing schemes and available markets, work on public awareness or participation, etc. There could be possibilities to
    - Coordinate efforts and to split up to cover larger areas, invite private companies or other organizations to handle collection of certain recyclables and in certain areas;
    - Cooperate on or complement each other in information campaigns;
    - Combine collection but handle different types of materials;
    - Expand the network internationally.
- If possible already now, support the non-government organizations or other key players and utilize them for, for instance, public awareness campaigns, since that is usually their forte and often neglected or not prioritized by the municipality in comparison with day-to-day operations in waste management.
- A simple and efficient measure is to collect small batteries for recycling or at least storage until a more permanent solution. Also, light bulbs, modern low energy lamps and fluorescent lights should be sorted separately and at least stored since such items contain

[66] Reuse station set up by Stockholm municipality, operated by LL Bolagen, 2019

mercury, very toxic in the environment. There are also recycling schemes available abroad, even Sweden is exporting such waste abroad for recycling.

Phase 2

- Start a multi-sectoral pilot in an area based on the learnings in Phase 1 or prepare a large-scale intervention directly but introduce it step-wise to learn and adjust.

13.4 Bulky waste

It is urgent to alleviate the current situation where bulky waste and sometimes industrial waste is either dumped in the 1100 L bins for municipal waste collection or next to them, or randomly at empty lots.

There are in principle three ways to arrange collection of bulky waste

1) Separate collection routes with heavy compaction trucks or open trucks with overhead crane. The collection could be arranged as
    - on-call service where the customers have to call the company and give the address for collection
    - pre-defined routes with spaces for bulky waste at paved areas, maybe inside a building, at pre-determined locations with satisfactory space. The disadvantage is that the site may be used for household waste and other undefined waste.
2) Special collection points at suitable places located with regard to availability, traffic, disturbance, etc. with big steel containers, size 10-30 m^3. The containers have to be collected by roll-off trucks.
3) Full-scale recycling centers of western European type (see picture below) The centers are built for access by private cars and small trucks and are equipped with containers where the various fractions can be unloaded. Reception of not only bulky waste but also recyclables and, most importantly, hazardous waste is arranged. Staff on site advise and direct the residents how to sort and where to unload the waste. It is also possible to arrange a special area where reusable items such as furniture and functioning electrical items can be re-utilized by others.

All of the above solutions are currently used in countries like Sweden and Germany. However, because of its convenience, the option with recycling centers has increased in popularity and one such center may receive 2,000 visitors – both individuals and company cars – in a day. Typically, a medium-sized municipality would have one such center and a city the size of Yerevan would have four to six. They are often operated by a contractor that receives a bonus for higher recycling yields. The obvious disadvantage is that it is necessary to have access to a private car and a trailer to use them. To build recycling centers is an ultimate solution but will take time.

Figure 37. Collection of bulky items (l) and construction waste (r), often left at the curbside or in household waste bins.[67]

Phase 1

- There must be information and dissemination to ensure that people and companies are aware that municipal 1100 L bins are not supposed to be used for bulky waste and that there are other solutions.
- The only workable option which could be started immediately is to use the on-call model and sign up contractors to carry out the collection. According to verbal information from the contractor Davars, this company already carries out this service to some customers, so this activity could easily be formalized and expanded to involve also other certified and registered companies.

Phase 2

- Depending on how the on-call system described above is working, setting up steel containers at selected points can be tried. A precondition is that the collected waste is disposed of at a landfill and not just a scrapyard or similar since there with most certainty will be household waste including organic waste dumped in the containers.
- Bulky waste containers could also be set up temporarily and supervised, for instance next to a building undergoing renovation.

Phase 3

- The ultimate solution is to build recycling centers (see picture under the section on "Reuse and recycling") which are open 7 days a week and manned with staff to overlook the activities and guide the public and companies disposing of their waste through sorting in different containers. Some of the waste, such as wood, metals and plastics, can be recycled and it is more cost-efficient to the fractions sorted like this from the start and in large volumes, so it may interesting for a PPP setup where the contractor is not just operating the plant on behalf of the city but owns and trade the material.

13.5 Construction and demolition waste

Soil, earth and blasted rock, although not useable for the contractor, is normally not regarded as CDW as it often can be used as filling material in other projects. It is also not hazardous in any way. Remainder of concrete blocks and similar can also be regarded as filling material. In other big city

[67] Photo credit: Davars Ltd.

areas in Europe and the US, there are often special landfills for such inert, non-hazardous materials, where portions of the filling material are sold to other contractors.

Scrap metals, particularly steel and copper, but also aluminum, can be sold to the international market for quite high prices. Usually there are vendors for this material in all large cities.

Used wood does not represent any value at present in Yerevan, but if some kind of incinerator is built for heat and electricity production, the chipped wood may be paid for. Wood or wood chips may also be used on small scale for household stoves.

Of the plastics, mainly polyethylene has a relatively high value (and PET) and there is already an informal market for this in Armenia.

Cardboard also has a good potential if the quality is acceptable.

Construction waste will be generated during construction of new buildings, but also during maintenance and reconstruction works. The most efficient means of reducing construction waste generation is close cooperation and monitoring of the private developers for them to minimize spill through proper dimensioning of materials, skilled construction workers and architects and an overall understanding of economic and careful material handling, storage and construction.

Still, there will be waste produced, and below are recommendations how to introduce segregation at the construction site to enable recycling.

First of all, **re-usable materials** or products should be taken out and preferably stored under a roof until it can be sold or given to the next user.

Secondly, there will be large volumes of **soil and clay, stones, rocks** etc. from excavation works. This is best to use for cut and fill to avoid unnecessary transport and procurement costs.

For larger rocks or uneven ground material, it may be beneficial to bring a crushing machine to produce gravel on site rather than buying virgin gravel and have the rocks transported away. However, it is vital to ensure the physical and geotechnical properties of this material in case it is being used for road construction or in building fundaments.

During the building construction phase, the materials can be sorted in the following fractions into containers or bins or bags:

- Scrap metal
- Plastics
- Wood
- Paper packaging material, corrugated cardboard
- Residual waste

There can also be

- bricks and masonry
- concrete and steel
- soil, sand and gravel

If there are large volumes of plasterboard (gypsum), this material can be brought back to the supplier and re-fed into their production.

In Europe, big bags manufactured of armored plastics are more and more used for collection of bulky waste and construction waste of moderate size, up to about 2 m length. The system is convenient for narrow sites for example in downtown areas as they take up little space and are easy to collect by trucks with overhead cranes. They are strong enough to be filled with gravel, concrete, bricks, etc. They can be used repeatedly and cost very little compared to containers.

Hazardous waste, e.g. paint, solvents, ink, varnishes, cleaning agents, etc. must not be thrown into a container but collected and stored separately. It is unknown if there is proper handling of such waste available in Armenia; it is assumed that this waste will have to be landfilled or stored within a landfill site, or other safe site until proper treatment of the waste is available. It should be noted that asbestos often can be found in old buildings which produces harmful particles when being crushed. Hence, removal of asbestos should be made prior to demolishing the building. All asbestos-containing waste must be handled causing as little damage as possible and put in closed plastic bags and be disposed of without opening the bags to avoid spreading of dust and landfilled in a separate area with proper cover.

E-waste should also be taken out and stored separately for possible reuse and recycling. During the construction phase, this refers mainly to cables, broken lamps and other equipment that cannot be installed for some reason.

Some examples of segregation of waste materials at construction sites can be found in the figure below.

Figure 38. Examples of waste segregation at construction sites[68]

The developers may be charged a different fee per ton depending on if it is segregated or not. This is also a common incentive at waste treatment plants: the cleaner and more recyclable material, the lower the fee. Scrap metals are usually paid for by the recipient company.

Construction waste may be sorted into different kinds of containers and bins, which are then transported out of the construction area and to its final treatment or disposal:

- Containers or skips to be picked up by a hook-lift
- Big bags to be picked up by a crane
- Bins (660L or possibly 1000L or 1100 L if the waste is not too heavy) to be collected with a rear-end loader or similar

Containers and skips, as seen above, come in different shapes and sizes and must be chosen depending on estimated volumes per waste fraction and collection frequency. A disadvantage may be to store wood in open containers, as it will reduce its quality for construction or fuel purposes. E-waste should not be stored openly at all.

[68] Pictures from www.masterbuilder.co.in/mcg-orders-gurgaon-builders-segregate-construction-waste-project-sites/ and BAM Construction

A cheaper and more flexible solution for smaller amounts may be using so called big bags, sturdy textile bags with handles. These bags can also be placed higher up in the building compared to containers that may be too large or heavy.

For smaller amounts, plastic bins can be used and have advantages such as that they are equipped with lids, can be easily moved (on wheels) and do not rust or leak easily.

For collection of containers, there is a need of at least 3 m times 15 m space to manage one container.

Action plan

As the collection of CDW waste is not a primary municipal responsibility, it is recommended that the public sector concentrates on the legislation and the monitoring system and additionally on the safe disposal of such waste. The most immediate requirement is to ensure that there are disposal facilities available for CDW waste. In Yerevan and most of the cities the municipal dump is aimed for municipal waste only which leaves only illegal dumps for the CDW and industrial waste.

Phase 1

- Evaluate the existing system for monitoring of building permits and the CDW production and how it can be used to estimate future waste volumes and waste composition.
- If information is scarce or missing, make an inventory of CDW; it could be combined with other industrial waste. List the present origin, estimated volumes, rough composition and the disposal site(s). Note also the contractors in charge of the collection. Note if some re-use or recycling is being done.
- Start an improvement plan for old dumpsites for CDW in line with the proposal for municipal waste landfills (refer to the sections on Landfilling).
- It is also important to recycle as much as possible of the CDW since it takes up a lot of space at the landfills. One immediate step to take is to ensure that all inert materials is tipped on a special area where it can be used for landfill cover.

Phase 2

- Introduce new legislation with stricter rules for re-use and recycling of CDW.
- If no proper landfills exist, make plans for establishment and construction of new ones.
- Continue with the improvement plan for old dumps.

Phase 3

- Construct new landfills and/or other types of treatment/disposal facilities.

Figure 39. Collection vehicles for construction waste[69]

13.6 Automotive waste

Currently, the exact amounts of waste from enterprises dealing with car repair, mechanical workshops and scrapyards are not known. However, it is more important to map out such activities and firms to ensure that the waste management is improved.

Initially, the first action is to improve from simple dumping of liquids and no separation of hazardous waste to raised awareness among operators to at least collect e.g. batteries separately and either storing the liquids or discarding into the sewage. Also, information about the risks of using the waste oil as fuel is important. Any emptying of the scrap vehicles and storage of oils, solvents and other chemicals should always be done on a hard, impermeable surface where spill can be collected and absorbed if needed.

Phase 1

- There is need for better knowledge about hazardous waste and particularly from car repair shops or other enterprises dealing with end-of-life vehicles. Thus, the facilities and companies involved in this should be mapped out clearly with a contact person to be the entry point to follow up on permits and waste management. Hands-on recommendations about proper management of the facilities' hazardous waste may be developed in a simple informatory leaflet and then distributed to the identified facilities.

Phase 2

- A more thorough investigation of car repair shops and scrap yards is undertaken. After identifying as many facilities as possible, a few should be visited and informed about proper management of the hazardous waste.
- During the inspection visits, the amounts of waste generated is estimated and the amounts may be extrapolated for the assumed total numbers of repair shops and scrap yards.

It should be noted that even in countries with very organized data collection system on waste amounts, all waste generators are not visited. Although they are requested to report on their types and volumes of waste plus handling, the data can differ depending on their reporting; hence, the waste amounts must be extrapolated based on a few study objects.

[69] http://eos.en.ecplaza.net/products/eos-enviro-20-iso-container_1780124 and www.bigbag.se

13.7 Industrial waste

To understand and be able to inspect and validate the generation of waste from different kinds of industrial activities, in general profound knowledge regarding the operations is necessary. The inspectors are usually dependent on information and data from the operator.

Phase 1

- As a first step, the data and forms collected by the Inspectorate should be requested to get a first impression on the validity of the data reported regarding industrial activities and enterprises.
- Contact should be made with the Chamber of Commerce and Industry to establish what kind of information is available regarding list of industrial enterprise and activities.
- The Inspectorate list and the Chamber of Commerce list may be compared and consolidated.

Phase 2

- To validate that all enterprises of a certain size are listed and reporting to the Inspectorate, contact should be made with the local authorities to find out if enterprises are missing in the Inspectorate list.
- Questionnaires regarding waste amounts generated and waste management (sorting, collection and subsequent treatment are sent out to all identified industrial enterprises and facilities.
- Transportation documents and/or invoices from recipient transportation companies can be requested to follow-up on waste disposal.
- On-site follow-up inspections are made, possibly by the Inspectorate during regular inspections.

Phase 3

- Once the situation is better understood and sources of certain wastes have been identified, and provided that the companies are open about their waste production and willing to improve, there can be cross-sectoral or cross-company trade with certain waste. For instance, cement kilns need fuel and can incinerate plastic or other waste in large volumes from another industry. However, this is not the responsibility of the government although it can be encouraged.

13.8 E-waste

Since e-waste contains many precious metals and poses a large environmental threat, separate collection of e-waste is a priority. In Europe, there is a producer responsibility for EEE and subsequently for e-waste. In order to upgrade the system for e-waste management, the producer responsibility has proven quite successful.

There are recent examples of EPR from other countries, for instance Rwanda (see figure below). An important learning is that all involved have to be on board and take their respective role and the financing and operation of the system seriously.

Figure 40. Case showing the importance of stakeholder coordination in new regulatory systems (Rwanda 2019)

CASE

Rwanda has taken a decision to be the number one country in Africa to provide all children with computers. In remote villages, it means that solar energy must be used. A large-scale attempt to regulate e-waste, all producers (mainly importers) and other pertinent stakeholders were approached to start the process of introduction of producer responsibility.

A proposal for new regulation for producer responsibility was later put forward to the national government. The client understood the importance of bringing in the impacted stakeholders right away, prior to drafting the regulations. If producer responsibility is introduced, it is crucial to allow the producers to find their own solutions for arranging of the system, both financially and practically.

Phase 1

- Arrange for simple collection and storage of small batteries (battery boxes). A study must be undertaken for the practical introduction of battery collection. In parallel, an information campaign must be launched to explain why it is crucial to not to throw the small batteries in the household waste. Separate collection of light bulbs and fluorescent lights should be considered as well.
- It is not clear if the Armenian market is ready to introduce a producer responsibility system for EEE and e-waste. Hence, it is recommended that producers of EEE (i.e. importers, retailers and manufactures) are approached to discuss the possibilities to introduce a such a legal system. A first step could be to organize a seminar with identified stakeholders. A training component should be included to raise the awareness among the stakeholders regarding waste in general and hazardous waste in particular.
- More capacity development in general and coordination between various offices, organizations and companies is needed, which became clear during the workshop on hazardous waste that was held during this project with relevant stakeholders in the area of solid waste management, it is recommended that future workshops could include the development of an action plan that addresses not only the legal framework but monitoring, collection routines or drop-off points and other concrete measures.

Phase 2

- In the future, there must be a separate, regulated and monitored system for collection, handling, dismantling and recycling of EEE and e-waste including registration of contractors for collection, segregation at source in residential and commercial areas, other drop-off points at, for instance, stores selling e-products. If a producer responsibility is introduced, the government should monitor and may promote and assist during the implementation process if necessary.

13.9 Healthcare waste

As described earlier, the low rates of healthcare waste generation per bed in the hospitals visited suggests that there might be hazardous waste sorted as non-hazardous. Thus, it seems that there must be further capacity development at hospital and other waste generating sources to distinguish between various types of waste and implement sorting and proper handling. It is crucial to inform staff about the importance of separating the infectious waste and sharps, to avoid contamination of non-hazardous waste as well as threat to the health and safety. This should have priority over elaborate data collection.

The Iraqi case below is one example where the focus was taken from waste amounts to proper procedures in the hospitals concerning separation of waste at source to avoid contamination of non-

hazardous waste and hence try to reduce the environmental risks at the disposal sites and safeguard the workers in the waste management chain.

Figure 41.Case about healthcare waste inventory (Iraq, 2009-11)

CASE

A project in the Medical Center in Iraq, comprising about nine different hospital units with various disciplines. The Ministry of Environment was the beneficiary. Initially, the task was to execute a weighing campaign for all the different hospitals, but since there was no separation at source of the waste generated in the hospital, the focus was changed to more practical instructions and training components. The new approach to learn about separation and proper management turned out to be much more useful for the staff responsible for healthcare waste on the national level, instead of trying to establish waste amounts.

Another important issue is the handling of mercury-containing waste from the healthcare establishments. It is positive that such waste, if identified at the recipient treatment facility, is not incinerated in the kiln/incinerator. However, a more long-term solution will be needed in the long run.

The following actions are recommended on short and long term:

Phase 1

- There must be a more thorough activity to gather information on healthcare establishments from different sources, such as the Ministry of Health (MoH) and what establishments they are regularly visiting, and the Inspectorate. The number and locations of the establishments from the MoH are verified through meetings with responsible staff at the Ministry.
- If the establishments are in compliance with the regulations on having a contract with either one of the licenced companies is followed-up. Also, this information is checked with the currently licenced companies and then comparing the customers listed with the licenced companies and the information that lies with the Ministry of Health.

Phase 2

- Inspections and visits to several healthcare establishments in various regions should be undertaken in cooperation with the Ministry of Health to verify separation at source and confirm contracts with the licenced companies. If there is no or lacking separation at source, the establishment must be informed about the importance of this to avoid contamination and ensure safe handling of waste, and possible fined for non-compliance.
- The management of mercury-containing waste should be more robust. There should be at least separation at source of such waste (for instance batteries, thermometers, mercury sphygmomanometers if used, etc) and proper storage while waiting for export for recycling or other solutions.

13.10 Other hazardous waste

For hazardous waste in general, it is not crucial to know the exact volumes but rather to raise awareness with both the general public and other waste generators on what is hazardous and how should it be sorted, stored, handled and transported. One example would be the hazardous components in construction and demolition waste. Training and education of staff involved in business and industry is necessary.

Phase 1

- When recording the number of trucks to the current landfills/dumpsites, a visual inspection of the truck load can be made to get an idea of whether industrial waste is entering the municipal sites or not, what are the approximate volumes and typical types of waste, and

how serious is the issue and subsequent challenges with mixing with other wastes, lack of monitoring at the dumpsite etc.

- If deemed possible, assign a special area at the landfill for hazardous waste to avoid it being spread to other fractions.

Phase 2

- Gather information from the Inspectorate and possibly the Armenian Chamber of Commerce and Industry regarding different branches/enterprises etc.
- Another action would be to contact any business association for companies to get input on what kind of companies are present and compare if they are reporting to the Inspectorate.

Phase 3

- Arrange waste training seminars for companies; entities involved should be the Inspectorate, Armenian Chamber of Commerce and Industry, business associations etc.
- Follow-up of waste amounts should be part of the inspections made by the Inspectorate.

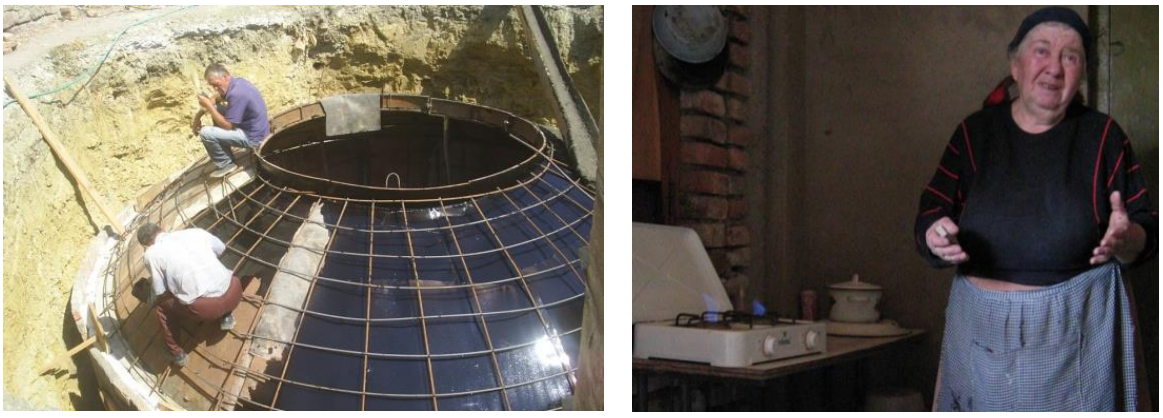
13.11 Agricultural waste

The agricultural waste, if just considering the waste from produce, is not a waste stream to be particularly concerned about with respect to waste at this stage. The fact that most of the farms are small with low financial income, the use of chemicals and animal drugs is probably low, which is very beneficial for the environment and for the quality of the food produced. However, as the economy and agri-businesses develop further, the issues with particularly this kind of waste will increase.

During the waste composition analysis carried out in Ararat, it was noticed that there was much less organic waste in the municipal waste stream. This is an example of a municipality where the urban and rural societies are close. Most of the waste produce that is generated in the farms will probably be utilized in some way; for composting on the farm premises and subsequently utilized as fertilizer or as animal forage.

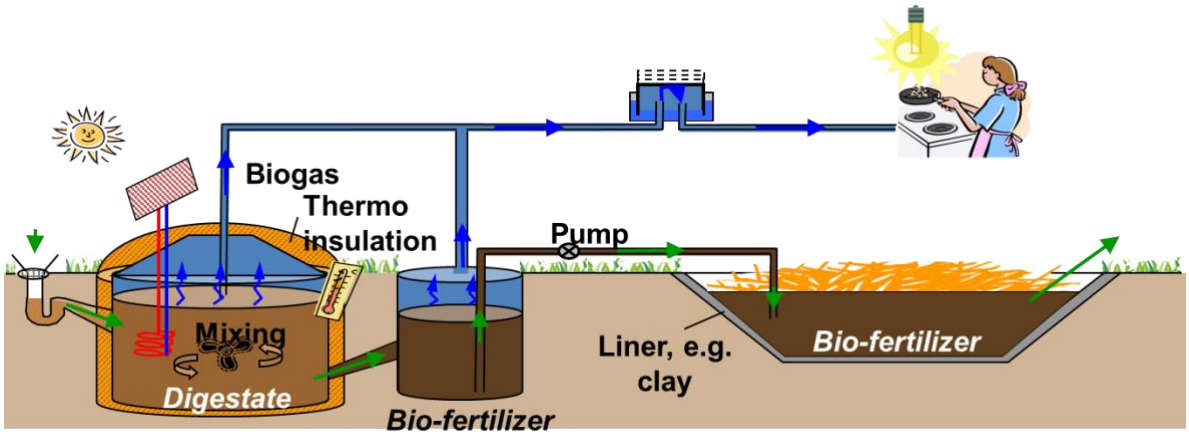
However, there is a good potential for introducing small-scale anaerobic digestors to provide biogas for heating and cooking purposes and to enhance the quality of the digestate (the solid/liquid product after digestion) that is used as a fertilizer. The biogas for heating and cooking is particularly interesting in areas where deforestation is a problem, since the biogas as fuel can replace wood. Such projects have been proven very successful in for instance Georgia (see example in figure below).

Figure 42 Construction of a biogas reactor/dome in Georgia (r) and a Georgian woman making use of the gas



For a simple layout of the technology with semi-underground biogas dome, see the figure below.

Figure 43. Principals of a simple biogas reactor, typically used in agricultural areas



Phase 1

- Composting of particularly straw, hay, bark or any carbon-rich, fibrous material together with more nitrogen-rich material such as fats, manure, etc. can be initiated at farms in windrow composting anytime and could be encouraged by the government.

Phase 2

- The potential for biogas generation from agricultural waste, for the local farm or on a more large-scale basis, may be investigated in terms of volumes, types of waste and their suitability for biogas production, financial and operational aspects etc. in a feasibility study.

13.12 Treatment of organic waste

In principle, there are two main established ways of treating organic waste; *biological treatment* and *combustion (incineration)*. Biological treatment comprises *composting* (aerobic, with oxygen supply) or anaerobic *digestion* (without oxygen supply). Furthermore, a short description of plasma gasification and pyrolysis is also included in this section. Since the energy content is important when considering incineration and plasma gasification, the topic of calorific value is briefly addressed.

Biological treatment

The main purpose of biological treatment is the circulation of nutrients in society as a means of closing the eco-cycle. Hence, all biological treatment requires uncontaminated waste which means adequate sorting of the waste at source. To take out the organic waste from the residual waste to be deposited also reduces problems with rodents, smell, GHG emissions and fires at the landfill. Furthermore, it can be a source of clean energy and/or natural fertilizer.

Composting facilities can be of any size and very basic without any large investments depending on the type and volumes of organic waste. Park and garden wastes are usually quite simple to handle, but in Yerevan and other cities, it is mixed with other municipal waste, thus taking up valuable space in collection trucks and also getting downgraded quality-wise. This kind of waste should be collected separately to reduce load on trucks and roads to landfill and instead be shredded locally and simply treated through windrow composting. There should be good potential for this in the smaller cities where the urban-rural linkages are stronger than in Yerevan.

Figure 44. Windrow composting

Anaerobic digestion is the most common method of treating food waste on large scale. It is generally more attractive than composting, since energy can be recovered and the residuals, the digestate, is easier for crop to absorb than compost. Anaerobic digestion produces biogas, which consists mainly of methane and carbon dioxide.

Biogas is a renewable source of energy. After refinement, during which the carbon dioxide is removed, it can be used as a vehicle fuel. It can also be used for cooking, heating or electricity generation.

When considering anaerobic digestion, which is a waste-to-energy technology, the sizing must be considered. In general, biogas facilities are much smaller in size compared to incinerators. The main reason being that the operations are quite different, and that the digestion process is hard to operate if too large-scale.

North of Stockholm (in Brista), a new anaerobic digestion facility is being constructed; with a planned capacity of 30,000 tons of food waste and garden waste. In Sweden there are also facilities with a capacity of 150,000 tons per year, but most plants are smaller in size. The decision on what size to select depends on several things, like access to suitable waste and how to utilize the gas. In Sweden, most biogas is upgraded to vehicle fuel, but in Yerevan it is probably not the first choice.

When assessing anaerobic digestion in a city setting, waste streams that may be easily quality controlled should be considered such as food waste from restaurants, commercial areas like grocery markets etc. at least in the first phase. Based on experience, organic waste from households is more difficult to control; those waste streams can wait until later.

Incineration

Incineration of waste with energy recovery is an established method for waste treatment. The quality of the waste is less sensitive compared to biological treatment since the residues are usually landfilled and not recovered. However, it is preferred to reduce the contamination level in the waste incinerated as well, since the need for flue gas cleaning is reduced if the quality of the waste fuel is high.

A rule of thumb is that an incinerator should be large; the reason being that a large installation can bear the costs for adequate flue gas cleaning, attract competent staff and being able to operate 24/7. The recommendation is to have only one facility for Yerevan, since the city is approximately the same size as Stockholm. In Stockholm, there is one incineration facility although the waste generation is much higher in Stockholm than in Yerevan. The capacity of the plant in Stockholm (Högdalen) is 700,000 tons per year, including industrial waste.

Waste generated in Stockholm is also transported to neighboring cities, but one facility operated properly, and full time would be enough in Yerevan. Incineration facilities are usually built in sections/lines and new sections can be added on if needed. The utilization of the energy must also be considered, the ideal situation is if electricity can be generated and the heat used as well, e.g. for

district heating. Upgrading of old heating systems like was done in the Avan district[70] might be something to investigate further if considering incineration.

Plasma gasification

As a curiosity, plasma gasification with production of hydrogen gas is being discussed now in Sweden and many countries. Plasma gasification is a process which converts organic materials into synthetic gas.

Inside the gasifier, the hot gases from the plasma torch or arc contact the feedstock, such as municipal solid waste, auto shredder wastes, medical waste, biomass or hazardous waste, heating it to very high temperatures in an oxygen-depleted environment. This extreme heat maintains the gasification reactions, which break apart the chemical bonds of the feedstock and converts them to a synthesis gas (syngas). The syngas consists primarily of carbon monoxide and hydrogen—the basic building blocks for chemicals, fertilizers, substitute natural gas, and liquid transportation fuels. The syngas may also be sent to gas turbines or reciprocating engines to generate produce electricity or combusted to produce steam for a steam turbine-generator.

Since the feedstocks reacting within the gasifier are converted into their basic elements, even hazardous waste becomes a useful syngas.

Inorganic materials in the feedstock are melted and fused into a glassy-like slag, which is non-hazardous and can be used in a variety of applications, such as road-bed construction and roofing materials. It is used commercially as a form of waste treatment and has been tested for the gasification of biomass and solid hydrocarbons, such as coal, oil sands, and oil shale.

Pyrolysis

Pyrolysis is a process of chemically decomposing organic materials at elevated temperatures in the absence of oxygen. The process typically occurs under pressure at temperatures above 430°C. The end products of incineration are mainly carbon dioxide and water, while the end products of waste pyrolysis plant are mainly combustible low molecular weight compounds. Incineration is an exothermic process while pyrolysis is an endothermic process, which needs to absorb large amount of heat. There are no success stories associated with pyrolysis as a waste treatment method, therefore this method cannot be recommended.

Calorific value

The calorific value of mixed waste depends on various factors, such as waste composition, moisture content, etc. Waste with a high content of kitchen waste has usually a lower calorific value than waste with larger portion of packaging waste such as plastics and paper. In the early 90'ies in Sweden, prior to separation of packaging waste but long-term separate collection of newspapers and print, the calorific value of the household waste was on average 13 MJ/kg.[71] The energy content was expected to be lower with the introduction of producer responsibility and separate collection of packaging waste. As an illustration of the complexity of waste as a fuel, the incinerator design and manufacturer company Igniss Energy, Incineration Technology,[72] states that the calorific value of domestic waste without separate collection of recyclables is between 7-16 MJ/kg and with recycling 10-14 MJ/kg.

[70] https://www.undp.org/content/undp/en/home/ourwork/ourstories/armenia--heating-homes--warming-lives.html

[71] Swedish Environmental Protection Agency and Department of Energy), Energy from waste- study during the 1980'ies and according to practical experience from Swedish incineration facilities

[72] http://www.igniss.com/calorific-value-waste

Since the waste composition in Armenia today is quite similar to the waste composition in Sweden in the 1980's, it is fair to assume that 13 MJ/kg is a fair estimate; newspaper and print is not a very large fraction in Armenia currently and packaging waste is not separately collected. However, when planning for an investment such as incineration with energy recovery or plasma gasification, a more comprehensive feasibility study is recommended to establish the true calorific value. Also, other potential waste streams should be considered as well.

13.13 Landfilling

As described in the previous chapter on Landfills and dumpsites, there are several on-going and planned projects to construct sanitary landfills and improve overall waste management.

Currently, the pre-qualification stage of the landfill construction tender has come to the final round. Eight organizations have submitted applications and now the documents submitted are being clarified, after which the committee session will be invited to prepare a final list of pre-qualified applicants, and then applicants will receive a request for price proposals.

Projects for the remaining marzes will follow but experience shows that this kind of projects take much longer time to complete than planned. In the worst-case scenario, some regions may have to wait for 10 years or more until a new landfill is constructed, thus having to rely on their existing dumpsites for many years to come.

Although the new landfills are to be financed by loans, the total costs for waste management will rise. The operation of the new facilities will have costs on an entirely different level than today, when almost nothing is spent on the existing landfills. So, the economic situation will be critical, particularly in view of the fact that there is a palpable resistance from the general public to raise today's very low tariffs.

Additionally, remediation of the old landfills and dumpsites will also be costly, although partly financed with additional loans. The state will have to take the lion's share of the costs but also the municipalities will bear their share of the burden.

Considering this scenario, it is recommended that the municipalities make some basic improvements of their existing dumpsites. Such a package of simple, basic measures can be given national government support, such as offering design and operational guidelines, conducting trainings, and offering basic investment funds for roads, gates, etc. Such a package of support to local governments can be given a politically high-profile name that gives the program national visibility and mobilizing community interest and awareness raising. This way, the landfills' function could be considerably improved in a cost-efficient way with better utilization of the area and a much nicer appearance. The general rule is that keeping a facility in good order motivates all involved to keep it that way. The costs would of course rise, but the financial input to at least carry out parts of the program would not be unsurmountable, at least not for the larger cities.

Such a simplified landfill management could lay the basis of more sophisticated sanitary landfill management by incrementally introducing standards and practices as well as preparing and training staff nationally.

The program should be split in phases with the most urgent work being started immediately. Key components of such a simplified regime should be the following:

Phase 1

- One of the most important and acute measures is to improve the condition of the access roads. In all the visited landfills (except the main road outside Nubarashen), the roads are hardly trafficable and the wear and tear on the waste trucks is devastating. A simple measure, which does not seem to have been carried out anywhere, is to go over the road

surface a few times with a scraper. Asphalted roads are preferable, however, with some regular maintenance, gravel roads are acceptable.

- A site manager should be appointed to register and guide incoming vehicles. The current operation as observed is often very limited with no consistency or little presence. This leads to non-controlled activities, that waste is being dumped along the access road and randomly all over the landfill area, creating a large tipping wound. This in turn increases the leachate generation and pollution risks as well as landslide or unwanted settling of the waste. There is indeed regulatory framework[73] for design and operation of landfills that could be partly applied despite it being a dumpsite.
- A simple gate should be installed so the trucks could only enter the site at prescribed times.
- The site manager should find a way to keep track of the incoming trucks, for example by introducing a record book, where the arrival time, the truck's registering number and the driver's estimate of the load weight is noted. Waste other than MSW should also be noted separately. This would immediately improve the information about incoming waste.
- A plan should be made for how the tipping should be done on the landfill area. By this, the area would be better utilized.
- Promote simple measures for composting of park and garden waste in a special designated area at the existing dumpsites.
- A clean-up program should be initiated with the goal to take away all waste spread outside the limits as a first stage. To do this, some kind of equipment is necessary, for example a front-end loader. If the site area is clean the motivation to keep it tidy increases.

Phase 2

This phase comprises work which is as important as the measures in phase 1, but since it will require more funds, it is put in phase 2.

- The whole tipping area should be cleaned up as much as possible and the old waste be moved to the active tipping area. Ditches to reroute rainfall and avoid further contamination and reduce leachate production can be constructed at an existing site.
- The waste in the finished tipping areas should be covered with sand and soil. The finished layers of the active tipping area should be covered as well. This work will involve hiring a heavy excavator/front-end loader plus a truck for transporting imported soil material. In most cases such cover material can be found close to the landfill at presumably low cost.
- A wire mesh fence should be built surrounding the landfill area. This will keep stray dogs and other animals away and also reduce the spreading of wind carried plastics outside the landfill.
- A weighbridge should be installed and a small office building built where the instrument for the weighbridge can be placed.
- Basic training should be extended to landfill staff about site management and operation.
- The observed volumes and disturbance from plastic bottles, film and other plastic waste could be reduced if plastics are sorted out prior to landfilling. The existing, informal recyclers currently picking waste at the landfill/dumpsites could be engaged in some way.

[73] The 2009 Decree N 321-Ա of RA Ministry of Urban Development on Approving guidelines on design and operation of landfill design and Order N 812 on Application

- Additional source separation of packages of glass, metals and paper would reduce the incoming waste to the landfills marginally which is positive, but it would first and foremost be a good exercise on the road to a more sustainable society.

Phase 3

The 3rd phase should include measures to upgrade the operation of the landfill even further and invest in more equipment and installations such as compactors, leachate collection and treatment, and collection and utilization of landfill gas. These measures will require high investments and costs and it is likely that the alternative will be to build a new landfill.

Thus, phase 3 will instead comprise final closure and remediation of the old landfill, which also is very costly. This procedure is not described in this report.

Phase 4

In modern waste management, the landfill is not a site for simple dumping of mixed wastes but rather an industrial site with clear boundaries and tipping areas for different types of waste depending on their characteristics and possibilities to upgrade and use. Thus, when collection and gate control is working more efficiently, the landfill is just a part of a larger concept, a waste treatment facility. Examples of actions in this direction are the following:

- All wastes that can be used for construction in ground work, such as soil, sand, stones, gravel, etc., can be stored separately and crushed to desired size.
- Contaminated soil can be treated separately by natural bacteria under certain conditions and should not be mixed with other wastes.
- An area for windrow composting with a shredder and frontend loader for turning the organic waste (park and garden waste) can be set up.
- There should be a separate, allocated area for hazardous waste not to contaminate other materials and to avoid occupational health hazards, for instance by ripping asbestos-containing demolition waste from going over it with a compactor.
- Wood, paper and some plastics can be shredded on site to produce a fuel if there is a market for it.

An example of what this kind of extended waste treatment facility can look like is given in the figure below.

Figure 45. Example of a waste treatment facility including a sanitary landfill, windrow composting, wood chipping, gravel production etc.

13.14 Business models

From the previous section on various business models, it can be concluded that the current setup of using contractors for operation of landfills and waste collection is not a PPP but merely utilizing the private sector for a municipal service or obligation. Furthermore, for a PPP to be interesting for a private company, there must be a positive cost-benefit relationship. In waste management, the revenues are often exaggerated and the municipality must subsidize the operations and PPP is not seen as the first choice. Furthermore, Armenia qualifies for soft loans from various development banks, such as the EBRD, with competitive conditions and often a grant part which makes it more attractive than the private market. Using such loan facilities, the government can invite companies to bid for SWM contracts which includes purchase of trucks and other equipment as well as operation of the contract for a number of years, typically 5-10 years. Such projects are currently being tendered in both Yerevan (build and operate, BOT) the new Nubarashen landfill) and in the Kotayk and Gegharkunik SWM project (purchase and operation of waste trucks and container stations and construction and operation of a sanitary landfill).

However, for an investment with high capital expenditure as well as O/M costs, requiring advanced operation, e.g. a combined heat and power plant for waste incineration, a PPP solution could be investigated, together with other alternatives.

For any type of cooperation with or procurement of products and services from the private sector, the public entity must have both technical, legal and financial/procurement skills. This cannot be overstated, since there are numerous examples globally of poor procurement and subsequent issues with impossible contractual obligations, non-performance, unsustainable operations, mismatch with other urban infrastructure or administrative procedures, etc.

In the marzes, where regional landfills are being planned, the model with jointly owned limited companies (joint stock companies) is recommended. All municipalities using the landfill could be share-owners, thereby having the same interest in the successful implementation of the project. The ownership of each member should usually reflect the size of the municipality, but there could be flexibility in this respect. It is also possible to let some small municipalities stand outside the owner company, but still use the landfill by a contractual agreement. This arrangement could also enhance capacity building and transfer of knowledge between municipalities. The larger municipalities usually have more staff and resources available, while the smaller ones may offer space for a landfill, for example. However, municipalities may also be unwilling to engage with each other for long-term investments, taking future political uncertainties or priorities into account.

If the municipalities are not willing to formally form a company, they can still join hands in procurement of waste collection services to mobilize and combine resources in, for instance, procurement, monitoring and available space for waste handling.

CASE

In the northern part of the Stockholm region, 10 municipalities have created a joint limited company SÖRAB for the primary purpose of securing available waste treatment for the population. Initially, when the company was formed in 1978, it was important to secure access to landfill space. Gradually, the focus is more on strategic planning, support in procurement, access to technical and other knowledge within the company, etc.

Phase 1

- It is recommended that the model to form a municipal limited company should be chosen for the Kotayk and Gegharkunik project mentioned above. Preparation agreements between the municipalities and formulation of a contract could start immediately and legal expertise must support the process on long term. Once the agreement is approved, establishment of the legal company can proceed.
- If this process is successful, the model can be extended to other areas.

Phase 2

- In order to handle such large investments and contractors in various contract forms, there must be capacity development with the public entities on procurement, contract management, monitoring and supervision, etc.

13.15 Institutional and organizational aspects

In order to secure the entire waste management chain, legislation in combination with enforcement and awareness in society is crucial. The old idea of “out of sight, out of mind” is not sustainable. In Sweden as an example, all waste generators (the public through the municipality) are responsible for managing their waste also when handing it over to a licensed waste hauler/treatment facility. This means that the collecting entity must record and reciprocate to the waste generator the waste amounts collected and what treatment facility accepted the waste. If, for some reason, the collecting company or treatment facility would not fulfil their obligations, the generator could in theory be responsible for the waste.

Taking hazardous waste from the healthcare units as an example from Armenia. The units that were visited by the consultant team all had an agreement with either one of the two licensed companies for collection and subsequent treatment of the hazardous fraction of the waste. However, the staff at the healthcare units did not know exactly the fate of the waste and did not get any feedback from the collector other than amounts of waste collected. There may be a risk that the collection company may not fulfil their obligations and the waste may be dumped somewhere illegally.

The collection of the fee is apparently very costly and left to the communities to deal with. Another issue is that the registers on actual residents per address are not reliable. Thus, the collected fees do

not reflect the population.[74] The digitalization of both registering and fee collection has been discussed at the Ministry of Finance and should be introduced as soon as possible, since it is presently hard to cover the actual costs but also to make informed decisions on future investments, routing, etc. An increase in fee level seems off the table, since people in the rural areas simply have small means and depend on their own crops, family and local trade for subsistence. However, industries and commercial entities could contribute more to the system.

The leadership pledge is also vital in SWM projects, since it involves many actors and requires a broad approach. The lack of waste collection is also often regarded as a clear sign of municipal incompetence and may trigger unwanted events. If the municipal waste is not removed from the inner parts of a city for a week or two, there may be a general feeling of apocalypse or lawless land and lead to crimes and violence. This in turn may lead to public contempt with the elected leaders and political instability. Thus, waste collection and preferably proper disposal is a basic infrastructure that is necessary to provide at all times, regardless of political leadership. The knowledge and experience must be firmly rooted with city officials and their powers must be extended to enable them to operate more independently.

As an action plan, a two-stage approach is recommended:

Phase 1

- Ensure proper enforcement of existing regulatory framework, such as gate control at Nubarashen or other dumpsites/landfills.
- Make the fee collection system more effective through digitalization.
- Make the plan and activities on waste management more visible to the general public, offer a hotline or engage people for public awareness campaigns.

Phase 2

- Introduce stricter legislation on private sector and other waste generators to record, document and report their waste types and volumes to the responsible local or national authorities.
- Introduce differentiated fees or varying fees depending on waste quantity and/or willingness to segregate waste at source.

13.16 Capacity development

In view of the current situation with illegal and generally poorly managed dumpsites and very little alternative waste management, such as recycling, there is clearly a need for capacity development on different levels. This view is further enhanced by the fact that new sanitary landfills are being planned and that proposals on other waste management technologies keep on coming from contractors. This will require not only a much higher technical competence but also strengthened capacity in environmental, financial and organizational aspects. It may also require more specific capacity in how to handle procurement and PPP in relation to waste management projects and investments, since it is unfortunately quite common world-wide that these partnerships fail or that the local or national government end up with an unreasonable contract. A concrete example of that is waste-to-energy plants in Asia, where the contractor has terms including an even supply of waste per day. If the local government fails to bring the “fuel” – possibly due to faulty collection trucks, heavy rainfall, cash flow issues for payment of vehicle fuel or staff – there is a penalty to pay to the

[74] Sanitek Ltd.

contractor for non-delivery. This situation also blocks the local government from exploring other treatment methods since all effort is put on maintaining the waste fuel supply.

For instance, even though there is today surely academic capacity in proper handling of sewage sludge, in practice, the sludge may be disposed of without any monitoring openly at the dumpsite. Thus, something is lacking in terms of institutional or financial capacity and monitoring and enforcement.

Another example is the lack of active operation of the dumpsites or documentation of number of trucks and estimated types and volumes of waste transported.

Thus, the recommendation must be to look at all parts of the chain in the wanted waste management system and look at what voids need to be filled in terms of various technical competences (e.g. leachate treatment of gas extraction) but probably focus more on how – administratively, institutionally, organizationally – to make the new system actually work. Just reading about how to drive a car doesn't make you a good driver – you have to be guided in doing it live.

Waste management and especially poor waste management is something that is very obvious to the general public and causes immediate and often exaggerated reactions. Issues in other parts of urban infrastructure, say leaking water supply system or flaws in building construction, are only seen when there is major breakdown or when the consequences, such as people getting sick from polluted water, are already there.

In conclusion, capacity development actions could be phased as follows.

Phase 1

- The public must get clear and consistent information about the current and planned waste management, so that they understand the system and their role in it. This information must indeed be supported by real action, or the risk is high that people lose trust in the authorities. Any speculation or rumors should be avoided.
- The public should also get general knowledge about pollution, particularly created by themselves when littering, dumping or burning waste, for instance.
- Technical and operational training related to improved operation of the waste collection and landfill management has been mentioned in other sections of this report. To understand the reality on the ground, it is recommended that also supervisors, municipal officials and others involved in decision-making and management are trained.
- In order to take informed decisions, municipal or state government officials and possibly politicians should also be trained in a more comprehensive way on sustainable waste management systems as a whole, including technology, financing, management, environmental and health aspects, etc.

Phase 2

- There must be specific information and education campaigns (IEC) in relation to the introduction of source-sorting of waste, collection of e-waste or chemicals, or something else.
- More training of staff, officials and politicians is required depending on the technologies and systems in the future waste management system.

13.17 Socio-economic and environmental risks

The current SWM situation in Armenia is challenging from both a socio-economic and environmental point-of-view, which has been mentioned initially in this report and is also one of the main drivers for a national SWM road map with a more sustainable and systematic approach.

Some of the observed and assumed risks are the following:

- Illegal dumpsites lead to pollution of air, soil and water in several ways and to short- and long-term health hazards, for instance through long-term leakage of various compounds including heavy metals and chemicals as well as emissions of methane gas formation and from spontaneous fires. The health and environmental impacts are both local and global contributing to climate change.
- Dumping of organic waste attracts various animals e.g. rodents and birds, which may spread disease.
- Lack of control, monitoring and operation of the dumpsites lead to fires and risk of explosions and landslides. There is also a potential risk for landfill gas spreading far away from the dumpsite area, thus posing a risk of explosions in buildings etc.
- People, informal recyclers, are illegally rummaging the waste, risking their own health with particularly infections from cuts or contact with chemicals but also inhaling smoke from dumpfires or other emissions from the waste. There may also be social hierarchies and larger networks involved in other more or less illegal activities connected to the scavenging, taking advantage of the poorest people to carry out this kind of work.
- The dumpsite area is often relatively close to the urban area, reducing the possibilities for urban expansion and destroying valuable land, thus a direct economic loss.
- Poor waste collection logistics leads to overflowing chutes and bins, which in turn attract insects, rodents and other animals bringing disease and other issues into residential areas.
- Occupational health connected to waste collection is clearly a risk although it could be resolved relatively easily by better understanding of the conditions and use of protective gear and better overall choice of equipment.
- Livelihood opportunities are wasted from poor material recovery, literally burying the money at the landfill.

The role of waste management and particularly dumpsites for global warming merits special mentioning. Looking at various sources of greenhouse gas emissions,[75] the energy sector stands out but the industrial processes also emits CO_2 while agriculture and waste has no or relatively little impact. However, looking at emissions of methane gas (CH_4), the waste sector has a fair amount and since methane gas is 25 times more potent, the waste sector is actually responsible for more GHG emissions than industry in terms of CO_2 equivalents.

[75] Strategic Environmental Assessment (SEA) Report "Strategic Development Plan, Road Map and Long Term Investment Plan for the Solid Waste Management Sector in Armenia" 2017

Figure 46. Emissions of GHG in Armenia by sectors (Gg) (2010)

Sectors	CO_2	CH_4	N_2O	HFC	CO_2 hшմ.
Energy	4231.0	35.64	0.094	0	5008.6
Industrial processes and product use	225.9	0	0	0.133	481.1
Agriculture	0	44.26	1.26	0	1320.5
Waste	7.64	27.77	0.202	0	653.4
Total	4464.54	107.67	1.556	0.133	7463.6

*Without forestry and other land use

The road ahead must face these challenges and try to resolve them; however, it should be noted that the "green economy" with, for instance, more recycling of packaging material and e-waste plus various waste-to-energy options also poses risks.

One of the most obvious risks is environmental and health risks from a poorly operated incineration plant, where large volumes and material turnaround can quickly lead to serious impacts through air pollution and improper ash handling.

Another one is that increased collection of HZW including e-waste will also lead to more handling of these materials, which requires skills, protective gear and safe transport and storage. Especially illegal or uncontrolled dismantling of various electronic equipment e.g. mobile phones and laptops have increased very rapidly all over the world and create black markets where these concerns are ignored.

Again, there is an obvious risk with new systems being implemented that existing informal systems will be destroyed and the livelihood for scavengers taken away. Formal and informal systems can be combined, as shown in the case below.

Figure 47. Case about engaging the informal sector (Philippines 2007-09)

CASE

In a municipal solid waste management project, dumpsite closure and remediation measures were included. The informal recyclers, called scavengers, were offered to instead sort waste given a regular salary at the new waste facility, at a conveyer belt and with proper protective gear. They were also engaged in windrow composting of park and garden waste, which required a lot of manual input. This way, a lot of conflict at the closed dumpsite could be avoided and the recyclers got a safer working environment and regular income.

Finally, an overarching concern is connected to large, donor- or private sector funded infrastructure projects, namely that the implemented technology or system cannot be "owned" by the public entity (state, province, municipality) with their current institutional, organizational and financial system. With a BOT, for instance, there is a great risk that the receiving part will not be ready to own and operate the technology and thus, also pollution control may fail. Poor conditions in the solid waste management area tend to attract external financers and suppliers of equipment/waste treatment facilities selling "solutions" that at first seem to be inexpensive and efficient but at the very end turn out to be very costly and even worsen the situation.

Again, to ensure a sustainable system, all links in the chain – legal framework, steady leadership, continuous monitoring of everything, financial stability, long-term planning and contingency, capacity development, etc. – must be in place.

14. Final conclusions and the way forward

There is enough baseline data

As mentioned earlier in this report, a lot of studies and research on solid waste management have indeed been done in Armenia. The academic level is high and so is the international network thus influx of ideas and solutions from other countries. Furthermore, the law on waste and municipal regulatory framework as well as participation in international agreements such as the Basel convention on hazardous waste are quite advanced. Still, the lack of implementation is staggering when it boils down to solid, efficient day-to-day operations with reduced environmental and health impacts.

Thus, one of the conclusions in this report is not to exaggerate the value of data collection and studies to come up with the "perfect solution". Recent experience from other countries shows that this is not an exact science, and that definitions vary even within EU. Many waste streams and waste fractions are difficult to measure since the number of operators is very large. Due to resource reasons, comprehensive surveys can rarely be made. Instead, some operators are selected and surveyed and based on the outcome, estimates are being made for all operators within a certain area.

Although the need to continue the journey of regular WCA in cities should be pursued with the same methodology as in this project, there is enough baseline data and any future studies should narrow down the analysis to focus on a specific technology or proposed system, say the potential construction of a biogas plant for a city with agricultural activity, or available paper and cardboard fractions for recycling including the actual market for that. As an example, the WCA shows high volumes of soft plastics, but that does not necessarily mean that the material is available or of such quality that it can be recycled easily.

A lot of things can be done right now…

As described in the Recommendations sections, many measures can be taken now in a first phase without need for any major cost implications, changes in regulatory framework, or other things that may require more time.

One such immediate measure, which would affect everything from lifetime of the collection vehicles and the landfill, working conditions, and recycling potential, would be to arrange separate collection of bulky waste including construction and demolition waste and remove it from the municipal waste stream. This goes also for park and garden waste as well as hazardous wastes. If used furniture or other reusable items could be handled through a more efficient second hand market, preferably locally, the need for transport and landfilling would decrease and important steps towards a more circular economy would be taken.

… but changes in waste management can take time

As mentioned earlier, there is reference to Sweden throughout this report. Sweden has been an EU member since 1995 and often incorporates the EU directives in the Swedish national legislation with tougher requirements. The primary purpose is to inspire from Sweden's success in sustainable waste management, but it should also be noted that it has taken Sweden some 30-40 years of policy-making, planning and strategic investments in collaboration with other sectors such as wastewater and energy to reach this status. For the private companies to pick up business opportunities in waste management, there must also be regulatory stability so that the legal requirements or economic conditions are not changed.

Focus less on technology and more on soft solutions

Another conclusion is that there is, as often in countries that are undergoing rapid urbanization and subsequent waste concentration, too much focus on waste treatment technology. Technical investments are only interesting when backed up by solid operation and maintenance, competent staff, and monitoring and enforcement. There could be a step-by-step practical approach, where soft solutions such as improved operations, fee collection, and producer's responsibility are equally or even more important than investing in best available technology (BAT).

Prioritize and cooperate

Prioritization of projects and measures in SWM must be done when resources are scarce. Some of the things that should be prioritized currently pose acute environmental and sanitary risks, such as improved management of the collection and disposal system but also separate handling of hazardous waste and monitoring of the flows of WEEE.

Cooperation with the private sector as well as NGOs, academe or other sectors should be encouraged as long as the roles and responsibilities are clear and the deals are fair. Engaging private contractors may require improved procurement procedures or capacity, or more cooperation than what is the case today. Regions and municipalities could also cooperate, through for instance municipal limited companies, to a larger extent to pool their resources and have economy of scale for large investments such as the planned landfills.

Be clear, firm and careful in public communication

One of the measures that should be taken as soon as possible is to close down all waste chutes in order to improve environmental and health conditions for both residents and waste collection staff as well as make the collection more cost-efficient. This is certainly going to be challenging and opposed by the public. However, most decisions in waste management, whether it concerns the location of a transfer station or collection point for recyclables, or even the slightest increase of fees or taxes, are usually opposed.[76] Nevertheless, changes have to be made and the work ahead must be carefully designed to also find incentives to drive that change, such as reduced collection fees for households or businesses that segregate their waste. Concurrently, monitoring and enforcement of existing laws must be strengthened regarding, for instance, illegal dumping of waste or littering.

Another important message in public communication is to be careful not to lose credibility and trust. If, for instance, a system for waste segregation at source is introduced in combination with public awareness campaigns, the system must be upheld all the way and the local government must "do their part".

[76] This statement is based on the consultants' collective experience from over 100 waste management projects in over 25 countries.

APPENDICES

Appendix 1 - WASTE COMPOSTION ANALYSIS METHODOLOGY

Appendix contents

INTRODUCTION

This guide describes the Swedish methodology for manual sorting of municipal solid waste – also referred to as Waste Composition Analysis - for the purpose of determining the composition of waste, split into a number of well-defined fractions. The methodology, Report U2013:11), and the application of it is not legally established in Sweden but is a result of the collective work of the Swedish Waste Management Association which represents all the Swedish municipalities and has been used in over 4 000 tests. The methodology is to a large extent built on the EU document "Methodology for the Analysis of Solid Waste (SWA-Tool)" of 2004, which is also a guide only and not an EU Directive.

ABOUT THE GUIDE

Target group

The guide for manual sorting of MSW is written for project managers and buyers of such services in municipalities, and also for sorting staff and organizations dealing with this type of analyses. For the operational staff, a hands-on step-by-step summary is provided in Appendix 1.7.

Applicability

The guide is primarily aimed at manual sorting of municipal waste. The method is not directly applicable for manual sorting of bulky waste, which has a much different composition with many large objects, but the methodology can serve as inspiration also for such type of sorting, when required.

Structure of the guide

The guide contains the following sections

1. Planning
2. Preparatory studies
3. Sampling
4. Preparation of samples for manual sorting
5. Manual sorting
6. Analysis

Templates, examples, and other detailed instructions can be found in appendices listed below:

Appendix no.	Contents
Appendix 1.1	Material fractions
Appendix 1.2	Data sheet
Appendix 1.3	Evaluation template
Appendix 1.4	Description of the Analysis Area
Appendix 1.5	Sub-areas and Mother sample
Appendix 1.6	List of equipment and protective clothing
Appendix 1.7	Waste Composition Analysis, step-by-step

VOCABULARY

Waste composition analysis (WCA)	Analysis of composition in a certain defined quantity of waste by sorting out a number of predetermined fractions and subsequent weighing of each fraction
Analysis area	The geographical area which has been chosen for the analysis, e.g. a city or a part of a city
Sub-area	The smaller area (within the analysis area) from where the samples for sorting are taken/collected
Stratification	Subdivision of the in-homogenous parent population into more homogenous sub-populations, e.g. high-rise areas, villa areas, commercial areas, called strata
Sampling route	A selected collection route, representing a sub-area
Mother sample	The total quantity of waste collected in the analysis area
Splitting of samples	Taking out samples from the Mother sample
Sub-samples	The amount of waste, in the form of one or several samples, taken from the mother sample
Quantification	Determination of the quantity of waste in a certain area, e.g. sub-area
Correction factors for moisture and dirt	Factors, based on experience, which can be used to correct the weight of a fraction for abnormal moisture and dirt. Generally used for packaging and paper.

PLANNING

- **Decide the purpose of the sorting project**
    - This is important when for example selecting the areas from where the waste will be collected, the stratification criteria, which fractions shall be sorted and how the results shall be presented and how they will be used.
- **Start the planning for the practical work early, preferably some months before the actual sorting starts. This phase includes the following main elements**
    - Secure a suitable site for the sorting with regard to the following considerations:
        - Location in regard to the collection route(s) and the landfill to avoid long driving distances
        - Location with regard to disturbance of neighbors
        - Make sure there is a permission to carry out the sorting
        - A paved area for mixing of the mother sample is essential. If not available a large tarpaulin is required.
        - A roof or a simple building is recommended for the manual sorting to prevent waste spreading, rainfall and summer heat for the staff
    - Agree with a waste contractor or municipality to borrow/arrange a waste truck with staff for the sampling and a front end loader for mixing and sampling.
    - Employ and educate sorting staff in due time, 4-5 persons are needed for each test.
    - Make preparations to acquire all necessary equipment as per the list (Appendix 1.6).
- **Make a detailed time schedule and a budget for the project**
- **Plan the working environment early** including vaccinations, protecting clothing, etc.
- **Carry out training of staff**

PREPARATORY STUDY

- **Collect and document relevant facts about the analysis area**
    - This could be number of inhabitants, households in various housing areas, income in various groups, age distribution, seasonal differences, etc. which is of interest for the study.
      Appendix 1.4 shows a template which can be used to document this information.

- **Decide stratification criteria with regard to the desired results**
    - Stratification is the statistical subdivision of the in-homogenous population into more homogenous sub-populations called strata. The variation within strata is usually smaller than the overall population and such stratification therefore increases the accuracy of the results.
    - Typical stratification criteria can be
        - Residential structure (high-rise apartment buildings, villas, etc.)
        - Commercial influx, e.g. high restaurant density
        - Seasonable variations

- **Plan representative routes within each sub-area which have the desired waste types**
    - Make sure enough waste is collected - minimum 4 tons or approximately 45 m^3 corresponding to ca 45 bins (1100 L).
    - Plan the routes in normal periods without big holidays, tourist invasions, etc.
    - Give each mother sample a unique name; it is practical to use a name which shows where it is collected (geographically).
    - Document information on the sub-area and the mother sample (Appendix 1.5).

COLLECTION OF MOTHER SAMPLE

- T**he mother sample should be about 45 m³ or 45-60 bins (1100 liters), corresponding to 0,5-1 truck load** (this is in compliance with the EU SWA Tool document, recommendation 10, which specifies a volume of ca. 45 m³ for household waste in cases where the variation coefficient of the waste is unknown, which is the case in Armenia)
- **Plan as representative routes as possible**
    - Bigger routes give more representative samples.
    - If possible, try to include several days waste production.
    - Avoid collection points which are known to be abnormal.
    - For analysis of household waste, avoid waste that seem to come from small industries, mechanical workshops and commercial activities, like large markets and restaurants.
    - For analysis of the broader sense of MSW, commercial waste can be included.
- **Note the name and telephone number of the collection staff**
    - It is useful to be able to contact the collection staff for questions during the sorting.
- **Follow the collection staff**, preferably the whole route
- **Avoid too much compaction in the collection truck** to simplify sorting
- **Make sure that the planned route is kept and that bulky items are taken out**
- **Weigh the truck** after the collection has been finalized, full and empty, unless the tare weight is known
- **Document relevant facts about the route**, when needed (no. of households, the number of days the waste represents, etc.)
- **Protect the collected mother sample from external impacts**, e.g. rain, wind, animals etc.. , while it is stored and prepared for taking out sub-samples
- **Make sure the sorting area is prepared when the truck arrives** including staff, equipment and protective clothing
- It is important that the tipping area is **paved and clean**

TAKING OUT SUB-SAMPLES

- **Mix the mother sample carefully with a wheel loader** with minimal possible crushing of the waste. Cut some of the larger plastic bags open.
- Put the waste in **a long string or in a square** before taking out sub-samples
- **Take the sub-samples randomly** along the string, or choose every second square when using the quartering method
- **Take out about 500 kg**, preferably as 5 sub-samples, each of about 100 kg
- **Remove any obviously misplaced sizeable item**, such as an A/C, large computer, etc. that may have been found only after emptying the truck/ bins
- **Place the sub-samples in plastic bins** with lids to protect them from external impacts
- **Mark the bins** clearly with water resistant paint
- Manual sorting should commence **within 1-2 days** after collection depending on season (summer 1 day, winter 2 days)

MANUAL SORTING

- **Check that the sorting staff is educated and equipped in accordance with the specified lists before the work starts**

- Go through the safety routines including protective clothing and personal hygiene.
- Repeat the definition of the sorting fractions.
- Clarify the roles and responsibilities of the staff.
- Describe the closing of each work session.

- **Start the manual sorting**
  - Sort the waste carefully and make sure to include all waste in the sample.
  - Sort each sub-sample separately.
  - Place a suitable amount of waste on the table. Cut the bags open carefully and investigate the contents before it is spread over the table. Any visible sharp objects (needles, syringes, razor blades, knives) or poisonous material (rodenticides, medical waste, etc.) should be identified and sorted out first. If weapons or ammunition is found the police/military should be contacted for advice. Fine material like cat sand or coffee grounds should not be spread over the table but should be sorted out early and be placed where it belongs to simplify the remaining sorting.
- **Sorting the rest of the waste**
  - The sorting shall be done in the 22 secondary fractions according to the Appendix 1.1. Waste fractions.
  - To avoid mistakes, mark the bags/containers clearly with the code of the fraction to be placed inside them.
  - Fine materials like cat sand and coffee grounds shall be brushed together and placed in the correct fraction. Use brush and a small hand shovel.
  - Food remains and the like shall be removed from packaging. Only clean packaging is put in the respective packaging fractions (paper, plastics, metals, etc.). The food remains shall be sorted as "kitchen waste". Unopened food containers can be put in the food waste fraction.
  - Packaging containing liquids or paints which can be hazardous shall not be opened. The package including its content is classified as hazardous materials.
  - Bottles or cans with fluid food should be emptied and the contents (except water) shall be put in the food fraction. In order not to put too much liquids in the food fraction the contents can be weighed and then discarded.
  - All small objects shall be identified and taken out for sorting in the relevant fraction. Examples: cigarette butts, tops, paper clips, capsules and button batteries.

- **Take photos of the work and the fractions.** This is useful for the reporting work.
- **Weigh all fractions after the sorting is ready.** Use scales as specified in Appendix 1.6.
- **Fill in the weights of each fraction in the Data sheet**. See Appendix 1.2.

ANALYSIS

- **Put together all documentation** from the sorting analyses including purpose, methodology, background information about the areas and the waste, the achieved results and photos
- **Calculate the relevant results of the sorting operation**
    - Calculate the share of each fraction by dividing the weight of the fraction by the weight of the total sub-sample. Give the results in percentage (%).
    - Calculate the average value for all 5 sub-samples of each fraction.
    - Calculate the standard deviation of the 5 sub-samples for each fraction.
    - There is an Excel template for the calculations in Appendix 1.3.
- **Make corrections for moisture and dirt**
    - Packaging is always to a certain degree contaminated by dirt and wetted by various liquids. This will give higher weights for the fractions than for dry and clean fractions. Thus, compensation could be done to get correct values. This is complicated to analyze in each test. Therefore, Swedish and International tests have resulted in certain recommended correction factors which can be used for normal sorting tests.

      The following correction factors are used in Sweden:
        - Packaging of paper and plastics 0.56
        - Metal packaging and newsprint 0.65

      The actual measured weight of these fractions shall be multiplied with the above factors to get the dry and clean weight of the fraction in question.
- **Make comparison with other results of sorting analyses, if any**
- **Analyze possible sources of errors; examples:**
    - Difficulty in defining a representative analysis area
    - Unwanted waste like bulky, industrial, etc. in the bins
    - The truck doesn't follow the decided route
    - The mixing is not done properly
    - Considerable amounts of special waste, such as leaves, soil, etc.
    - Seasonable effects of the waste compositions
- **Write a report** with all documentation, important observations/conclusions and a discussion about possible error sources and their effects on the results.

CLOSURE OF THE WCA PROJECT

- Save excess materials like bags, containers, paper rolls, etc. for future tests
- Clean all plant and equipment carefully with cleaning agents and water
- Clean floors and tipping area with water and brushes
- Make sure no waste or other debris is left on the site

Appendix 1.1 - WASTE FRACTIONS

PRIMARY FRACTION	SECONDARY FRACTION	DESCRIPION	TYPICAL EXAMPLES
A. Organic 	**A1. Kitchen waste**	All biodegradable waste originating in domestic kitchens	Food leftovers, unopened food packages, liquid food, bread, fruit and vegetables, coffee and tea grounds, coffee filters, egg shells, napkins, used kitchen roll paper
	A2. Garden waste	All biodegradable waste from private gardens	Grass cuttings, hedge trimmings, leaves, pruning, tree branches, weeds, fruit, flowers, garden soil
	A3. Other biodegradable waste	All biodegradable waste not applicable to either of the two above	Animal remains, bones, feces
B. Paper and cardboard 	**B1. Newspaper, etc.**	Printed matters	Newspapers, journals, brochures, newspaper-type advertising publications, printing paper (from private homes), receipts, paperbacks,
	B2. Corrugated cardboard	Corrugated cardboard packaging	Boxes, wrappings
	B3. Paper packaging	Packaging consisting of minimum 50% paper	All types of paper packaging (boxes and bags) for e.g. milk, yogurt, cereals, eggs, cacao, sugar, etc., envelopes with paper filling
	B4. Other paper	All paper not applicable to the above	Postcards, tickets, post-it tags, paper wall coverings, books with hard cover
C. Plastics 	**C1. Soft plastic packaging**	Packaging consisting of minimum 50% soft plastics which can be easily formed to a ball	Plastic bags, plastic film, plastic bags, plastic wrappings for food and snacks, envelopes with plastic filling
	C2. Styrofoam	Packaging consisting of min 50% of styrofoam	Food trays for e.g. fast food, protection foam for appliances
	C3. Dense (hard) plastic packaging	Packaging consisting of min. 50% of dense plastics (which can be bent and cracked)	Plastic bottles, cans, trays, lids, deodorant bottles, drinking straws
	C4. Other plastics	Non-packaging soft and dense plastics	Toys, tooth brushes, DVD discs and boxes, credit cards, pens and pencils, dish washing brushes, plastic files, disposable cutlery, espresso capsules
D. Glass 	**D1. Glass packaging**	Packaging consisting of min. 50% glass, clear and colored (if color separated)	Bottles and cans of glass
	D2 Other glass	All glass not being packaging	Drinking glasses, mirror- and window glass, knick-knacks, vases

PRIMARY FRACTION	SECONDARY FRACTION	DESCRIPION	TYPICAL EXAMPLES
E. Metals 	**E1. Metal packaging**	Packaging consisting of min. 50% metal (will stay folded if bent, in comparison to plastics which strives to get back to its original form)	Cans (with or without lids), bottles, trays, tubes, capsules, lids, aluminum folio, heat candle holders, empty spray bottles, empty and dry paint cans, espresso capsules of metal
	E2. Other metals	Non-packaging metal objects	Screws, nails, paper clips, tools, cutlery, umbrellas, frying pans and casseroles, disposable grills
F. Other inorganic	**F1. Other inorganic**	Inorganic material not applicable to other fractions and which is not hazardous	Cat sand, porcelain, ceramics, ashes, porcelain fuses, stones, gravel, bricks, glass wool
G. Hazardous waste (excluded WEEE) 	**G1. Hazardous waste**	Waste which is poisonous, explosive, corrosive, Inflammable, environmentally hazardous or contagious, infectious	Syringes, sharp objects (knives, razor blades, etc.), medicine, bloody waste, paint, enamel paint, glue, cans with paints etc., fuels and solvents, gasoline, kerosene, white spirit, used motor oil, oil filters, cleaning agents, insect pesticides, mercury-containing objects(e.g. thermometers), photo chemicals, various hazardous waste, e.g. asbestos, car wax, repellant, polish, spray cans with contents
H. Mixed WEEE 	**H1. Mixed WEEE**	All items operated on batteries or the electric network (equipped with a cable)	Batteries, chargers, drilling tools, fire detectors, toasters, coffee brewers, toys driven electrically, electric razors, hair dryers, fluorescent tubes, all kinds of bulbs, electric tooth brushes, telephones, irons, computers, TV consoles, torches, load speakers,
I. Other	**I1. Wood**	Objects made by wood (not impregnated)	Hangers, wood toys, wood pieces from repair work, corks
	I2. Textiles	Used and worn out textiles	Clothes, tatters, towels, curtains, table cloths, bedclothes
	I3. Diapers, sanitary napkins, etc.		Diapers, sanitary packs, cotton
	I4. Other	Everything not applicable to other fractions	Leather, shoes, bags and carrier bags, rugs with mixed materials, rubber, Paper files, disposable razor blades, tops, butts, soap, vacuum cleaners' bags

Appendix 1.2 - DATA SHEET

Date of taking the mother sample		Date of sorting	
Name of the mother sample			
Number of sub-samples		Weight of subsample (kg):	
SORTING RESULTS			
Primary fraction	**Secondary fraction**	**Weight (kg)**	**Notes**
A. Organic	A1. Kitchen waste		
	A2. Garden waste		
	A3. Other biodegradable waste		
B. Paper and cardboard	B1. Newspaper, etc.		
	B2. Corrugated cardboard		
	B3. Paper packaging		
	B4. Other paper		
C. Plastics	C1. Soft plastics packaging		
	C2. Styrofoam		
	C3. Dense plastics		
	C4. Other plastics		
D. Glass	D1. Glass packaging		
	D2. Other glass		
E. Metals	E1. Metal packaging		
	E2. Other metals		
F. Other inorganic	F1. Other inorganic		
G. Hazardous waste (excluded WEEE)	G1. Hazardous waste		
H. Mixed WEEE	H1. Mixed WEEE		
I. Other	I1. Wood		
	I2. Textiles		
	I3. Diapers, sanitary napkins, etc.		
	I4. Other materials or items not fitting in elsewhere		
Total*			

*Check that the total weight of fractions is the same as the weight of the sub-sample

Appendix 1.3 - EVALUATION TEMPLATE

Analysis area				Number of households			Weight of mother sample (kg)		
Sub-area				Number of days					
Primary fraction	**Secondary fraction**	**Subsample 1 (kg)**	**Subsample 2 (kg)**	**Subsample 3 (kg)**	**Subsample 4 (kg)**	**Subsample 5 (kg)**	**Average weight**	**Standard deviation**	**Notes**
Organic	Kitchen waste						-	-	
	Garden waste						-	-	
	Other biodegradable						-	-	
Paper and cardboard	Newspaper and print						-	-	
	Corrugated cardboard						-	-	
	Paper packages						-	-	
	Other paper						-	-	
Plastics	Soft plastics packaging						-	-	
	Styrofoam						-	-	
	Dense plastics						-	-	
	Other plastics						-	-	
Glass	Glass packaging						-	-	
	Other glass						-	-	
Metals	Metal packaging						-	-	
	Other metals						-	-	
Other inorganics	All other inorganics						-	-	
Hazardous waste	All haxardous waste						-	-	
Mixed WEEE	All electric items, battery or high voltage						-	-	
Other	Wood						-	-	
	Textiles						-	-	
	Diapers, sanitary napkins, etc						-	-	
	Other, not applicable elsewhere						-	-	
Total sum (kg)									

To access the electronic version of the template please visit the project website:

https://wqcs-ace.aua.am/deliverables/reports/

Appendix 1.4 - DESCRIPTION OF THE ANALYSIS AREA

In the template below insert the information about the Analysis area.

ANALYSIS AREA	
Name of the area	
BASIC INFORMATION ABOUT THE AREA	
Type of buildings **(high-rise, low-rise apartment building, villas, rural, etc.)**	
BASIC INFORMATION ABOUT WASTE COLLECTION	
Waste fractions collected	
Type of collection bins/containers	
Typical collection frequency	
Source separation, if any	
OTHER DATA (IF AVAILABLE)	
Number of inhabitants	
Income level, age structure	
Separate collection of hazardous waste	
Collection of bulky waste	
Waste tariff	
Seasonal variations	
Other important information	

Appendix 1.5 - SUB-AREAS AND MOTHER SAMPLE

Information about sub-areas and mother samples for the sorting project can be inserted below.

NAME OF THE MOTHER SAMPLE			
Name of mother sample **(e.g. apartments, villas, commercial, mixed)**			
WEIGHT OF THE MOTHER SAMPLE			
Weight in kg			
INFORMATION ABOUT THE MOTHER SAMPLE			
No of households (if available) of which:			
Apartments			
Villas			
Commercial			
Rural			
No. of days the mother sample represents (e.g. 1 day, 3 days, a week)			
DATE			
Date of collection			
Date of sorting			
OTHER			
Other important information			

Appendix 1.6 - LIST OF EQUIPMENT AND PROTECTIVE CLOTHING

List of equipment required for sampling and sorting

- Minimum 1 waste truck with minimum 6 ton capacity
- A front-end loader or similar to mix the waste and to take out samples
- A weigh-bridge to record the weight of the truck load
- A surfaced area where garbage can be unloaded from trucks and be mixed, or a large tarpaulin. Minimum size 10x10 m.
- A structure with minimum a roof; to avoid wind spreading of waste, a complete building is preferable. It can be quite simple, but windows or electrical light is necessary
- One or several sorting tables, depending on their size. One sorter needs about 2-3 m^2 table area. The table surface should be water resistant and easy to clean. The table(s) may have holes to allow waste fractions to be dropped into bags/containers, but it is not important.
- Electronic scale with 0,1 kg accuracy
- A number of paper bags and small containers (bucket size and upwards) for solid waste
- Plastic bags, minimum 100 L
- Tape to fix the bags at the table
- A pair of heavy scissors to separate various material
- Sharp knife to open waste bags
- Shovels and small spades to handle waste and fractions
- A magnet to separate magnetic metals from non-magnetic
- A 10 mm sieve
- Marking pens for plastic and paper surfaces
- Sorting protocol and pen
- Mobile phone with camera
- Wet napkins for hand cleaning
- Disinfection liquid to clean table and equipment
- Dish brush and rags for cleaning
- Dish washing liquid
- Brooms and brushes for cleaning floors and other surfaces.

List of necessary safety equipment for staff

- Overall or jacket/trousers which protect against moisture and sharp objects
- Disposable overall
- Rubber aprons
- Heavy shoes with steel front top and nail protection
- Thick gloves that protect against sharp objects, injection needles, etc.
- Fresh air mask or other breathing protection with gas filter
- Eye protection glasses
- Hearing protection
- Eye wash
- Anti-bacterial wash for hands and face
- First aid kit.

It is strongly recommended that all staff involved in sampling, sorting, and analysis is vaccinated against tetanus, polio and hepatitis A.

Appendix 1.7 - WCA STEP BY STEP

I. Collection

Mother sample
45 m^3 (4-5 tons)
or around 45 bins

Example of mother samples:

Test 1 - High-rise residential (chutes)

Test 2 - Low-rise residential, villas (curb-side bins)

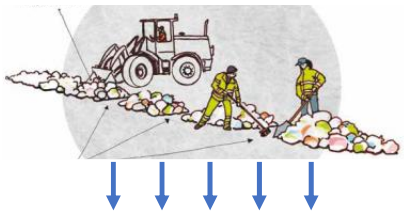
Test 3 - Commercial (curb-side bins)

II. Weighing and unloading

Weigh the truck full and empty (tare) at weighbridge.

Unload at paved area.

III. Mixing and sampling



Let the front loader mix and put the waste in a string.

Take out **5 sub-samples** of ca 100 kg each. Total ca 500 kg.

IV. Weighing

Put each sub-sample in a bin with known tare weight.

Weigh each bin precisely.
Fill in weight of sub-sample.
Empty waste on the table.

Weigh all bins and buckets (tare) to be used for waste fractions.

V. Manual sorting

Don't forget your protective gear!

Sorting each subsample

1. Remove sharp and dangerous objects. Finding explosives call police.
2. Remove fine material, coffee ground, cat sand.
3. Sort in 22 fractions acc. to instructions. Put the waste in plastic bags OR small bins with labels (glass, metal, HZW, WEEE).
4. Empty water from bottles and save in separate bin. Empty the liquids (milk etc.) and store in a bin as kitchen waste.
5. Weigh each fraction.
6. Fill in the weight for each fraction in Data Sheet (see Appendix 1.2).
7. Empty the bags or bins and put the waste in landfill. Wash the bins/buckets. Clean the table.
8. Go back to the step 1 for the next subsample.

Appendix 2 - WASTE COMPOSTION ANALYSIS TESTS IN YEREVAN

Appendix contents

YEREVAN TESTS SUMMARY

Date:	June 8, June 10, June 12, 2019				
Analysis Area	Yerevan				
Sub-area	Summary Test 1-3				
		Fraction average in percentages			
Primary fraction	**Secondary fraction**	**Test 1** High-rise area with chutes	**Test 2** Low-rise area, curbside	**Test 3** Commercial / restaurants	**Fraction average (%)**
Organic	Kitchen waste	42.48	10.69	49.66	34.28
	Garden waste	2.05	35.82	1.40	13.09
	Other biodegradable	0.89	1.64	5.99	2.84
Paper and cardboard	Newspaper and print	1.83	0.86	0.19	0.96
	Corrugated cardboard	2.74	3.22	6.93	4.30
	Paper packages	2.39	1.59	3.13	2.37
	Other paper	0.55	0.39	2.71	1.22
Plastics	Soft plastics packaging	14.79	11.12	11.12	12.34
	Styrofoam	0.12	0.06	0.29	0.16
	Dense plastics	3.50	2.70	4.63	3.61
	Other plastics	0.96	1.91	0.59	1.15
Glass	Glass packaging	5.84	3.08	5.87	4.93
	Other glass	0.62	0.75	0.38	0.58
Metals	Metal packaging	0.67	0.62	0.44	0.58
	Other metals	1.42	3.67	0.74	1.94
Other inorganics	All other inorganics	2.05	9.09	1.67	4.27
Hazardous waste	All haxardous waste	0.39	0.31	0.48	0.39
Mixed WEEE	All electric items	0.30	0.13	0.01	0.15
Other	Wood	0.31	0.22	0.82	0.45
	Textiles	9.37	6.21	1.06	5.55
	Diapers, sanitary napkins, etc	4.65	2.85	0.40	2.63
	Other, not applicable elsewhere	2.08	3.07	1.48	2.21
Total (%)		**100.00**	**100.00**	**100.00**	**100.00**

YEREVAN TEST 1 – HIGH-RISE AREA WITH CHUTES AND BUNKERS

Date	Monday, June 10, 2019								
Analysis Area	Yerevan				Weight of Mother sample (kg)				7,420
Sub-area	Test 1 High-rise area with waste chutes				No of days				
		Sub-samples (kg)							
Primary fraction	**Secondary fraction**	**1**	**2**	**3**	**4**	**5**	**Average weight** (kg)	**Standard deviation**	**Percentage %**
Organic	Kitchen waste	30.82	41.32	36.70	42.28	43.28	38.88	4.62	42.48
	Garden waste	3.46	1.02	1.06	1.90	1.92	1.87	0.88	2.05
	Other biodegradable	0.30	1.40	0.65	0.44	1.30	0.82	0.45	0.89
Paper and cardboard	Newspaper and print	1.26	1.44	4.00	1.00	0.66	1.67	1.19	1.83
	Corrugated cardboard	3.40	3.70	1.00	3.08	1.36	2.51	1.11	2.74
	Paper packages	2.22	2.60	2.74	1.68	1.70	2.19	0.44	2.39
	Other paper	0.44	0.62	0.28	0.18	1.00	0.50	0.29	0.55
Plastics	Soft plastics packaging	15.32	12.30	14.00	14.62	11.42	13.53	1.45	14.79
	Styrofoam	0.14	0.12	0.18	0.06	0.04	0.11	0.05	0.12
	Dense plastics	3.82	3.42	3.22	3.40	2.14	3.20	0.57	3.50
	Other plastics	1.20	1.00	0.56	0.72	0.92	0.88	0.22	0.96
Glass	Glass packaging	4.04	4.04	4.36	6.24	8.04	5.34	1.58	5.84
	Other glass	0.42	0.44	0.44	0.20	1.32	0.56	0.39	0.62
Metals	Metal packaging	0.60	0.40	0.82	0.82	0.44	0.62	0.18	0.67
	Other metals	1.78	0.76	1.38	0.88	1.70	1.30	0.42	1.42
Other inorganics	All other inorganics	0.74	1.32	4.12	2.06	1.16	1.88	1.20	2.05
Hazardous waste	All haxardous waste	0.42	0.38	0.18	0.28	0.54	0.36	0.12	0.39
Mixed WEEE	All electric items	0.02	0.16	0.26	0.60	0.32	0.27	0.19	0.30
Other	Wood	0.16	0.50	0.30	0.24	0.22	0.28	0.12	0.31
	Textiles	10.34	9.90	9.10	8.18	5.34	8.57	1.78	9.37
	Diapers, sanitary napkins, etc	3.10	3.30	4.50	3.80	6.60	4.26	1.27	4.65
	Other, not applicable elsewhere	4.20	1.00	2.50	0.56	1.28	1.91	1.31	2.08
Total (kg)	**457.61**	**88.20**	**91.14**	**92.35**	**93.22**	**92.70**			**100.00**

YEREVAN TEST 2 – LOW-RISE AREA WITH CURBSIDE BINS

Date	Saturday, June 8, 2019								
Analyze Area	Yerevan				Weight of Mother sample (kg)				7,200
Sub-area	Test 2 Low-rise area with curbside collection				No of days				
		Sub-samples (kg)							
Primary fraction	**Secondary fraction**	**1**	**2**	**3**	**4**	**5**	**Average weight**	**Standard deviation**	**Percentage %**
Organic	Kitchen waste	11.76	14.18	10.64	7.30	7.92	10.36	2.53	10.69
	Garden waste	40.70	32.04	37.50	27.68	35.64	34.71	4.50	35.82
	Other biodegradable	0.06	0.54	1.60	5.70	0.06	1.59	2.13	1.64
Paper and cardboard	Newspaper and print	0.36	0.34	0.86	0.80	1.80	0.83	0.53	0.86
	Corrugated cardboard	2.84	4.04	2.26	3.52	2.92	3.12	0.61	3.22
	Paper packages	1.52	1.24	2.32	1.40	1.24	1.54	0.40	1.59
	Other paper	0.24	0.34	0.50	0.20	0.60	0.38	0.15	0.39
Plastics	Soft plastics packaging	8.74	8.94	12.46	9.26	14.46	10.77	2.29	11.12
	Styrofoam	0.02	0.06	0.06	0.15	0.02	0.06	0.05	0.06
	Dense plastics	2.24	2.24	2.94	2.04	3.60	2.61	0.58	2.70
	Other plastics	1.62	2.86	1.42	1.00	2.34	1.85	0.67	1.91
Glass	Glass packaging	2.50	2.50	5.14	2.30	2.46	2.98	1.08	3.08
	Other glass	0.68	1.54	0.86	0.15	0.42	0.73	0.47	0.75
Metals	Metal packaging	1.14	0.50	0.46	0.50	0.38	0.60	0.28	0.62
	Other metals	4.44	2.60	3.32	5.10	2.30	3.55	1.07	3.67
Other inorganics	All other inorganics	4.64	13.70	8.18	11.30	6.22	8.81	3.30	9.09
Hazardous waste	All haxardous waste	0.12	0.18	0.58	0.22	0.40	0.30	0.17	0.31
Mixed WEEE	All electric items	0.12	0.02	0.16	0.04	0.30	0.13	0.10	0.13
Other	Wood	0.22	0.12	0.32	0.15	0.28	0.22	0.08	0.22
	Textiles	5.32	5.04	5.20	9.10	5.44	6.02	1.55	6.21
	Diapers, sanitary napkins, etc	3.94	3.00	2.92	1.82	2.12	2.76	0.74	2.85
	Other, not applicable elsewhere	2.06	5.62	1.40	4.50	1.30	2.98	1.76	3.07
Total (kg)	**484.47**	**95.28**	**101.64**	**101.10**	**94.23**	**92.22**			**100.00**

YEREVAN TEST 3 – COMMERCIAL AREA WITH HIGH RESTAURANT DENSITY

Date	Wednesday, June 12, 2019									
Analyze Area	Yerevan					Weight of Mother sample (kg)			8,880	
Sub-area	Test 3 Commercial area with high restaurant density					No of days				
		Sub-samples (kg)								
Primary fraction	**Secondary fraction**	**1**	**2**	**3**	**4**	**5**	**Average weight**	**Standard deviation**	**Percentage %**	
Organic	Kitchen waste	55.54	44.42	46.36	58.28	43.18	49.56	6.15	49.66	
	Garden waste	0.68	3.80	0.56	0.80	1.16	1.40	1.22	1.40	
	Other biodegradable	1.50	13.88	5.76	1.34	7.42	5.98	4.61	5.99	
Paper and cardboard	Newspaper and print	0.42	0.08	0.12	0.08	0.26	0.19	0.13	0.19	
	Corrugated cardboard	5.14	5.10	6.70	8.70	8.96	6.92	1.66	6.93	
	Paper packages	3.14	1.80	4.06	2.72	3.92	3.13	0.83	3.13	
	Other paper	4.00	2.50	2.60	2.54	1.90	2.71	0.69	2.71	
Plastics	Soft plastics packaging	13.56	8.04	10.54	10.22	13.12	11.10	2.03	11.12	
	Styrofoam	0.42	0.12	0.60	0.18	0.14	0.29	0.19	0.29	
	Dense plastics	5.22	4.26	4.28	3.62	5.70	4.62	0.74	4.63	
	Other plastics	0.88	0.40	0.70	0.36	0.60	0.59	0.19	0.59	
Glass	Glass packaging	6.68	8.06	4.50	4.12	5.94	5.86	1.44	5.87	
	Other glass	0.62	0.20	0.62	0.14	0.30	0.38	0.21	0.38	
Metals	Metal packaging	0.42	0.60	0.42	0.18	0.56	0.44	0.15	0.44	
	Other metals	0.40	0.76	0.32	1.42	0.78	0.74	0.39	0.74	
Other inorganics	All other inorganics	0.60	1.52	1.68	4.02	0.50	1.66	1.27	1.67	
Hazardous waste	All haxardous waste	0.56	0.40	0.54	0.34	0.56	0.48	0.09	0.48	
Mixed WEEE	All electric items	-		0.06	-	-	0.01	0.02	0.01	
Other	Wood	0.20	0.04	0.06	1.90	1.90	0.82	0.88	0.82	
	Textiles	0.20	1.96	0.96	1.08	1.08	1.06	0.56	1.06	
	Diapers, sanitary napkins, etc	0.30	0.62	0.38	0.26	0.44	0.40	0.13	0.40	
	Other, not applicable elsewhere	-		7.00	0.14	0.24	1.48	2.76	1.48	
Total (kg)	**498.96**	**100.48**	**98.56**	**98.82**	**102.44**	**98.66**			**100.00**	

Appendix 3 - WASTE COMPOSTION ANALYSIS TESTS IN 5 CITIES

Appendix contents

ARARAT TEST 1

Date	Monday, June 17, 2019								
Analyze Area	Ararat				Weight of Mother sample (kg)				3,750
Sub-area	Low-rise residential				No of days				
		Sub-samples (kg)							
Primary fraction	**Secondary fraction**	**1**	**2**	**3**	**4**	**5**	**Average weight**	**Standard deviation**	**Percentage %**
Organic	Kitchen waste	50.88	35.54	47.60	38.30	37.00	41.86	6.17	43.14
	Garden waste	2.24	7.46	2.70	0.50	0.82	2.74	2.50	2.83
	Other biodegradable	0.14	0.10	0.06	0.50	0.08	0.18	0.16	0.18
Paper and cardboard	Newspaper and print	0.10	0.38	0.70	0.35	0.72	0.45	0.23	0.46
	Corrugated cardboard	1.76	1.48	2.02	2.38	1.98	1.92	0.30	1.98
	Paper packages	1.92	1.16	1.00	0.76	1.36	1.24	0.39	1.28
	Other paper	0.56	0.32	0.14	0.32	0.32	0.33	0.13	0.34
Plastics	Soft plastics packaging	9.40	8.02	10.00	6.72	10.08	8.84	1.29	9.11
	Styrofoam	0.04	0.02	0.04	0.04	0.18	0.06	0.06	0.07
	Dense plastics	2.32	1.42	2.80	3.20	2.52	2.45	0.59	2.53
	Other plastics	0.46	0.80	0.60	0.50	1.78	0.83	0.49	0.85
Glass	Glass packaging	1.36	2.88	3.37	2.22	2.30	2.43	0.68	2.50
	Other glass	0.62	0.70	0.90	0.30	0.26	0.56	0.24	0.57
Metals	Metal packaging	0.60	0.18	0.48	1.26	0.20	0.54	0.39	0.56
	Other metals	0.48	0.22	1.10	0.40	0.42	0.52	0.30	0.54
Other inorganics	All other inorganics	2.20	18.62	2.74	8.45	13.10	9.02	6.25	9.30
Hazardous waste	All haxardous waste	1.14	0.90	0.56	0.60	0.58	0.76	0.23	0.78
Mixed WEEE	All electric items, battery or high voltage	0.08	0.14	0.02	0.06	0.94	0.25	0.35	0.26
Other	Wood	0.66	0.32	0.22	4.20	0.08	1.10	1.56	1.13
	Textiles	15.98	13.76	11.50	18.48	14.88	14.92	2.32	15.37
	Diapers, sanitary napkins, etc	4.24	3.24	5.16	3.90	3.06	3.92	0.75	4.04
	Other, not applicable elsewhere	0.20	1.02	2.50	4.14	2.70	2.11	1.38	2.18
Total (kg)	**485.21**	**97.38**	**98.68**	**96.21**	**97.58**	**95.36**			**100.00**

ARARAT TEST 2

Date	Tuesday, June 18, 2019								
Analyze Area	Ararat					Weight of Mother sample (kg)			1,800
Sub-area	Villas					No of days			
		Sub-samples (kg)							
Primary fraction	**Secondary fraction**	**1**	**2**	**3**	**4**	**5**	**Average weight**	**Standard deviation**	**Percentage %**
Organic	Kitchen waste	18.22	5.44	6.10	6.80	5.74	8.46	4.90	18.52
	Garden waste	19.40	7.86	10.04	9.70	5.56	10.51	4.72	23.01
	Other biodegradable	0.50	0.06	0.54	0.58	0.42	0.42	0.19	0.92
Paper and cardboard	Newspaper and print	0.14	0.06	0.06	2.16	0.02	0.49	0.84	1.07
	Corrugated cardboard	2.92	2.40	2.48	2.32	2.10	2.44	0.27	5.35
	Paper packages	2.68	1.18	1.40	1.10	1.06	1.48	0.61	3.25
	Other paper	0.20	0.30	0.28	0.08	0.10	0.19	0.09	0.42
Plastics	Soft plastics packaging	11.48	6.00	6.26	1.98	5.08	6.16	3.07	13.48
	Styrofoam	0.06	0.06	0.06	0.02	0.08	0.06	0.02	0.12
	Dense plastics	2.30	0.64	1.82	7.42	1.30	2.70	2.43	5.90
	Other plastics	1.54	0.96	1.46	0.26	0.48	0.94	0.51	2.06
Glass	Glass packaging	1.28	1.90	0.90	0.92	0.62	1.12	0.44	2.46
	Other glass	0.10	0.22	0.02	0.18	0.02	0.11	0.08	0.24
Metals	Metal packaging	0.88	0.16	0.22	0.42	0.52	0.44	0.26	0.96
	Other metals	3.34	0.26	1.06	0.54	2.46	1.53	1.18	3.35
Other inorganics	All other inorganics	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hazardous waste	All haxardous waste	1.40	0.66	0.82	2.00	0.12	1.00	0.65	2.19
Mixed WEEE	All electric items	0.76	0.54	0.10	0.54	0.02	0.39	0.28	0.86
Other	Wood	0.14	0.02	0.04	0.48	0.20	0.18	0.17	0.39
	Textiles	2.20	3.66	5.52	4.28	1.84	3.50	1.35	7.66
	Diapers, sanitary napkins, etc	1.76	2.44	2.14	0.54	2.54	1.88	0.72	4.12
	Other, not applicable elsewhere	1.92	0.90	2.82	1.94	0.80	1.68	0.75	3.67
Total (kg)	**228.42**	**73.22**	**35.72**	**44.14**	**44.26**	**31.08**			**100.00**

HRAZDAN TEST 1

Date	Saturday, June 29, 2019								
Analysis Area	Hrazdan					Weight of mother sample (kg)			5,300
Sub-area	High-rise residential					No of households			
		Sub-samples (kg)							
Primary fraction	**Secondary fraction**	**1**	**2**	**3**	**4**	**5**	**Average weight** (kg)	**Standard deviation**	**Percentage %**
Organic	Kitchen waste	66.12	66.18	53.18	60.30	55.98	60.35	5.25	60.84
	Garden waste	0.42	0.48	0.94	2.44	0.58	0.97	0.76	0.98
	Other biodegradable	0.36	0.44	0.86	0.00	0.00	0.33	0.32	0.33
Paper and cardboard	Newspaper and print	0.16	0.34	0.88	0.74	1.40	0.70	0.43	0.71
	Corrugated cardboard	1.40	1.52	1.66	0.98	0.72	1.26	0.35	1.27
	Paper packages	2.02	0.56	1.04	1.10	1.38	1.22	0.48	1.23
	Other paper	0.32	0.66	0.22	0.02	0.40	0.32	0.21	0.33
Plastics	Soft plastics packaging	8.16	8.02	7.26	9.64	9.32	8.48	0.88	8.55
	Styrofoam	0.04	0.24	0.10	0.22	0.10	0.14	0.08	0.14
	Dense plastics	1.64	2.06	1.50	1.28	2.32	1.76	0.38	1.77
	Other plastics	0.62	0.90	0.82	1.32	1.58	1.05	0.35	1.06
Glass	Glass packaging	3.12	3.28	1.76	0.80	1.40	2.07	0.97	2.09
	Other glass	0.18	0.24	0.12	0.36	0.54	0.29	0.15	0.29
Metals	Metal packaging	0.20	0.26	0.08	0.64	1.18	0.47	0.40	0.48
	Other metals	0.86	0.24	0.18	0.58	0.56	0.48	0.25	0.49
Other inorganics	All other inorganics	4.22	2.32	14.84	3.16	6.66	6.24	4.54	6.29
Hazardous waste	All haxardous waste	0.24	0.24	0.44	0.96	0.24	0.42	0.28	0.43
Mixed WEEE	All electric items	0.06	0.04	0.00	0.32	0.00	0.08	0.12	0.08
Other	Wood	0.50	0.34	0.84	0.94	0.36	0.60	0.25	0.60
	Textiles	4.42	5.80	7.70	6.00	6.60	6.10	1.07	6.15
	Diapers, sanitary napkins, etc	3.80	4.82	3.92	6.44	5.80	4.96	1.03	5.00
	Other, not applicable elsewhere	0.44	0.90	0.88	1.04	1.22	0.90	0.26	0.90
Total (kg)	**496.02**	**99.30**	**99.88**	**99.22**	**99.28**	**98.34**			**100.00**

HRAZDAN TEST 2

Date	Monday, July 1, 2019								
Analysis Area	Hrazdan					Weight of mother sample (kg)			4,300
Sub-area	Villas					No of households			
		Sub-samples (kg)							
Primary fraction	**Secondary fraction**	**1**	**2**	**3**	**4**	**5**	**Average weight** (kg)	**Standard deviation**	**Percentage %**
Organic	Kitchen waste	40.72	24.42	39.68	31.86	40.50	35.44	6.41	35.73
	Garden waste	17.46	19.24	28.14	6.56	23.54	18.99	7.23	19.14
	Other biodegradable	3.12	0.16	0.02	0.34	0.20	0.77	1.18	0.77
Paper and cardboard	Newspaper and print	0.74	0.12	0.16	0.30	0.10	0.28	0.24	0.29
	Corrugated cardboard	1.50	0.82	1.20	1.22	0.86	1.12	0.25	1.13
	Paper packages	1.72	0.94	0.72	0.48	0.58	0.89	0.44	0.90
	Other paper	2.10	1.28	0.84	0.68	1.18	1.22	0.49	1.23
Plastics	Soft plastics packaging	6.42	7.58	6.94	4.88	5.20	6.20	1.02	6.26
	Styrofoam	0.04	0.06	0.06	0.10	0.08	0.07	0.02	0.07
	Dense plastics	1.58	1.36	1.78	1.62	1.82	1.63	0.16	1.65
	Other plastics	3.36	0.64	1.68	1.74	1.88	1.86	0.87	1.88
Glass	Glass packaging	2.18	2.24	2.60	5.30	1.44	2.75	1.33	2.77
	Other glass	0.20	0.66	0.84	8.14	0.52	2.07	3.04	2.09
Metals	Metal packaging	0.58	0.80	0.16	0.68	0.62	0.57	0.22	0.57
	Other metals	1.20	0.40	1.06	4.04	0.98	1.54	1.28	1.55
Other inorganics	All other inorganics	2.60	8.90	0.82	13.16	5.88	6.27	4.42	6.32
Hazardous waste	All haxardous waste	0.54	9.54	0.70	0.92	0.66	2.47	3.54	2.49
Mixed WEEE	All electric items	0.10	0.00	0.70	1.08	0.16	0.41	0.41	0.41
Other	Wood	0.00	0.28	0.12	0.14	0.10	0.13	0.09	0.13
	Textiles	5.10	9.92	6.66	8.66	3.06	6.68	2.45	6.74
	Diapers, sanitary napkins, etc	7.22	7.44	3.92	5.34	7.08	6.20	1.36	6.25
	Other, not applicable elsewhere	1.84	2.38	0.34	1.32	2.26	1.63	0.74	1.64
Total (kg)	**495.90**	**100.32**	**99.18**	**99.14**	**98.56**	**98.70**			**100.00**

HRAZDAN TEST 3

Date	Tuesday, July 2, 2019								
Analysis Area	Hrazdan + Tsaghkadzor				Weight of mother sample (kg)				4,300
Sub-area	Commercial				No of households				
		Sub-samples (kg)							
Primary fraction	**Secondary fraction**	**1**	**2**	**3**	**4**	**5**	**Average weight** (kg)	**Standard deviation**	**Percentage %**
Organic	Kitchen waste	59.48	63.10	54.34	56.50	49.88	56.66	4.49	57.77
	Garden waste	5.72	2.60	6.66	6.42	10.82	6.44	2.63	6.57
	Other biodegradable	0.08	0.10	5.08	0.14	0.00	1.08	2.00	1.10
Paper and cardboard	Newspaper and print	0.30	0.56	0.00	0.32	0.04	0.24	0.20	0.25
	Corrugated cardboard	2.52	2.34	5.60	1.76	2.18	2.88	1.38	2.94
	Paper packages	2.22	1.80	1.86	1.38	3.30	2.11	0.65	2.15
	Other paper	0.70	0.86	0.72	0.82	1.10	0.84	0.14	0.86
Plastics	Soft plastics packaging	8.00	9.48	7.47	7.28	9.12	8.27	0.88	8.43
	Styrofoam	0.16	0.60	0.02	0.36	0.08	0.24	0.21	0.25
	Dense plastics	2.52	2.24	2.90	2.08	2.22	2.39	0.29	2.44
	Other plastics	0.82	0.38	0.30	0.58	2.48	0.91	0.80	0.93
Glass	Glass packaging	1.72	3.96	5.36	4.38	5.22	4.13	1.31	4.21
	Other glass	0.26	0.24	0.28	0.30	0.72	0.36	0.18	0.37
Metals	Metal packaging	0.82	0.62	0.36	0.36	0.34	0.50	0.19	0.51
	Other metals	0.50	0.86	0.08	0.36	0.30	0.42	0.26	0.43
Other inorganics	All other inorganics	0.68	3.18	0.40	4.30	1.92	2.10	1.48	2.14
Hazardous waste	All haxardous waste	1.96	0.22	0.20	0.44	0.50	0.66	0.66	0.68
Mixed WEEE	All electric items	0.60	0.00	0.30	0.06	0.72	0.34	0.29	0.34
Other	Wood	1.10	0.46	0.34	0.30	0.30	0.50	0.31	0.51
	Textiles	7.10	2.90	2.26	4.82	1.86	3.79	1.94	3.86
	Diapers, sanitary napkins, etc	0.80	1.22	3.00	1.48	1.82	1.66	0.75	1.70
	Other, not applicable elsewhere	1.06	0.50	2.10	2.72	1.36	1.55	0.78	1.58
Total (kg)	**490.41**	**99.12**	**98.22**	**99.63**	**97.16**	**96.28**			**100.00**

GYUMRI TEST 1

Date	Saturday, July 6, 2019								
Analysis Area	Gyumri				Weight of mother sample (kg)			8,200	
Sub-area	Low-rise sesidential				No of households				
		Sub-samples (kg)							
Primary fraction	**Secondary fraction**	**1**	**2**	**3**	**4**	**5**	**Average weight** (kg)	**Standard deviation**	**Percentage %**
Organic	Kitchen waste	55.46	49.20	43.70	54.00	50.54	50.58	4.12	51.27
	Garden waste	0.64	0.42	0.68	1.34	7.00	2.02	2.51	2.04
	Other biodegradable	1.04	0.02	0.60	0.12	0.04	0.36	0.40	0.37
Paper and cardboard	Newspaper and print	0.30	0.00	0.94	1.30	2.70	1.05	0.94	1.06
	Corrugated cardboard	1.58	2.32	2.88	2.36	1.26	2.08	0.58	2.11
	Paper packages	2.36	1.50	2.00	1.68	2.56	2.02	0.40	2.05
	Other paper	1.20	0.34	0.48	0.32	0.14	0.50	0.37	0.50
Plastics	Soft plastics packaging	12.20	11.16	13.22	11.56	11.26	11.88	0.76	12.04
	Styrofoam	0.10	0.00	0.02	0.02	0.02	0.03	0.03	0.03
	Dense plastics	2.08	1.96	1.96	2.22	1.30	1.90	0.32	1.93
	Other plastics	0.88	0.84	1.34	1.22	3.20	1.50	0.87	1.52
Glass	Glass packaging	1.56	1.26	2.32	2.06	1.64	1.77	0.38	1.79
	Other glass	0.22	0.14	0.10	0.18	0.12	0.15	0.04	0.15
Metals	Metal packaging	0.58	0.38	0.58	0.80	0.34	0.54	0.17	0.54
	Other metals	0.38	0.68	0.16	0.10	0.76	0.42	0.27	0.42
Other inorganics	All other inorganics	1.10	8.20	5.80	3.80	1.20	4.02	2.73	4.07
Hazardous waste	All haxardous waste	0.72	0.20	0.70	0.46	0.32	0.48	0.21	0.49
Mixed WEEE	All electric items	0.40	0.06	0.00	0.08	0.14	0.14	0.14	0.14
Other	Wood	0.24	0.68	1.16	0.08	0.42	0.52	0.38	0.52
	Textiles	13.08	15.82	17.40	9.34	6.76	12.48	3.96	12.65
	Diapers, sanitary napkins, etc	3.04	2.60	2.80	4.34	4.30	3.42	0.75	3.46
	Other, not applicable elsewhere	0.70	0.98	0.60	0.58	1.26	0.82	0.26	0.84
Total (kg)	**493.30**	**99.86**	**98.76**	**99.44**	**97.96**	**97.28**			**100.00**

GYUMRI TEST 2

Date	Sunday, July 7, 2019								
Analysis Area	Gyumri					Weight of mother sample (kg)			2,500
Sub-area	Commercial					No of households			
		Sub-samples (kg)							
Primary fraction	**Secondary fraction**	**1**	**2**	**3**	**4**	**5**	**Average weight** (kg)	**Standard deviation**	**Percentage %**
Organic	Kitchen waste	54.86	57.88	56.54	48.02	36.00	50.66	8.08	52.20
	Garden waste	4.22	11.22	10.18	11.70	1.20	7.70	4.22	7.94
	Other biodegradable	0.34	0.40	0.42	0.12	0.10	0.28	0.14	0.28
Paper and cardboard	Newspaper and print	0.44	0.58	0.10	0.00	0.00	0.22	0.24	0.23
	Corrugated cardboard	3.84	1.08	1.32	2.90	1.90	2.21	1.03	2.27
	Paper packages	1.34	1.28	1.30	0.98	0.40	1.06	0.35	1.09
	Other paper	1.66	0.88	1.10	0.96	0.60	1.04	0.35	1.07
Plastics	Soft plastics packaging	8.46	9.74	7.04	7.40	4.04	7.34	1.90	7.56
	Styrofoam	0.42	0.04	0.04	0.08	0.04	0.12	0.15	0.13
	Dense plastics	2.26	1.76	1.42	1.70	0.60	1.55	0.55	1.59
	Other plastics	0.58	0.46	0.36	0.86	0.44	0.54	0.17	0.56
Glass	Glass packaging	3.50	1.94	2.64	2.18	1.20	2.29	0.76	2.36
	Other glass	0.00	0.00	0.04	0.00	0.00	0.01	0.02	0.01
Metals	Metal packaging	1.48	0.34	1.62	2.80	0.50	1.35	0.89	1.39
	Other metals	1.40	0.70	0.12	0.00	0.20	0.48	0.52	0.50
Other inorganics	All other inorganics	4.08	1.90	11.44	9.14	44.00	14.11	15.33	14.54
Hazardous waste	All haxardous waste	0.44	0.32	0.10	0.06	0.00	0.18	0.17	0.19
Mixed WEEE	All electric items	0.50	0.32	0.00	0.24	0.00	0.21	0.19	0.22
Other	Wood	0.10	0.46	0.20	0.10	0.00	0.17	0.16	0.18
	Textiles	7.32	2.82	1.02	4.50	4.30	3.99	2.08	4.11
	Diapers, sanitary napkins, etc	0.52	3.06	0.04	1.50	0.90	1.20	1.04	1.24
	Other, not applicable elsewhere	0.74	0.36	0.04	0.00	0.50	0.33	0.28	0.34
Total (kg)	**485.28**	**98.50**	**97.54**	**97.08**	**95.24**	**96.92**			**100.00**

GYUMRI TEST 3

Date	Monday, July 8, 2019								
Analysis Area	Gyumri					Weight of mother sample (kg)			7,680
Sub-area	Villas					No of households			
		Sub-samples (kg)							
Primary fraction	**Secondary fraction**	**1**	**2**	**3**	**4**	**5**	**Average weight** (kg)	**Standard deviation**	**Percentage %**
Organic	Kitchen waste	64.20	40.90	65.84	49.40	56.46	55.36	9.31	56.52
	Garden waste	6.18	6.70	3.78	12.18	2.18	6.20	3.41	6.33
	Other biodegradable	1.04	0.04	0.20	0.04	0.00	0.26	0.39	0.27
Paper and cardboard	Newspaper and print	0.00	1.36	0.28	0.26	0.74	0.53	0.48	0.54
	Corrugated cardboard	1.46	1.40	2.68	1.00	2.22	1.75	0.61	1.79
	Paper packages	0.80	0.86	1.16	1.36	1.44	1.12	0.26	1.15
	Other paper	0.32	0.74	2.10	1.22	0.26	0.93	0.68	0.95
Plastics	Soft plastics packaging	5.38	4.60	7.74	4.74	3.42	5.18	1.43	5.28
	Styrofoam	0.06	0.02	0.02	0.06	0.02	0.04	0.02	0.04
	Dense plastics	1.00	0.58	0.94	1.08	1.80	1.08	0.40	1.10
	Other plastics	0.40	0.44	1.68	0.72	0.22	0.69	0.52	0.71
Glass	Glass packaging	2.42	7.00	2.10	2.76	2.90	3.44	1.80	3.51
	Other glass	0.20	0.22	1.32	0.02	0.10	0.37	0.48	0.38
Metals	Metal packaging	0.28	0.18	0.04	0.24	0.24	0.20	0.08	0.20
	Other metals	0.86	4.32	0.10	0.94	0.52	1.35	1.52	1.38
Other inorganics	All other inorganics	0.84	7.76	0.20	3.70	0.58	2.62	2.86	2.67
Hazardous waste	All haxardous waste	0.22	0.74	0.20	0.06	0.12	0.27	0.24	0.27
Mixed WEEE	All electric items	1.08	0.12	0.30	0.36	0.10	0.39	0.36	0.40
Other	Wood	0.14	1.06	0.02	1.04	0.22	0.50	0.46	0.51
	Textiles	8.22	14.48	2.42	7.58	11.90	8.92	4.11	9.11
	Diapers, sanitary napkins, etc	4.18	3.80	4.18	3.96	5.02	4.23	0.42	4.32
	Other, not applicable elsewhere	0.50	1.54	0.30	4.00	6.34	2.54	2.31	2.59
Total (kg)	**489.76**	**99.78**	**98.86**	**97.60**	**96.72**	**96.80**			**100.00**

KAPAN TEST 1

Date	Saturday, July 13, 2019								
Analysis Area	Kapan				Weight of mother sample (kg)				4,600
Sub-area	Residential + Commercial				No of households				
		Sub-samples (kg)							
Primary fraction	**Secondary fraction**	**1**	**2**	**3**	**4**	**5**	**Average weight** (kg)	**Standard deviation**	**Percentage %**
Organic	Kitchen waste	61.10	58.70	65.20	65.80	63.60	62.88	2.65	64.02
	Garden waste	1.06	1.20	3.40	2.50	4.80	2.59	1.40	2.64
	Other biodegradable	0.00	3.60	0.00	1.60	0.04	1.05	1.42	1.07
Paper and cardboard	Newspaper and print	0.44	0.70	0.30	0.35	0.40	0.44	0.14	0.45
	Corrugated cardboard	2.20	2.00	3.02	2.50	2.40	2.42	0.34	2.47
	Paper packages	1.43	1.60	1.30	1.00	1.00	1.27	0.24	1.29
	Other paper	0.74	0.43	0.10	0.25	0.00	0.30	0.26	0.31
Plastics	Soft plastics packaging	5.86	7.20	7.20	6.90	7.80	6.99	0.64	7.12
	Styrofoam	0.04	0.04	0.02	0.02	0.02	0.03	0.01	0.03
	Dense plastics	2.92	2.90	2.00	2.00	2.10	2.38	0.43	2.43
	Other plastics	1.24	0.70	0.70	0.80	1.80	1.05	0.43	1.07
Glass	Glass packaging	4.40	4.20	5.00	4.30	3.70	4.32	0.42	4.40
	Other glass	1.60	1.70	1.30	1.10	0.90	1.32	0.30	1.34
Metals	Metal packaging	0.48	0.26	1.00	0.50	0.40	0.53	0.25	0.54
	Other metals	0.08	1.50	0.13	0.50	0.80	0.60	0.52	0.61
Other inorganics	All other inorganics	3.96	4.70	2.04	2.20	0.50	2.68	1.49	2.73
Hazardous waste	All haxardous waste	0.54	0.40	0.10	0.42	1.02	0.50	0.30	0.51
Mixed WEEE	All electric items	0.44	0.04	0.50	0.20	0.04	0.24	0.19	0.25
Other	Wood	0.04	0.30	0.70	0.30	0.40	0.35	0.21	0.35
	Textiles	2.80	2.50	2.40	2.50	3.60	2.76	0.44	2.81
	Diapers, sanitary napkins, etc	3.02	3.50	2.40	2.50	3.40	2.96	0.45	3.02
	Other, not applicable elsewhere	0.14	0.24	0.60	0.45	1.30	0.55	0.41	0.56
Total (kg)	**491.06**	**94.53**	**98.41**	**99.41**	**98.69**	**100.02**			**100.00**

KAPAN TEST 2

Date	Sunday, July 14, 2019									
Analysis Area	Kapan					Weight of mother sample (kg)			1,440	
Sub-area	Villas					No of households				
		Sub-samples (kg)								
Primary fraction	**Secondary fraction**	**1**	**2**	**3**	**4**	**5**	**Average weight** (kg)	**Standard deviation**	**Percentage %**	
Organic	Kitchen waste	50.04	54.26	64.80	56.22	62.50	57.56	5.40	57.88	
	Garden waste	4.90	5.33	5.26	2.50	4.10	4.42	1.05	4.44	
	Other biodegradable	0.00	0.22	0.26	1.82	0.46	0.55	0.65	0.56	
Paper and cardboard	Newspaper and print	0.18	0.14	0.12	1.86	0.45	0.55	0.67	0.55	
	Corrugated cardboard	1.90	0.26	0.55	1.26	0.80	0.95	0.58	0.96	
	Paper packages	1.70	2.80	1.22	1.24	1.37	1.67	0.59	1.68	
	Other paper	0.18	0.34	0.34	0.14	0.20	0.24	0.08	0.24	
Plastics	Soft plastics packaging	6.80	10.40	8.50	9.46	7.90	8.61	1.24	8.66	
	Styrofoam	0.06	0.10	0.02	0.02	0.04	0.05	0.03	0.05	
	Dense plastics	3.44	4.14	3.44	3.04	3.10	3.43	0.39	3.45	
	Other plastics	1.74	0.56	1.60	0.52	0.85	1.05	0.52	1.06	
Glass	Glass packaging	5.60	5.62	4.04	7.64	5.10	5.60	1.17	5.63	
	Other glass	0.08	0.34	0.16	0.00	0.12	0.14	0.11	0.14	
Metals	Metal packaging	0.92	1.00	0.64	0.40	0.60	0.71	0.22	0.72	
	Other metals	0.48	0.60	0.18	0.32	0.40	0.40	0.14	0.40	
Other inorganics	All other inorganics	5.50	1.94	1.20	4.48	2.60	3.14	1.60	3.16	
Hazardous waste	All haxardous waste	0.80	0.74	0.90	1.42	0.75	0.92	0.26	0.93	
Mixed WEEE	All electric items	0.00	0.46	0.00	0.00	0.10	0.11	0.18	0.11	
Other	Wood	0.18	0.54	0.00	0.00	0.00	0.14	0.21	0.14	
	Textiles	8.40	4.60	3.80	1.88	4.50	4.64	2.12	4.66	
	Diapers, sanitary napkins, etc	3.52	1.10	2.70	2.60	2.00	2.38	0.80	2.40	
	Other, not applicable elsewhere	3.80	2.24	1.46	1.50	1.88	2.18	0.86	2.19	
Total (kg)	**497.28**	**100.22**	**97.73**	**101.19**	**98.32**	**99.82**			**100.00**	

VANADZOR TEST 1

Date	Friday, July 19, 2019								
Analysis Area	Vanadzor				Weight of mother sample (kg)				6,130
Sub-area	Residential				No of households				
		Sub-samples (kg)							
Primary fraction	**Secondary fraction**	**1**	**2**	**3**	**4**	**5**	**Average weight** (kg)	**Standard deviation**	**Percentage %**
Organic	Kitchen waste	56.86	63.96	57.20	55.40	63.25	59.33	3.55	60.32
	Garden waste	2.92	1.30	1.46	1.30	1.76	1.75	0.61	1.78
	Other biodegradable	1.52	0.00	0.00	0.35	0.47	0.47	0.56	0.48
Paper and cardboard	Newspaper and print	0.90	0.26	9.60	0.18	2.15	2.62	3.56	2.66
	Corrugated cardboard	0.54	1.65	2.15	2.38	1.30	1.60	0.65	1.63
	Paper packages	1.60	0.62	0.50	0.40	0.60	0.74	0.44	0.76
	Other paper	1.46	0.20	1.26	0.38	0.65	0.79	0.49	0.80
Plastics	Soft plastics packaging	8.10	7.70	7.70	6.42	7.00	7.38	0.60	7.51
	Styrofoam	0.02	0.06	0.10	0.02	0.04	0.05	0.03	0.05
	Dense plastics	1.72	1.20	1.12	1.12	1.00	1.23	0.25	1.25
	Other plastics	0.84	0.40	0.40	0.26	0.36	0.45	0.20	0.46
Glass	Glass packaging	1.08	2.90	0.80	1.80	1.30	1.58	0.74	1.60
	Other glass	0.26	0.10	0.00	0.30	0.10	0.15	0.11	0.15
Metals	Metal packaging	0.36	0.26	0.14	0.36	0.21	0.27	0.09	0.27
	Other metals	0.34	0.22	0.40	0.56	0.20	0.34	0.13	0.35
Other inorganics	All other inorganics	4.16	4.10	0.70	1.20	2.00	2.43	1.45	2.47
Hazardous waste	All haxardous waste	0.40	0.26	0.08	0.34	0.20	0.26	0.11	0.26
Mixed WEEE	All electric items	0.14	0.00	0.60	0.10	0.15	0.20	0.21	0.20
Other	Wood	0.38	0.34	0.06	0.14	0.10	0.20	0.13	0.21
	Textiles	13.26	9.80	9.90	20.72	11.50	13.04	4.04	13.25
	Diapers, sanitary napkins, etc	2.90	2.30	2.46	1.72	1.80	2.24	0.44	2.27
	Other, not applicable elsewhere	1.08	1.50	1.22	1.36	1.05	1.24	0.17	1.26
Total (kg)	**491.82**	**100.84**	**99.13**	**97.85**	**96.81**	**97.19**			**100.00**

VANADZOR TEST 2

Date	Friday, July 19, 2019								
Analysis Area	Vanadzor				Weight of mother sample (kg)				4,700
Sub-area	Villas + Commercial				No of households				
		Sub-samples (kg)							
Primary fraction	**Secondary fraction**	**1**	**2**	**3**	**4**	**5**	**Average weight** (kg)	**Standard deviation**	**Percentage %**
Organic	Kitchen waste	39.80	28.80	28.24	30.60	31.70	31.83	4.17	32.30
	Garden waste	18.68	37.84	28.96	25.12	27.62	27.64	6.20	28.05
	Other biodegradable	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paper and cardboard	Newspaper and print	0.12	0.00	0.20	0.00	0.00	0.06	0.08	0.06
	Corrugated cardboard	0.04	0.58	0.12	1.20	0.47	0.48	0.41	0.49
	Paper packages	0.96	0.42	0.42	0.50	0.57	0.57	0.20	0.58
	Other paper	0.32	0.20	0.00	0.48	0.24	0.25	0.16	0.25
Plastics	Soft plastics packaging	3.56	2.90	3.80	4.30	3.59	3.63	0.45	3.68
	Styrofoam	0.38	0.04	0.00	0.04	0.04	0.10	0.14	0.10
	Dense plastics	1.00	1.16	0.40	1.20	0.94	0.94	0.29	0.95
	Other plastics	2.82	0.54	0.76	0.36	0.97	1.09	0.89	1.11
Glass	Glass packaging	2.96	2.36	0.70	1.70	1.91	1.93	0.75	1.95
	Other glass	0.36	0.24	0.50	0.48	0.39	0.39	0.09	0.40
Metals	Metal packaging	0.12	0.26	0.20	0.02	0.16	0.15	0.08	0.15
	Other metals	2.96	1.74	0.26	1.36	1.58	1.58	0.86	1.60
Other inorganics	All other inorganics	14.12	11.14	17.58	22.30	16.28	16.28	3.72	16.53
Hazardous waste	All haxardous waste	0.72	0.12	0.50	1.14	0.61	0.62	0.33	0.63
Mixed WEEE	All electric items	0.02	0.18	0.00	0.37	0.14	0.14	0.13	0.14
Other	Wood	0.42	0.22	0.08	0.06	0.78	0.31	0.27	0.32
	Textiles	6.20	5.50	10.74	4.02	6.60	6.61	2.24	6.71
	Diapers, sanitary napkins, etc	2.50	1.90	1.70	1.66	1.93	1.94	0.30	1.97
	Other, not applicable elsewhere	0.74	2.34	2.94	1.90	1.97	1.98	0.72	2.01
Total (kg)	**492.68**	**98.80**	**98.48**	**98.10**	**98.81**	**98.49**			**100.00**

Appendix 4 - SUMMARY OF ALL WASTE COMPOSTION ANALYSIS TESTS
(percentage per fraction by weight)

Test date (all tests have been done in 2019)		8-June	10-June	12-June	17-June	18-June	29-June	1-July	2-July	6-July	7-July	8-July	13-July	14-July	19-July	20-July	
Primary fraction	**Secondary fraction**	**Yerevan Test 1** High-rise residential chutes (%)	**Yerevan Test 2** Low-rise + villas residential (%)	**Yerevan Test 3** Commercial (%)	**Ararat Test 1** Low-rise residential (%)	**Ararat Test 2** Villas (%)	**Hrazdan Test 1** High-rise residential chutes (%)	**Hrazdan Test 2** Villas (%)	**Hrazdan Test 3** Commercial (Tsaghkadzor included) (%)	**Gyumri Test 1** Residential (%)	**Gyumri Test 2** Commercial (%)	**Gyumri Test 3** Villas (%)	**Kapan Test 1** High-rise + low-rise residential (%)	**Kapan Test 2** Villas (%)	**Vanadzor Test 1** High-rise residential chutes (%)	**Vanadzor Test 2** Villas (%)	**Average for all tests** (%)
Organic	Kitchen waste	42.48	10.69	49.66	43.14	18.52	60.84	35.73	57.77	51.27	52.20	56.52	64.02	57.88	60.32	32.30	46.22
	Garden waste	2.05	35.82	1.40	2.83	23.01	0.98	19.14	6.57	2.04	7.94	6.33	2.64	4.44	1.78	28.05	9.67
	Other biodegradable	0.89	1.64	5.99	0.18	0.92	0.33	0.77	1.10	0.37	0.28	0.27	1.07	0.56	0.48	0.00	0.99
Paper and cardboard	Newspaper and print	1.83	0.86	0.19	0.46	1.07	0.71	0.29	0.25	1.06	0.23	0.54	0.45	0.55	2.66	0.06	0.75
	Corrugated cardboard	2.74	3.22	6.93	1.98	5.35	1.27	1.13	2.94	2.11	2.27	1.79	2.47	0.96	1.63	0.49	2.48
	Paper packages	2.39	1.59	3.13	1.28	3.25	1.23	0.90	2.15	2.05	1.09	1.15	1.29	1.68	0.76	0.58	1.63
	Other paper	0.55	0.39	2.71	0.34	0.42	0.33	1.23	0.86	0.50	1.07	0.95	0.31	0.24	0.80	0.25	0.73
Plastics	Soft plastics packaging	14.79	11.12	11.12	9.11	13.48	8.55	6.26	8.43	12.04	7.56	5.28	7.12	8.66	7.51	3.68	8.98
	Styrofoam	0.12	0.06	0.29	0.07	0.12	0.14	0.07	0.25	0.03	0.13	0.04	0.03	0.05	0.05	0.10	0.10
	Dense plastics	3.50	2.70	4.63	2.53	5.90	1.77	1.65	2.44	1.93	1.59	1.10	2.43	3.45	1.25	0.95	2.52
	Other plastics	0.96	1.91	0.59	0.85	2.06	1.06	1.88	0.93	1.52	0.56	0.71	1.07	1.06	0.46	1.11	1.11
Glass	Glass packaging	5.84	3.08	5.87	2.50	2.46	2.09	2.77	4.21	1.79	2.36	3.51	4.40	5.63	1.60	1.95	3.34
	Other glass	0.62	0.75	0.38	0.57	0.24	0.29	2.09	0.37	0.15	0.01	0.38	1.34	0.14	0.15	0.40	0.53
Metals	Metal packaging	0.67	0.62	0.44	0.56	0.96	0.48	0.57	0.51	0.54	1.39	0.20	0.54	0.72	0.27	0.15	0.57
	Other metals	1.42	3.67	0.74	0.54	3.35	0.49	1.55	0.43	0.42	0.50	1.38	0.61	0.40	0.35	1.60	1.16
Other inorganics	All other inorganics	2.05	9.09	1.67	9.30	0.00	6.29	6.32	2.14	4.07	14.54	2.67	2.73	3.16	2.47	16.53	5.54
Hazardous	All haxardous waste	0.39	0.31	0.48	0.78	2.19	0.43	2.49	0.68	0.49	0.19	0.27	0.51	0.93	0.26	0.63	0.73
Mixed WEEE	All electric items, battery or high voltage	0.30	0.13	0.01	0.26	0.86	0.08	0.41	0.34	0.14	0.22	0.40	0.25	0.11	0.20	0.14	0.26
Other	Wood	0.31	0.22	0.82	1.13	0.39	0.60	0.13	0.51	0.52	0.18	0.51	0.35	0.14	0.21	0.32	0.42
	Textiles	9.37	6.21	1.06	15.37	7.66	6.15	6.74	3.86	12.65	4.11	9.11	2.81	4.66	13.25	6.71	7.32
	Diapers, sanitary napkins, etc	4.65	2.85	0.40	4.04	4.12	5.00	6.25	1.70	3.46	1.24	4.32	3.02	2.40	2.27	1.97	3.18
	Other, not applicable elsewhere	2.08	3.07	1.48	2.18	3.67	0.90	1.64	1.58	0.84	0.34	2.59	0.56	2.19	1.26	2.01	1.76

Appendix 5 - DESCRIPTION OF MANUAL SORTING TESTS OF MSW IN YEREVAN

Appendix contents

INTRODUCTION

The need for first-hand, baseline data is needed in Yerevan and Armenia in general, as most studies have not included actual research but rather estimates and standard figures for municipal solid waste (MSW) generation. Thus, a Waste Composition Analysis (WCA) based on the Swedish and EU guidelines has been undertaken in Yerevan during the period 7-13 June 2019 with financial support and guidance from AUA. The methodology used is described in the document *"Methodology for Waste Composition Analysis of MSW"* (Appendix 1).

This document describes the actual execution of the project in Yerevan - from planning and collection of waste to analysis of results - and gives a review of the challenges and how they were met. It also gives some advice for the forthcoming work in Armenia, based on the experience of the first tests.

The first part in the project training of a local team in carrying out waste composition analyses (WCA). The training package included a theoretical session and the WCA itself on site at Nubarashen landfill in Yerevan, where the local staff carried out the work with guidance and support from the Swedish experts.

On 6 June, before the practical work commenced, a training session and workshop was held at the AUA with all involved staff. Swedish expert Mr. Anders Lärkert presented the methodology step-by-step supported by Ms. Karin Eberle, TL/SWM expert, and discussed practicalities and local conditions with the team. The session became a very active workshop where all matters, big and small were discussed and solved. The WCA program for the roll-out of the WCA in five (5) other municipalities, drafted together with the Ministry of Territorial Administration, was also established.

An illustrated summary of the various steps in the process was prepared, see Appendix 1.7.

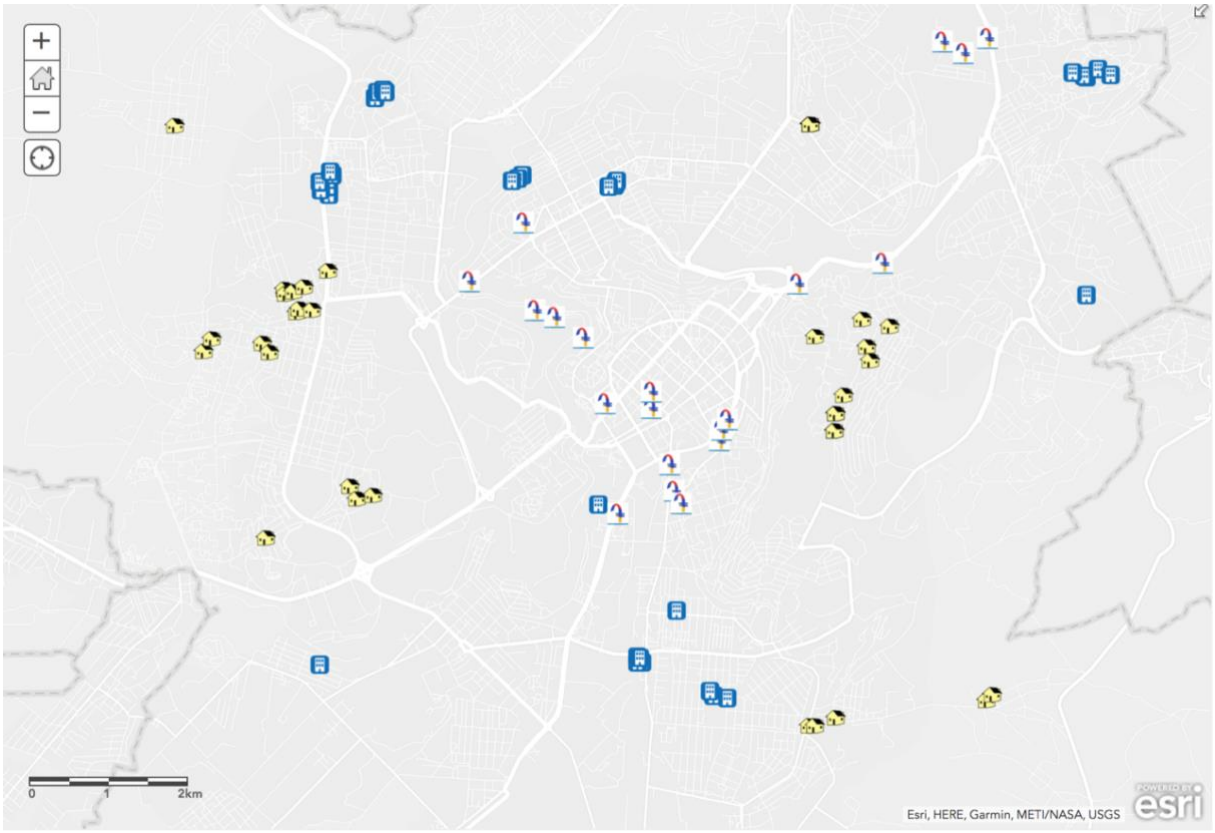
TIME SCHEDULE AND PREPARATIONS

The stratification or choice of sub-area was made to make it comparable with other cities and also to be able to distinguish between residential waste and commercial waste, if possible. It was decided to carry out three tests in Yerevan:

- Test 1 Sub-area 1: High-rise residential areas with chutes (“household waste”)
- Test 2 Sub-area 2: Villas and low-rise residential area, curbside collection (“mixed waste”)
- Test 3 Sub-area 3: Commercial areas with high restaurant density (“commercial waste”)

Following the instructions of the Operation Manager, see below, addresses and pick-up points for samples were chosen. In the figure below, the three test rounds and sampling points can be found – Test 1 for high-rise areas in yellow, Test 2 for low-rise and curbside collection in blue, and Test 3 for commercial areas with white dots.

Figure 48. Selected pick-up points for collection of representative waste samples in Yerevan



The following time schedule was kept, see below.

Figure 49. Time schedule for mother sample collection for WCA in Yerevan

Time	Activity	Place
Friday 7 June		
22:00 – 03:00	Waste collection for **TEST 2 (Low-rise areas, villas, curbside bins)**	Collection in five (5) districts with geographical spread, ca 30 collection points and 3 bins per collection point = 90 bins, total over 5 tons
Saturday 8 June		
Early morning	Weighing of TEST 2 truckload Unloading at sorting station	Nubarashen landfill
05:00	Mixing with a "JCB" tractor, putting in string, taking out 5 samples of 100 kg each, each sample in 1 bin or bag	
06:00-13:00	Setting up sorting station, marking of bins Weighing and sorting	
Sunday 9 June		
13:00-17:00	Waste collection for **TEST 1 (multi-storey buildings, chutes)**	Collection in five (5) districts with geographical spread, 10 chutes in each district, 50 collection points, 2 bins per chute = 100 bins, total over 5 tons
Monday 10 June		

Early morning	Weighing of truck Unloading of TEST 1 truckload at Sorting station	Nubarashen landfill
05:00	Mixing with JCB, putting in string, taking out 5 samples of 100 kg each, each sample in 1 bin (660 l)	
06:00- 12 noon	Weighing and sorting	
Tuesday 11 June		
10 pm	Waste collection for **TEST 3 (commercial areas, bins)**	Collection in three districts with restaurants and supermarkets 20 collection points, 4 bins each = 80 bins (ca 70 kg/bin), total ca 5 tons
Wednesday 12 June		
Early morning	Weighing of truck Unloading of TEST 3 truckload at Sorting station	Nubarashen landfill
05:00	Mixing with JCB, putting in string, taking out 5 samples of 100 kg each, each sample in one bin or bag	
06:00-12 noon	Weighing and sorting	
12 noon	Packing up WCA equipment for road trip to other marzpetarans	

Staffing and equipment

- Project manager Mr. Harutyun Alpetyan, AUA
- Supervisor Mr. Artak Khachatryan
- Operation Managers Mr. Argishti Tigranyan and Mr. Hrach Sargsyan
- Sorting staff Mr. Andranik Khachatryan, Mr. Dmitri Sholev, and Mr. Gegham Muradyan
- Collection staff One driver and two collection staff

Collection vehicle

A heavy waste truck (22 m^3) with crew was provided by Yerevan municipality. Mr. Tigranyan supervised the collection, supported by Mr. Hrach. The truck was weighed at a weigh-bridge close to Yerevan, belonging to a private company.

Mixing

A front loader (JCB) was hired from a private company to mix the waste before sampling.

Sorting area

A site was arranged at the Nubarashen landfill by the Municipality of Yerevan. It was levelled out to a relatively hard surface area although not paved. The waste was unloaded on a tarpaulin for the first two tests, thereafter directly on the hardened ground.

Sorting equipment

The project leader had procured the necessary equipment according to the list in Appendix 1.6 to the Methodology document including safety protecting clothing for the sorting staff. The equipment was stored in a big van for mobility

DESCRIPTION OF TESTS

Test 2: V**illas and low-rise residential area, curbside collection**

Collection

Collection was carried out at night on 7 June. About 50 bins of size 1100 L were collected in 5 districts with low-rise buildings and curb-side collection. The operating manager supervised the collection and selected bins and districts to get a representative mother sample. Many bins were overfilled with overflowing waste on the ground, whereas some were only half-filled or less.

Most bins had no covers and were damaged, particularly the wheels, which made it very hard for the collection staff to move them to the waste truck. The reason could be that the bin lifts are lowered too fast after emptying, thereby damaging the wheels when hitting the ground. After the route was completed the truck was weighed on the weigh-bridge and unloaded at the sorting area on the landfill where a tarpaulin of size ca 10x10 m was placed. The weight was about 8 tons which was on the high side (about 5 tons was planned).

Mixing

The mixing started about 5.30 in the morning which meant that the waste was fresh. The mixing was done with a front loading tractor ("JCB") with double tools. First about 1/3 of the waste was removed to facilitate the mixing. The mixing operation took about 1 hour and the tarpaulin was partly damaged. The mixing was well performed and was deemed sufficient.

Taking out sub-samples

With regard to the size of the tarpaulin sub-sampling was not made from a string but from a square area which however gave representative samples. The JCB used a small bucket to fill a 90 L bin; several loads were necessary to get about 100 kg samples. The problem with the small bin was that some of the material such as big pieces of plastics and textiles and also light items like plastic bottles fell outside the bin. This was remedied to a certain degree but it could still have slightly affected the composition of the sample. Each sub-sample was placed in two plastic bags, each containing about 50 kg. The sub-sampling took about 30-45 minutes.

Sorting

As this was the first sorting day, it took some time to set up the tent and the tables and arrange and mark all bins for fractions, set tare weights for the bins in the scale, etc. For most fractions, plastic bins with size about 60 L were used; for the biggest fraction 90 L bins.

The sorting started around 8.30 and was completed about 5 o'clock in the afternoon. It took some time for the sorting team to learn the definition of the 22 fractions which slowed down the work initially. The first sample took about 1,5 hours but after a while the time was down to about 1 hour. Weighing and recording the results took about 15-20 minutes. Short breaks were made between each bag of 50 kg and there was a longer break for lunch. The sorting functioned well and the staff made a professional job. The weather was not hot in morning but the temperature rose in the afternoon.

Special comments regarding the fractions

The content of garden waste was unexpectedly high. As the mother sample was taken in 5 districts with several km in between the sampling should be quite representative. There are villas with big gardens in the districts. The high quantity could possibly also be seasonal. The food waste is low compared to the other tests. The packaging of plastics and paper was very dirty which adds to the weight. The inorganic fraction was heavy due to soil and sand, probably coming in with the garden waste.

Closure of the site

The municipality allowed the waste and fractions to be disposed of outside the site. Thus, removal of the waste after the session could be done in a simple way with the JCB. At other sorting sites, the waste and fractions may have to be loaded in a waste truck and transported away to a landfill.

The plant and equipment could not be left unattended during the night so everything had to be put in the van which also took some time, about 15-20 minutes.

Test 3: Commercial areas with high restaurant density - STOPPED

The test had to be stopped as the JCB had to be repaired. New dates were decided:

Collection Tuesday, 11 June
Sorting Wednesday, 12 June

Test 1: High-rise residential areas with chutes (9 June)

Collection

Collection of selected waste bins started about 13.00 on 9 June and was finished around 6 o'clock in the evening the same day. About 50 bins mostly of size 1100 L were collected in 5 districts with high-rise buildings and waste chutes. The operating manager supervised the collection and selected bins and districts to get a representative mother sample.

All the bins were filled by hand from the chute rooms in the buildings by a separate crew. Hence all the bins were filled up but not over-filled. As the waste came from chutes it was in principle entirely residential which also was the impression one got by looking at it. One observation was that all waste from the chute rooms was not removed in all cases which could have an impact when making quantification. Another observation was that the bins were in slightly better shape than in Test 2 (curbside bins).

The collection was delayed about a half hour by problems with the gear box but this had no effect on the sorting project. After the route was completed the truck was waiting with the waste in the compartment until a new JCB could come Monday morning to push away the old waste from Sunday's failed sorting. It was weighed on the weigh-bridge; the weight of the load was about 6.5 ton. After the old waste was removed the truck was unloaded at about 05.30 Monday morning. Most of the tarpaulin was destroyed, so the major part of the waste landed on the gravel surface.

Mixing

The mixing started about 05.30 in the morning. The mixing was done with the same type of loader as for test 2. The tarpaulin was partly torn the operator was asked to avoid touching the ground with the shovel while mixing which he managed to do. The mixing operation took about 0.5 hour. The mixing was well performed and was deemed sufficient.

Taking out sub-samples

For the sampling two 360 L bins had been acquired. With this size it was easier to get a representative sample as very little waste fell outside the bins. Each sub-sample was placed in two plastic bags, each containing about 40-50 kg. The sub-sampling took about 30-45 minutes.

Sorting

As this was the second sorting day the team was well prepared and the start-up was much faster than the first one. It took about 10-15 min to set up the tables and arrange the bins for fractions, the scale, etc. The actual sorting started around 6 o'clock and was completed about 2 o'clock in the afternoon. A relatively heavy rain in the afternoon had no negative effect on the work.

Special comments regarding the fractions

The material was rather homogenous which facilitated the sorting. The plastic fractions were big as there was a lot of packaging in the waste. There were some mattresses in the mother sample but otherwise no bulky items of any size.

Closure of the site

The plant and equipment could not be left unattended during the night so everything had to be put in the van which also took some time, about 15-20 minutes.

The waste would be pushed aside before the next sorting session.

Observations
No new observations of importance were made during this test.

Test 3: Commercial areas with high restaurant density

Collection
The collection of selected waste bins was made during the night Tuesday 11 June. About 50 bins of size 1100 L were collected in 5 districts with commercial areas with high density of restaurants. The operating manager supervised the collection and selected bins and districts to get a representative mother sample.

Most bins were filled to capacity and a few were overfilled with overflowing waste on the ground. Most bins had no covers and some were damaged, particularly the wheels, but generally the quality of the bins was relatively good. After the route was completed the truck was weighed on the weigh-bridge and unloaded at the sorting area on the landfill. The weight was about 5 tons which was as planned.

Mixing
The mixing started about 5 o'clock in the morning on Wednesday,12 June. It took about 30-40 minutes as the volume waste was slightly less than in earlier tests. As there was no tarpaulin the operator was careful not to get sand and gravel in the waste.

Taking out sub-samples
The mixed waste was formed as a square area with about the same depth. Samples were taken randomly from the heap with the JCB's shovel and filled into the smaller bins of 90 L which were used for Test 2. Some waste fell outside the bin but was placed into the bin by hand. Thus, the representation was considered acceptable. About 4 bins were needed to get the required weight, about 100 kg. The waste was relatively homogenous and contained almost no bulky items and very little garden waste.

Sorting
The sorting was started at 07.15 and the first sample took 55 minutes. The following samples took also about 50-55 minutes each. As the proportion of kitchen waste and plastics were dominant, the sorting went smoothly and relatively fast.

Comments regarding the fractions
Kitchen waste: The fraction was dominant and looked representative as coming from restaurants kitchens. Napkins were plentiful but were defined as "other paper" as they were dry and not so contaminated by food remains.

Other organic: One big skeleton part (of a cow) dominated

Closing down the sorting station at Nubarashen
After the third test, the site was closed down permanently. All equipment was cleaned and stored in the van. The waste had been removed already in the morning. The electric generator was tested and found in good order. The equipment, furniture, etc. was to be used for tests out in the country the following week.

Pictures were taken of all fractions at some point to be able to go back and check. All fractions were weighed on a weigh-scale on site, and everything was documented on data sheets and later on evaluation sheets (see appendices 1.2 and 1.3).

OBSERVATIONS AND LESSONS LEARNED FROM THE PRACTICAL WORK

- It was absolutely invaluable to have local guidance from operational staff that know the area well and can choose representative sampling points and suitable timing. This is very crucial since experience shows that sampling is far more important for accuracy than sorting.
- In curbside bins located in residential areas, one can find not only household and bulky waste but also large amounts of construction waste, park/garden waste, restaurant and commercial waste etc. It is important to remove some of the large items from the collection since the mere weight will dominate the sample.
- It can be difficult to identify a suitable place for unloading and sorting the waste in the regions' cities. Thus, it is necessary to have the flexibility of a mobile sorting station of the type that was used here.
- The tarpaulin needs to be of strong, heavy material to function as a base. Its size should be minimum 15x15 m.
- To facilitate mixing, it is advantageous if the waste heap can be approached from all sides with a front-loader or other suitable tractor with a bucket
- The sub-samples should preferably be loaded in 660 L bins to avoid spillage of the sample, also two 360 L bins is acceptable. The capacity of the scale has to be considered.
- To have holes in the sorting table is not necessary if the bins for the wet fractions are lower than the table, which was the case here. Then, the bins can be placed partly under the table, which proved to work well.
- The tent should have room under roof for the fraction bins also in case of heavy rain and intensive sunshine. It is preferable to have the upper parts of the sides covered for extra protection. A complete tent is the best as wind spreading of waste is avoided although it will be quite hot in the summer sun.
- The exercise is time-consuming, several hours, and tough, and it is advisable to have staff enough to allow for longer breaks and taking turns. Chairs should be available.
- It was hard to separate food and garden waste; thus, the results were somewhat mixed. However, apart from the inorganic parts e.g. sand, the rest is all biodegradable and may enter an organic treatment facility in combination, which makes separation including the exact distribution of the two fractions less important.

BRIEF ANALYSIS OF THE TEST RESULTS

The results of the individual tests 1-3 are presented in Appendix 2, namely the weight of each fraction, the average weight of the five sub-samples, the standard deviation, and the average percentage of each fraction.

The general picture of the test results is that most values are expected and lie within a normal range for waste composition tests in similar cities. It is very clear from the three tests which one is from households

only (Test 1) as there are large quantities of smaller packaging plus diapers and textiles. The latter two fractions could hardly be found in commercial waste (Test 3), however large quantities of corrugated cardboard (larger packaging for deliveries to supermarkets and restaurants) were there. In the mixed waste in curbside bins (Test 2), as expected, it was a mix of everything.

Here are some of the findings:

- Waste is relatively dry, but very dirty and contaminated with clay, sand and particles.
- There is a consistent high yield of organic waste i.e. total of kitchen waste and garden waste. The values vary between 45% and 65% which is quite high. Garden waste is mainly coming from curbside bins along the streets next to villas and commercial establishments. The garden waste, and consequently the total amount of organic waste, is naturally expected to decrease if the test is carried out during the winter season.
- Whole animal carcasses (sheep, chicken) could be found as well as sacks with feathers from ducks or chicken.
- There is far too much of bulky and construction/demolition waste in mixed curbside bins. In most places, that kind of waste was also littered and heaped around the bins, effectively blocking collection operation.
- In Test 2 with waste from curbside bins, it was not known how much of the waste came from households (villas) and how much from commercial activities, but villa waste seemed to dominate. However, the results show that kitchen waste amount is unusually low (ca 11%) while the garden waste number is very high (36%). As a total of organic waste, though, it is very close to the other two tests, i.e. between 46 and 50%. As described earlier the sampling was made in 5 districts with several km distance in between so it is not likely that the test happened to find an area with abnormal conditions.
- Considering the collection method in Yerevan with publicly accessible bin stations, it is likely that some garden waste may have come from public areas. This is further supported by the high amount of inert material like sand in Test 2 (9% compared to ca 2 in the other two tests); most of it being sand and gravel which supposedly derives from street cleaning. It is also believed that some kitchen waste, as in all tests already half biodegraded and relatively fine material, have slipped into the large garden waste quantity.
- The soft plastic fractions are quite high in all test areas. The plastic fractions are dirty, as are the paper fractions, which adds to the weight. Here, the correction factors described in the methodology report, could be used to get the dry weight of these fractions. (0,56 for paper and plastics).

In the photos below, there are some examples of sorted fractions – paper, cardboard and other paper (notably very dirty), the sorting table scattered with garden waste debris and soil, and below two plastic fractions with crushed and torn bottles, and finally the small amount of hazardous waste found in 100 kg of sub-sample.




- Both the hazardous waste fraction and the WEEE (electrical appliances, batteries, etc) fraction are found in very small amounts, considering the absence of separate collection systems for these fractions. This is however typical for other tests in similar areas and cities. It is a bit disturbing as it could indicate that the hazardous waste is disposed of elsewhere; for example, may a lot of liquid hazardous waste as oils, solutions, paint, etc be emptied in the sewage network system.
- The textile fraction from households (Test 1 and 2) is also relatively high compared to other studies (6-9%). It is difficult to have an opinion on the reasons for this.