Recycling of Household Waste in Armenia:

Personnel training, data collection including waste analyses, recommendations for waste management actions

Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit

Advisory Assistance Programme of the Bundesumweltministerium

Umwelt Bundes Amt
Für Mensch und Umwelt

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The responsibility for the content of this publication lies with the authors.

The Waste Composition Analyses on site would not have been possible without the very kind and active support of the Communities Association of Armenia and the local communities involved.

At this point the authors would like to once again sincerely thank the mayors of the five communities and above all Mrs. Natalya Lapauri, Executive Director of the Communities Association of Armenia. Furthermore thanks go to her and the President of the Communities Association of Armenia, Mr. Ermin Yeritsyan, for the excellent organisation of the final congress in Yerevan on May 26th 2011.

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Введение: Система управления отходами в Армении является малоразвитой. Бытовые отходы не сортируются и часто выкидываются недалеко от населённых пунктов. Организованные места захоронения отходов находятся на стадии образования либо отсутствуют вообще. В то же время существует неупорядоченная система мусоросборщиков. Они сконцентрированы в основном на сборе металла, стеклянных бутылок и в ограниченном количестве охватывают бумагу и прочие упаковки.

Но, можно было бы организовать раздельный сбор мусора и развить его до самостоятельной отрасли экономики, которая приносила бы доходы, как для бытовых домашних хозяйств, так и для предприятий.

Без достоверных данных об объемах отходов и их структуры, дальнейшее развитие такого процесса утилизации отходов является сложно выполнимой задачей.

Проект способствует долгосрочной перспективе, чтобы меньшее количество отходов захоранивалось на свалках в Армении и большее их количество утилизировалось.
Для этого армянские партнеры высшей школы и специалисты коммунального управления были ознакомлены (14-дневный интенсив-курс) с основами по современным системам управления отходами и обучены для проведения анализа по отходам. В пяти отобранных регионах Армении были собраны данные о количестве и структуре бытовых отходов в течение разных времен года. На основе этого были получены данные о потенциалах переработки бытовых отходов по фракциям, их количеству, возможной прибыли и даны рекомендации относительно мер по управлению отходами. Для одной из областей утилизации были рекомендованы конкретные меры кратко- и среднесрочной перспективы.
Благодаря передаче знаний и учебных материалов от университета им. Отто фон Гэрике государственному университету архитектуры и строительству г. Еревана проект сделал возможным последующее образование новой специальности по охране окружающей среды в армянском высшем учебном заведении.

Результаты проекта были представлены 26.05.2011 на конференции в Ереване перед представителями министерств, коммунальных органов управления и университетов Армении.</td></tr>
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Анализ сортировки отходов, структура отходов, поступления отходов, потенциал вторсырья, рециклинг/переработка, сбор отходов и их учёт, вторичное сырье, мотивация и работа с общественностью, международное право по отходам, международное сотрудничество</td></tr>
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Background: In Armenia there is a little-organised waste management system. Household waste is not collected separately and is frequently buried in direct proximity of settlements. Regular landfills are unknown or only rudimentarily existent. Nevertheless, there is an informal organisation of garbage collectors. They focus mainly on metals, glass bottles and on a small scale on paper and other packaging. However, separate collection and recycling could develop into an important branch of industry, that generates income for the public households as well as for enterprises. On account of missing data on the amount of waste and the material composition of household waste, it is currently difficult to initiate such a process of waste industry development.

In the long term the project is intended to contribute to a reduction of waste disposal in landfills and an increase of recycling in Armenia.
For this purpose the Armenian university partners and experts of municipal management were familiarised with the basics of a modern waste management (in a 14-day intensive course in Germany) and qualified for the conduction of waste analyses. In 5 selected, representative locations in Armenia – in each of the four seasons - the amounts and compositions of household waste were collected. Based on this the recycling potentials of household waste were determined differentiated by waste groups, amounts and economic efficiency and recommendations for household waste management measures derived. As an example concrete measures were recommended for short-term and medium-term actions in one disposal area.
By transfer of knowledge and provision of teaching materials by the Otto-von-Guericke-Universität Magdeburg to the State University of Yerevan for Architecture and Civil Engineering the project furthermore enabled the creation of a basis for the development of an environmental-scientific course of studies at the Armenian University.

The results of the project were presented to experts of the Armenian ministries, the municipal administrations and universities at a conference in Yerevan on 5/26/2011.</td></tr>
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List of Abbreviations and Acronyms

AMD	Armenian Dram
CAA	Communities Association of Armenia
CIM	Centre of International Migration and development
EC	The European Union
EW	From German: Einwohner, English: inhabitant/s
LLC	Limited Liability Company
MSFZ	From German: Müllsammelfahrzeug, English: refuse collection vehicle
OvGU	Otto-von-Guericke Universität Magdeburg
RA	Republic of Armenia
SERO	From German: Sekundärrohstofferfassung, Wertstofferfassungssystem der DDR English: Assessment of secondary raw materials, system for assessment of recyclable materials of the DDR
UBA	Umweltbundesamt (Federal department on preservation of the environment of Germany)
USAID	United States Agency for International Development
YSUAC	Yerevan State University of Architecture and Construction

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1 Context of the Project

1.1 Background

In Armenia there is a little-organised waste management system. Household waste is not collected separately and frequently dumped in the immediate vicinity of settlements. Organized landfills are either unknown or exist only rudimentarily. However, there is an informal organisation of waste gatherers. They focus mainly on metals, glass bottles and on a small scale on paper and other packing material.

However separate collection and recycling of waste could develop into an important branch of economy that generates income, both for public budgets and for enterprises.

Due to missing data on quantities of waste created and material structure of household waste however it is currently a difficult task initiate such a process for further development of waste management.

Figure 1.1: Typical waste pre-collection point in Yerevan [FICHTNER]

1.2 The Project

The project is intended to contribute in the long run that in Armenia less waste is disposed of in landfills and larger portions are recycled.

For selected disposal areas in Armenia recycling potential of household waste is to be determined separated by waste group, quantity and economical efficiency and waste management measures are to be derived. For this purpose in the frame of German-Armenian university cooperation, the Armenian partners will be qualified for waste analyses and the quantities and structure of household wastes in selected areas of Armenia will be determined. Furthermore the project shall form the basis for a university cooperation between the Otto-von-Guericke-Universität of Magdeburg and the State University of Architecture and Building of Yerevan for the creation of an environmental-scientific course of studies..

- The Program: the Advisory Assistance Programme of the Bundesumweltministerium (BMU)
- Project Number: 380 01 207
- Country: Armenia
- Duration: 10/2009 – 03/2011
- Project management: Umweltbundesamt
- Project partner in Germany: Otto-von-Guericke-Universität of Magdeburg
- Local project partner: State University of Architecture and Building of Yerevan

2 Project Objective

The objective of the project is to give an estimate and description of the current waste management situation in Armenia based on well-founded gathering and analyses of data and to develop measures in the scope of their evaluation and suggest an overall concept to perceptively reduce the amount of waste in the landfills there and consequently reduce the pollution by leachate and landfill gas. Simultaneously, more waste components should be recycled. This way a contribution to preservation of resources and sustainable protection of the environment can be made.

The gathering of the initial waste management data is to be performed in different representative disposal areas and to take aspects such as structure of settlements, seasonal differences, number and type of waste groups, percentages and composition of the groups into account and prove them by detailed sorting analyses.

In the scope of the evaluation of the analysis and the discussion of the results conclusions concerning the state of waste management in the entire country will be made and recommendations of measures derived.

The project was performed by members of an interdisciplinary work-group environment and logistics (Umwelt und Logistik) at the Institute for Logistics and Material Flow Technology (Institut für Logistik und Materialflusstechnik) of the Otto-von-Guericke Universität of Magdeburg in cooperative partnership with the project partner on the Armenian side, the State University of Architecture and Building of Yerevan.

In the planned 18 months project duration the Armenian partners are to be trained simultaneously to enable them to perspectively become active on their own initiative. The transfer of knowledge comprises not only theoretical basics of developed waste management at example of Germany, but also includes practical execution of sorting analyses and evaluation of data. This should be achieved by joined proceeding of the project partners from Germany and Armenia in the performance of the project.

With this project the basis for university cooperation between the Otto-von-Guericke Universität and the State University of Yerevan is to be laid, and the foundation for the creation of an environmental-scientific course of studies in Armenia. For this purpose teaching materials for lectures on closed cycle economy and waste management logistics have been discussed and handed over.

3 Course of the Project – Measures performed structured by parts and steps of the project, activities and results

3.1 Kick-off-Meeting

The kick-off-meeting took place on November, 24th and 25th, 2009 at the State University for Architecture and Building of Yerevan. On the first day of the kick-off-meeting besides the getting to know each other of the cooperating partners the working schedule presented by the contractor was discussed.

In the course of the formation of opinion on the presented project representatives of the Umweltbundesamt (UBA) in its role as project manager and orderer, of the centre of international migration and development (CIM), the Ministry of Economy of the Republic of Armenia and the United States Agency for International Development (USAID) participated.

In the process, the possibilities for supplementing the training program for the Armenian experts in Germany according to the particular areas of interests on the side of the Armenians were analysed. For relevant translations of the design of the final report the 3 languages English, Russian and Armenian are interesting, in which process the Armenian side took responsibility for the design of the report in the Russian and Armenian language.

On the second day of the kick-off-meeting, the cooperation contract between the Otto-von-Guericke Universität of Magdeburg and the State University of Architecture and Building of Yerevan was signed.

Furthermore the towns and communities for the performance of the analysis of the composition of waste were determined. The choice was made for the city Vanadzor, the middle sized towns Sevan and Echmiadzin, the small town Talin and the village Mkhchyan.

To support the organisation of the execution of the waste analyses, ensure the transfer of the results to the responsible community authorities and safely transfer the funds from Germany to Armenia, the Communities Association of Armenia (CAA) was additionally included in the project as a reliable project partner. Reasons for this were the very good reputation of the Communities Association, the existing trust and well maintained business relations with the towns and communities in which the analyses of waste composition were to be carried out.

In addition the landfill of Nubarashen in Yerevan was visited and a reception by the mayor of the town Sevan by the Sevan lake was arranged. In Sevan a visit to the garbage collection company, and a tour of the local garbage collection points and landfills were organised. Through this first impressions of the actual waste management situation in Armenia were gained.

3.2 Research on Waste Management Situation in Armenia – Analysis of Current State

3.2.1 Introduction

The project was carried out in the scope of an agreement between Yerevan State University of Architecture and Building (YSUAC) in Armenia and the Otto-von-Guericke Universität of Magdeburg (OvGU) Institute for Logistics and Material Flow Technology (ILM) in Germany. Under the commission and with financial support of the Umweltbundesamt of Germany YSUAC and OvGU in the scope of this project cooperated concerning fundamental surveys on the actual situation of waste management in Armenia.

The research topic planned by the above institutions of higher education YSUAC and OvGU, comprises the following activities in the jointly compiled working plan:

• Compilation of work and activity schedule for the overall project,

• Selection of regions to be examined (rural area and four urban areas),

• Research on the demographic data of the selected regions,

• Content and organisation oriented preparation of sorting activities,

• Execution of the sorting campaigns in the regions at the chosen times,

• Evaluation of sorting results (quantitative, qualitative) ,

• Projection of results, evaluation and assessment,

• Development of a concept of measures for the entire country.

At the example of selected disposal areas in Armenia, the possibilities of sorting waste by groups and the advisability of separate waste pree collection for private households were to be examined It was the purpose of the project to derive conclusions and state recommendations of measures based on the results gained. The Armenian partners thereby profited from the know-how of the German scientists and, via the workshop at the beginning of the project, were familiarised with the basics of waste management activities enabling them to independently carry out sorting analyses and take corresponding preparatory actions to be able to make statements on the volume and composition of household waste in selected disposal regions of Armenia.

Subsequently the successfully performed project is to serve as a basis for further cooperation between OvGU and YSUAC, and also to support the creation of a new course of studies, "Environmental Protection" at the Armenian university.

For successful performance of the project, both parties rely on active participation of the local authorities in the towns concerned as well as the mediatory support of the Communities Association of Armenia (CAA).

The CAA is the co-coordinator of a number of organisational activities in the regions selected for the execution of the research activities (Fig. 3.1). Their financing was guaranteed by the project.

Research in the scope of the project continued throughout the year. For the analyses on the composition of samples the sorting campaigns were executed in the 5 chosen areas and in every season.

Figure 3.1: Administrative and territorial distribution – map of Republic of Armenia [PERRY]

3.2.2 Legal Framework

3.2.2.1 Legal Framework, internal Regulations and Solutions

In the Republic of Armenia (RA) there unfortunately are no legal provisions yet, that codify the handling of waste as general principles and instruments for activities in that direction in the sense of European standards. The legislation regulating this area in Armenia is still in the developing stage.

From the generally valid legal stipulations of RA the ones concerning the collection of waste and the laws regulating that process can be extracted:

• "Concerning administrative violations"

• "Concerning local self-government“

• "Concerning multiple dwellings“

• "Concerning condominiums“

Several international contracts on the regulation of environmental problems that more or less concern waste disposal as well have been signed by the Government of Armenia.

The law "On waste" regulating the collection of waste, was first passed in 2004. In the years 2005-2007 a number of governmental decisions on the conduction of the waste register, especially concerning hazardous waste were made and corresponding governmental regulations passed.

The law "On waste" in the RA does not regulate management of solid municipal waste, but allows the Armenian legislator the passing of sub-legislative regulations / statutes that regulate the choice of the location for landfills, the composition of the solid municipal waste and the volume of the generated, collected and transported waste.

For waste collection and disposal, as well as payment of the fees, an internal municipal legislation (statutes), implementing provisions and corresponding practicable solutions are missing as well. The fee for waste collection is 80-200 dram (AMD) per inhabitant and month (about from 0.15 to 0.40 €) and 3000-5000 Armenian Drams (AMD) for $1m^3$ transported waste for professional organisations (about from 5.85 to 9.77 €).

The individual contract on rendering of corresponding services between the inhabitants and the service-organisation is not concluded. The tariff is determined on the level of the communal authorities and under supervision of the local self-government and according to the law on the amount of local taxes and fees.

In some communities, waste collection is performed by the sub-municipal organisations. The enterprises for the organisation of waste collection according to law are selected on a competitive basis.

Legal Framework of the Republic of Armenia

The legal basis listed below exists in the Republic of Armenia (Tab. 3.1):

Table 3.1: Applicable laws in the Republic of Armenia (RA)

No	Law	Date of passing or ratification
1	"Land code of the RA“(first passed by the Parliament of the RA in 1992)	02.05.2001
2	"Water code of the RA“(first passed by the Parliament of the RA on 19.03.1992)	04.06.2002
3	The code "on mineral resources“ (first passed by the Parliament of the RA on 19.03.1992)	06.11.2002
4	"Code of the RA on forests“ (first passed by the Parliament of the RA on 01.11.1994)	24.10.2005
5	Law of the RA "On protection of atmospheric air“	01.11.1994
6	Law of the RA "On examination of influences on the environment“	12.12.1995
7	Law of the RA "On local self-government“	30.07.1996
8	Law of the RA "On flora“	22.12.1999
9	Law of the RA "On fauna“	03.05.2000
10	Law of the RA "On aero-hydrological activity“	09.03.2001
11	Law of the RA "On the use of ecological costs“	11.06.2001
12	Law of the RA "On lake Sevan“	14.06.2001
13	Law of the RA "One year program on restoration, protection and use of the ecosystem of lake Sevan“	27.12.2001
14	Law of the RA "On ecological formation and education of the population“ (information of the population)	17.12.2001
15	Law of the RA "On seismic protection“	06.07.2002
16	Law of the RA "On the granting of concessions for natural resources for purposes of research and exploration“	17.12.2001
17	Law of the RA "On changes to the code of the RA on administrative offences “	11.12.2002
18	Law of the RA "On waste“	24.11.2004
19	Law of the RA "On the ecological control“	11.04.2005
20	Law of the RA „On tariffs for damage compensation in consequence of offences against ecological regulations“	03.05.2005
21	Law of the RA "On concepts of the national water policy“	03.05.2005
22	Law of the RA "On particular nature reserves“ (first passed by the Parliament of the RA in 1991)	03.05.2005
23	Law of the RA "On the materials that lead to destruction of the ozone layer“	27.11.2006
24	Law of the RA "On the national water policy in the RA“	27.11.2006
25	Law of the RA "On ecological fees“ (first passed by the Parliament of the RA in 2000)	20.12.2006

The government of Armenia has assigned a priority in the country to the management of municipal and industrial waste. However, very many activities have been funded by international environmental protection agreements and have mainly focussed on the area of hazardous waste. The condition of waste management in Armenia does not conform to the priority set by the government of Armenia [FICHTNER].

The legal framework for municipal waste management (MSWM) basically serves the rationed allocation of various rights and obligations to the different levels of public administration, of environmental protection, fees and licensing. The framework conditions for allocation of rights and obligations to the different levels of administration are defined in section 5 of the constitution [FICHTNER, p. 4-3]. The currently most relevant legal regulations include:

- Law on waste (adopted 24.11.2004).
- Law on local self-government (dated 07.05.2002) which allocates the performance of waste collection and road cleaning to the local state agencies. The local state agencies determine the amounts of waste collection fees.
- Law on environmental fees ("environment and nature protection“) dated 28.12.1996. The law determines the amount of waste fees for depositing in landfills.
- The law on health and hygiene dated 16.11.1992 regulates the responsibility for monitoring and execution of health standards, which also affect procedures of waste management ("sanitary and epidemiological safety in context of pollution")
- Environmental protection laws on prevention of water and air. The law refers to emissions in the air, ground and water and is also applies for landfills.
- An assessment of environmental compatibility is required by law.

The definition of the term waste also does not conform to the EU waste framework directives and European standards. The Armenian definition of waste comprises a combination of household (municipal solid waste) and industrial waste. According to § 4 of the law on waste waste is defined as follows: “Industrial waste and household remains (hereafter referred to as “waste”) are rests of materials, raw materials, outputs, products and remains originating from industrial activities and consumption, as well as objects (products) that have lost their consumption attributes (value)”[FICHTNER, p. 4-3]. Unfortunately, the priorities and necessities determined by law have not been put into praxis so far, which renders the implementation of this law impossible [FICHTNER, p. 4-7].

Besides, the currently valid hierarchy on waste management in the European area (waste avoidance before recycling, recycling before disposal) is not taken into account in the legal regulations of Armenia. Waste legislation is still at the very beginning of development and a change of paradigms is not visible at this time. The big problem is the legal execution of already existing regulations. The implementation provisions for judicial and executive implementation of the legal regulations unfortunately are not sufficiently developed. Development of legal statutes on the local municipal level is hindered due to lack of authority.

3.2.2.2 International environmental legislature

International legislature that touches on the the area of municipal solid waste in the Republic of Armenia

The EU-Convention (Aarhus-Convention) of the Economic Commission of the United Nations for Europe (UNECE): "Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters", was passed on June 25th 1998 in the Danish city Aarhus and entered into force on 20th November 2001. Additionally, the following documents have been signed by Armenia:

- Kiev Protocol on Pollutant Release and Transfer Register (PRTR), passed on May 21th 2003
- UN-Biodiversity-Convention: Convention on Biological Diversity (CBD), in force since December 29th 1993
- Cartagena Protocol on Biosafety, in force since September 11th 2003
- Climate framework convention of the UN: "United Nations Framework Convention on Climate Change" (UNFCCC), adopted on May 9, 1992, in force since March 21, 1994
- Kyoto Protocol: Protocol to the United Nations Framework Convention on Climate Change (UNFCCC), adopted on December 11, 1997, in force since February 16, 2005
- Protocol to Convention on Long-Range Trans-boundary Air Pollution (Geneva Convention) from 1979 on Heavy Metals adopted on June 6, 1998
- Stockholm Convention on Persistent Organic Pollutants (POP-s), adopted on May 22, 2001, in force since May 17, 2004
- Gothenburg Protocol to Convention on Long-Range Trans-boundary Air Pollution (Geneva Convention) from 1979 on Acidification, Eutrophication and Ground-level Ozone, adopted in 1999, in force since May 17, 2005
- Protocol "on Strategic Environmental Assessment", adopted in Kiev in 2003, in force since July 11, 2010
- United Nations Convention to Combat Desertification (UNCCD) from 1994
- UN Convention "on the Control of Trans-boundary Movements of Hazardous Wastes and Their Disposal - Basel Convention" from March 1, 1989
- Vienna Convention for the Protection of Ozone Layer from March 22, 1985“
- Montreal Protocol "on Substances that Deplete the Ozone Layer” adopted on September 16, 1987, in force since January 1, 1989
- London adjustment of the Montreal Protocol on Substances that Deplete the Ozone Layer, 1990
- Copenhagen adjustment of the Montreal Protocol on Substances that Deplete the Ozone Layer, 1992
- UN and United Nations Economic Commission for Europe (UNECE): Convention "on the Protection and Use of Transboundary Watercourses and International Lakes“ in 1992

- Protocol on "Water and Health" of World Health Organization (WHO)
- Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques (ENMOD-Convention), adopted on December 10, 1976, in force since May 5, 1978
- European Landscape Convention – Florence Convention, adopted on 20.10.2000, in force since March 01, 2004
- Bern Convention: Convention on the Conservation of European Wildlife and Natural Habitats 1979, in force since June 1, 1982
- UNESCO – World Heritage Convention: „Convention Concerning the Protection of the World Cultural and Natural Heritage“, adopted on 16 November 1972, in force since 1975

3.2.3 General Regional Data

The Republic of Armenia is a land-locked country and has no access to the sea. The territory is 29 740 m^2 and covers 10 % of the north-eastern part of the Armenian highlands and has complex, diverse geological areas. The country is located between 38º50' - 41°18‘ northern latitude and 43°27'-46°37´ eastern longitude. The state is located 145 km from the Black Sea, 175 km from the Caspian Sea, 750 km from the Mediterranean and 960 km from the Persian Gulf. It measures approximately 360 km from the north-west to the south-east is and 200 km from the east to the west. The length of the border of the Republic of Armenia is 1 479 km. In the north, Armenia borders Georgia, in the north-east, the east and the north-west Azerbaijan, Iran in the south, Turkey in the west.

Armenia is a typical mountainous country. 4,8 % of its territory is covered by lakes, in particular Lake Sevan; 90 % are more than 1.000 metres above sea level. Starting at 375 metres (in the north-east the valley of the river Debed) 40 % of the territory are at a hight of 1,500-2 000 m up to 4,095 m (top of mountain Aragaz). The majority of the country is at a hight level of 1.500-2000 to 3.700 m. The differences of heights are an important factor for the formation of the diversity of climatic zones and landscapes.

The climate of Armenia is dry which is due to its relief and high position above sea level. The highest temperature of +43 ºC was measured in Artashat (Ararat region) and Megri (Megri region). In the summer months the air temperature in the high mountain areas is between +10 ºC and +24 ºC - +26 ºC. In the plains it is rather cold in winter; the temperature varies between -13 °C and +1 °C depending on the height of the region. In January the lowest temperatures of -42°C were measured in Pahakne in the north-west of the country. In Armenia the average total amount of precipitation per year is 592 mm, and the most important precipitation is that during the months April and May.

The driest areas are the Ararat valley and Megri where the annual precipitation is only 200-205 mm.

3.2.3.1 Short socio-economic Description of the selected Towns

The city of Vanadzor lies in a valley between the mountain ridges Bazum and Pambak at the mouth of the rivers Pambak, Tandsut and Wanadzor. The city's territory is over 25 km^2. The city centre lies 1,350 m above sea level. The city is about 145 km (via trunk road) respectively 224 km (by train) from Yerevan. The city's population is currently 104,800 inhabitants (data from 2009); these are mostly Armenians.

Figure 3.2: Town centre of Vanadzor [TOURIST]

Besides that a few Russians, Greeks and Ukrainians live in the town. The day before the 1988 earthquake, the population was 172.600 inhabitants.

The most densely populated area in the city is the city centre (Fig. 3.2), but in the suburbs of the city there are also many 9 story buildings. There are also districts with individual 1-2-story buildings. Industrially the city was dominated by chemical industry (chemical plant, chemical fibre plant, plant for polymeric glues), mechanical engineering ("Avtogenmash"), light industry ("Bazum", "Dav-Gar"), and the food-processing industry before disintegration of the USSR. There was also a thermal power station.

Sevan is a health resort in Armenia in the region of Geharkunik (Fig. 3.3) and is located at the north-western side of Lake Sevan. Via the highway network and the railway line it is 63 km to Yerevan. 23 300 inhabitants live here (data from 2009). In 1961 Sevan was granted the status of a town.

15,500 inhabitants or 67, 1 % of the overall population live in apartment houses. The remaining 7,800 inhabitants or 32, 9 % live in single-family houses in the residential districts Gomadzor and Tsamakaberd or in rural settlements.

Figure 3.3: Town Sevan [WIKI]

Currently there is a great lack of large industrial enterprises in the town.

During high season, the population rises significantly due to the tourists.

A major area of employment is the rendering of services to the tourists.

Echmiadzin (formerly Vagarshapat), a town in the region Armavir in Armenia, is one of the most important cultural and religious centres of the country. The town owes its name to its founder, king Vagarsh I (117-140). From the 2nd to the 4th century this was the capital of Great Armenia. In 1945 Vagarshapat was re-named Echmiadzin. That is the name of the local monastery Echmiadzin - the seat of the Armenian Catholicos, (head of the church of all Armenians) and the centre of the Armenian apostolic church.

Figure 3.4: Cathedral in Ecmiadzin [ARM_PEDIA]

The town of Echmiadzin (Fig. 3.4) is located on the Ararat plain; it is 15 km distant from the railway station of Echmiadzin and 20 km to the west of Yerevan. The population is 57,300 inhabitants (in 2009).

In Echmiadzin there were plastics and household appliance production plants, the Armenian branch of the production union "Elektron", the branch of the association "Armsuvenir", food-processing industry (wine factory, canning factory, etc.), enterprises for the manufacture of building materials, etc. during the Soviet Union.

Figure 3.5: Cathedral in Talin [WIKI1]

Talin – The small Armenian town in the region of Aragatzn (Fig. 3.5) is situated at the Yerevan-Gyumri highway and is located 66 km to the northwest of Yerevan and in 18 km to the north of the railway station Karmrashen. The population of the town is about 5,700 people (according to Goskomeete in the year 2009).

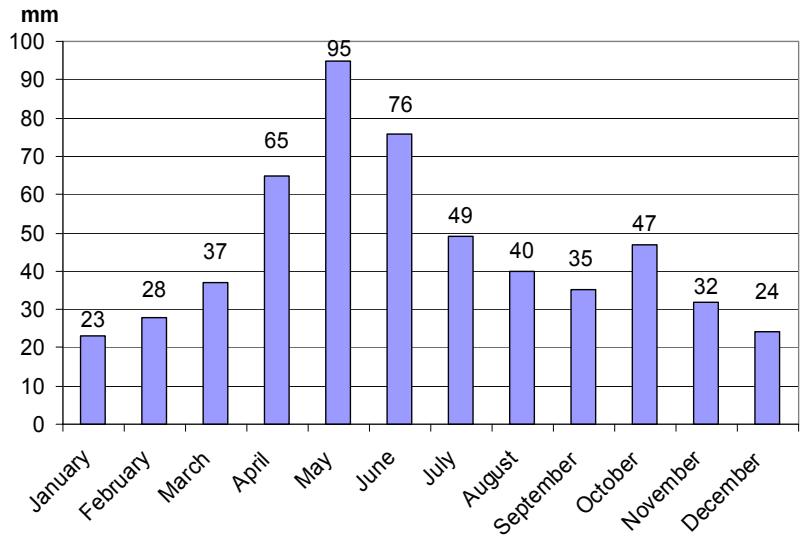
Figure 3.6: Village Mkhchyan in Ararat Region [SERGOYAN]

The village **Mkhchyan** (Fig. 3.6), is situated in the Ararat valley and is the biggest settlement in the Ararat region. The population is about 5,100 inhabitants (data from 2009). The economy has the main focus in agriculture. There exist also some small industrial enterprises. The number of households in the village is 1318 according to the data from 12/1/2009. The village surface amounts approx. 958,6 h.

3.2.3.2 Climate Data (Temperature, Precipitation)

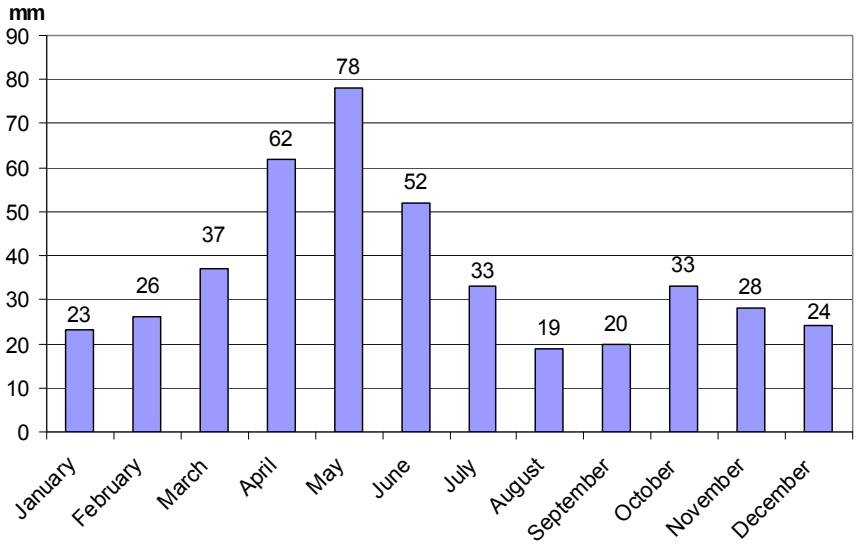
Precipitation

The precipitation data in the cities of Sevan, Talin, Vanadzor and Echmiadzin in the year 2009 are taken from the "Armenian Meteo Center" (Armgidrometzentrum) [ASHC] and are presented in Fig. 3.7 - 3.10. Considering the circumstance that the city of Emchiadzin and the village Mkhchyan are located in the same climatic zone, the data for this village and the city can be considered the same.



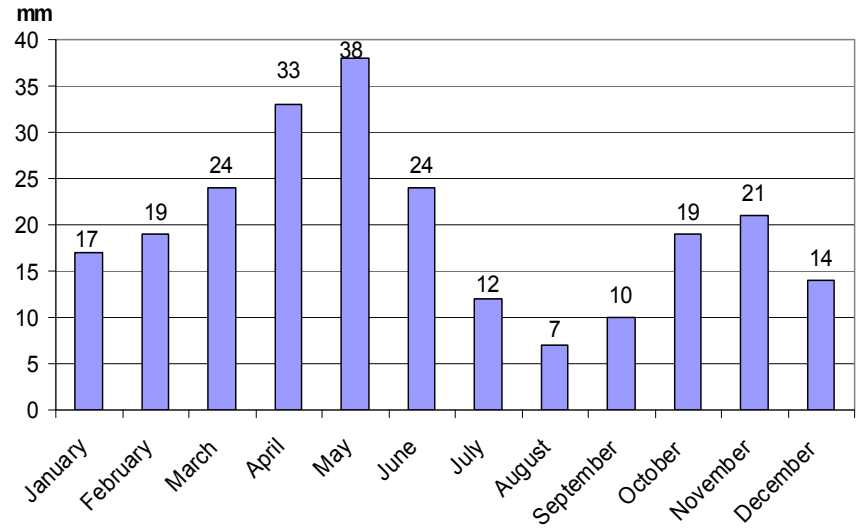
Precipitation accordingly the months (mm)	January	February	March	April	May	June	July	August	September	October	November	December
	23	28	37	65	95	76	49	40	35	47	32	24
Annual Precipitation (mm)	551											
Average monthly Precipitation (mm)	45.9											

Figure 3.7: Precipitation variations in Sevan



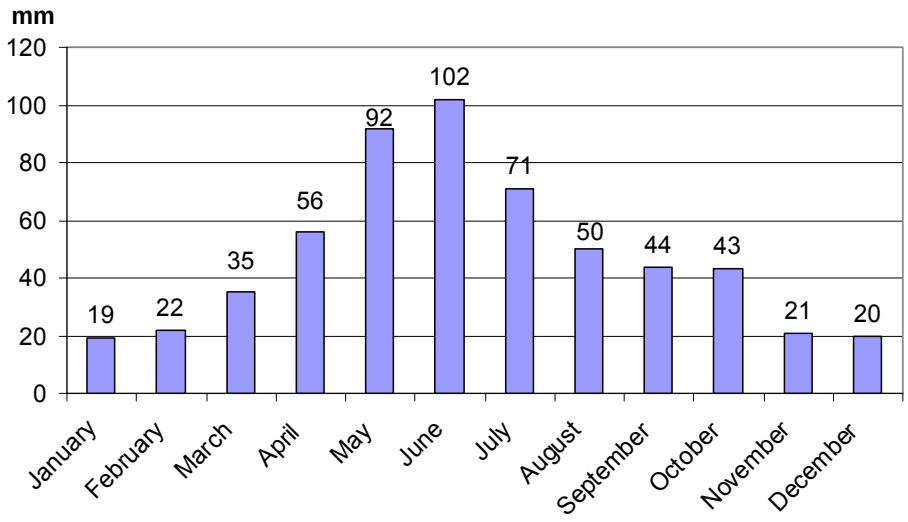
Precipitation accordingly the months (mm)	January	February	March	April	May	June	July	August	Septembe	October	November	December
	23	26	37	62	78	52	33	19	20	33	28	24
Annual Precipitation (mm)	435											
Average monthly Precipitation (mm)	36.3											

Figure 3.8: Precipitation variations in Talin



Precipitation accordingly the months (mm)	January	February	March	April	May	June	July	August	Septembe	October	November	December
	17	19	24	33	38	24	12	7	10	19	21	14
Annual Precipitation (mm)	238											
Average monthly Precipitation (mm)	19.8											

Figure 3.9: Precipitation variations in Echmiadzin und Mkhchyan

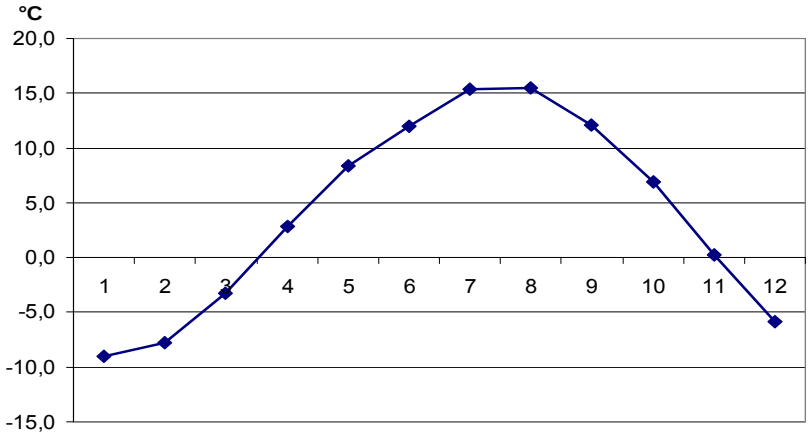


Precipitation accordingly the months (mm)	January	February	March	April	May	June	July	August	Septembe	October	November	December
	19	22	35	56	92	102	71	50	44	43	21	20
Annual Precipitation (mm)	575											
Average monthly Precipitation (mm)	47.9											

Figure 3.10: Precipitation variations in Vanadzor

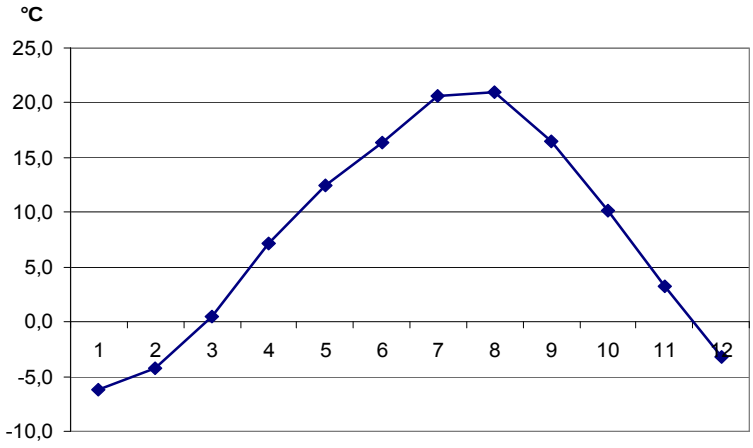
Air Temperature

The average temperatures were determined in the frame of research in the year 2009 in Sevan, Talin, Vanadzor, and Echmiadzin by the "Armenian Meteo Center" [A] and are presented in Fig. 3.11 – 3.14.



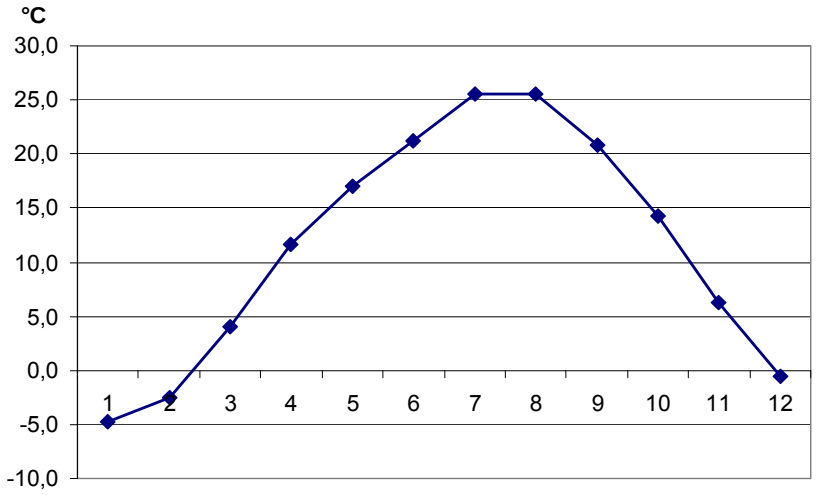
The monthly air temperature C°	January	February	March	April	May	June	July	August	September	October	November	December
	-9.0	-7.8	-3.3	2.8	8.4	12.0	15.4	15.6	12.1	6.9	0.2	-5.8
The average annual air temperature C°	3.96											

Figure 3.11: Curve of the monthly air temperature in Sevan



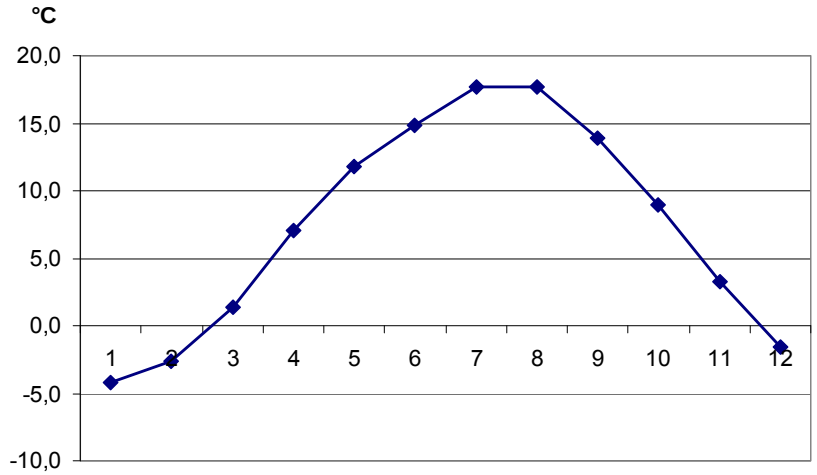
The monthly air temperature C°	January	February	March	April	May	June	July	August	September	October	November	December
	-6.2	-4.2	0.5	7.2	12.4	16.4	20.6	21	16.5	10.2	3.2	-3.2
The average annual air temperature C°	7.9											

Figure 3.12: Curve of the monthly air temperature in Talin



The monthly air temperature C°	January	February	March	April	May	June	July	August	September	October	November	December
	-4.8	-2.5	4.0	11.6	17.0	21.2	25.5	25.4	20.8	14.3	6.3	-0.6
The average annual air temperature C°	11.5											

Figure 3.13: Curve of monthly air temperature in Echmiadzin and Mkhchyan



The monthly air temperature C°	January	February	March	April	May	June	July	August	September	October	November	December
	-4.2	-.26	1.4	7.1	11.8	14.8	17.7	17.7	13.9	8.9	3.3	-1.6
The average annual air temperature C°	7.35											

Figure 3.14: Curve of monthly air temperature in Vanadzor

3.2.4 Economic and political Situation in Armenia

The constitution of the Republic of Armenia was approved in 1995. Armenia is presidential republic. The president is elected every 5 years. The president may for example still appoint the prime minister, who has to be confirmed by the parliament however. The legislator in Armenia is the National Assembly.

Armenia is divided into 10 regions (Marz). Each region has its government. The capital of Armenia, Yerevan, which has the status of a municipality. The mayor chooses a council of eldest. The selection of the council of eldest occurs every 4 years.

Armenia has a population of about 3,238,000 inhabitants, of which 2,075,000 or 64 % are to be considered urban population and 1,163,400 or 36 % rural population (according to the 2009 report of the National Statistical Service).

A typical resource intensive industry of Armenia, without the application of the latest resource protecting technologies would place an additional burden on the environment. According to the second National Action Programme for environmental protection (NEAP-2) the economic growth in countries like Armenia causes environmental damage at a scale of 8-10 % of annual gross national product. Today's budgetary receipts from ecological payments (0, 25 - 0,27 % of gross national product) are 20-40 times lower than the actual damage done to the environment.

Though the economy in Armenia had experienced a stable growth from 2000 on 2008, the country sustained a number of shocks as a result of the financial and economic crisis. The central Bank of the Republic of Armenia limited currency interventions in March 2009 and decided for exchange-policy which negatively affected trade and slowed down capital inflow. As a result of this policy the US dollar and Euro rose, and the AMD has fallen in price by 20%. US dollar exchange rate fluctuated between 360 - 380 AMD in 2009.

3.2.5 Service providers, their organizational structure and the relations resulting from their own and contractual obligations

Options for waste collection and recycling of municipal waste according to the law "On local self-government“ is carried out by the local government (LSGs).

According to the RA law "On waste", the fee for waste collection is to be determined by the local government and approved by the council of elders. The legal basis of the organizations concerned with waste is presented in Tab. 3.2.

The waste collection fees for the inhabitants vary in different regions (Marz) of Armenia. In Yerevan the fee is 150-200 dram (AMD) per inhabitant and in other areas (regions - Marz) about 80-120 AMD per inhabitant.

Table 3.2: Legal basis for services in the disposal of waste (waste disposal)

Organisations for waste disposal	Right of fee-collection and rendering of services according to the article 60 of the law on local self-government	Legal basis
The municipal organisations (funded by public budget)	Article 60. 2	Direct contract with the waste producers
Municipal organisations	Article 60. 4	Direct contract with the waste producers
Private organisations and enterprises	Article 60. 5	Contract with community in the frame of the law about the assignment or by direct contracts with the waste producers

3.2.6 Practical Implementation

3.2.6.1 Possibilities of Waste Recycling

In the municipalities of the RA waste recycling has in general not been performed yet. The collecting of valuable materials from waste was left to the informal sector up to now.

First attempts at organised recycling have resulted in Vanadzor from previous projects between CIM, USAID and the city of Leipzig. At the request of the municipal authorities (mayors) by participation in the intensive-course of the project there foundation of a private enterprise for the sorting of household waste was initiated; in the course of the practical implementation of which bigger problems arose.

In future the processing of solid household waste and the extraction of recyclable components thereof will be a prerequisite. Currently however employees without a fixed address (homeless) are working on all landfills to separate metal, glass, and plastic components from the buried waste and sell these to organisations that buy recyclable materials (see Tab. 3.3). The organized registration already at the waste producer, effective sorting, and recycling will become a important steps towards reduction the quantity of buried waste.

In the Republic of Armenia, there is the possibility of recycling glass, paper, as well as different kinds of plastic.

It should be noted that some data about the active waste disposal enterprises in Armenia have been collected via the study United Nations Development Program "Strengthening of the integrated application of waste in Armenia“(2006). The following enterprises are active in the area of recyclable waste:

- paper waste: GmbH "Armbumprom", GmbH"Karton-Verpackung", GmbH "50:50"
- metal: GmbH "Europa"
- plastic: GmbH„Eriwan Plus“, GmbH „Gary Group", "Firma TNT", GmbH „Grand San“.

Table 3.3. The organisations that buy recyclable waste [Data: USAID]

Names of the enterprises	The recycling waste	Capacity tons/year	Prices per kg of the bought material (AMD)*
Yerevan city			
Ltd. “Jurmagrin”	Waste paper	150	20-30
Ltd. “Saturn-Grin”	Waste paper	200	20-30
Ltd. “ Barbar”	Waste paper	300	20-30
Ltd. ”50-50”	Waste paper	1200	20-30
Private enterprise „K.Ozmanjan“	Waste paper	200	20-30
Private enterprise “Nikol Duman”	Ferrous and non-ferrous metals Waste paper	200-300 120	20-30
Ltd. “Lawa”	Waste paper	470	20-30
Ltd. “KEEA Basen“	Waste paper	130	20-30
Ltd. “Wasgen Abgarjan”	Waste paper	100	20-30
Ltd. “Usta Lal”	Waste paper	60	20-30
Ltd. “NTG and Sons”	Plastics	-	75-100
JSC “Plastik”	Plastics	-	75-100
Ltd. “Poliplast DW”	Plastics	-	75-100
Ltd. “Gjutarar”	Rubber	-	
Ltd. “Technobyt”	Rubber	-	
Ltd. “Europa”	Ferrous and non-ferrous metals	15000	
Ltd. “Gary-Group”	Rubber	-	
Ltd. “Energoservis”	Ferrous and non-ferrous metals	1500-2000	
Ltd. “Saranist” town Abowjan	Broken glass	1500-2000	
Ltd. “Grat” town Arzni	Broken glass	100	
Ltd. “Osipjan”	Broken glass	70	
Ltd. “Armglass”	Broken glass	2000-2500	
Ltd. “Glasswords”	Old glass	2000	
Ltd. “Woskegroup”	Ferrous and non-ferrous metals	4000	
Ltd.“Dsulkentron”	Ferrous and non-ferrous metals	4000-5000	
Ltd. “Gortofora” town Sevan	Paper and cardboard	450	
Ltd. “Tadui Kleopatra” Marz Armawir	Old paper	800	20-30
Ltd. „Oktemberjanskij“ ferrous alloy company	Scrap of molybdenum	1800, III class	
WFI „Awtomatika“ Town Vanadzor	Rubber	-	

* Prices equal about: 0.04 to 0.06 € respectively 0.15 to 0.20 € per kg

In the Republic of Armenia further possibilities for waste recycling, especially on the regional landfills should be created.

3.2.6.2 Current state of waste management and statistical basic data

The mentioned steps in this direction cannot be considered sufficient or satisfactory yet. The largest proportion of waste of urban and rural communities is construction waste which has arisen from the construction of houses and metal constructions. In most settlements of the AR wild dumps of illegal heaps of such wastes can be found despite local governments having made considerable efforts to remove un-permitted deposits and prevent their creation over the last years. The supervision has been increased and fines established etc.. The building waste can be used as secondary raw materials at the same time. This way the use of sand, rubble, gravel and other building materials is reduced.

On spontaneously created dumps in cities the emission of poisonous gases containing methane and carbondioxid, salt and poisonous metals is constantly visible. These emissions pollute the atmosphere, and threaten the ground and the cleanliness of bodies of water.

The Eco-check (test of environmental compatibility) in this sector is regulated by a great number of legal, and normative-technical documents. The monitoring (supervision) is carried out by the legislature of the RA as well as the local government. However there are omissions and problems that require solutions as soon as possible.

For the urban administrations the problem mainly consists of the recycling of solid household waste which urgently needs a solution. Household waste is very variable in its composition and types. Those are: wood, metal, glass, rubber, paper, food leftovers, garden waste, and plastic products: disposable cups, bottles, toys, polyethylene packages, bits of linoleum, building materials etc. The depositing of these wastes in landfills leads to spontaneous combustion during which detrimental substances such as nitroxides, sulphoroxides and carbondioxide are released into the atmosphere.

According to the Municipality of Yerevan in 2006, on the Nubarashen landfill 10 % of the household waste are paper or cardboard, 25 % food waste, 3 % textiles, 3 % polyethylene, 5 % glass, 43 % - stones, sediments, mud etc.

In consequence of non-observance of environmental protection measures in the management of landfills, spontaneous combustion of waste emitting dangerous substances occurs. The landfills generally are equipped with no or little technology. There is no accurate registration of waste, no cleaning of machines, no compression, no covering of the deposited waste with layers of earth.

There are no possibilities for sorting, recycling and extraction of recyclable materials from the waste. The sorting of waste for the recycling of paper, cardboard, metal, glass, plastic, is done spontaneously mostly by people intruding into the landfill (waste pickers).

Currently, only iron and nonferrous metals are sorted, partially plastic and glass packaging. According to official statistics [ARMSTAT], in the course of the year 2009, 14.8 million tons of waste was produced (see Tab. 3.4). By the end of 2009 (31.12.09), the volume of delivered waste for disposal from the territory of accountable organizations was 13,367 thousand tons in total.

The specific quantity of a waste in the RA is on average 4,552 kg per year and inhabitant and 51,8520 kg per 1 km^2 area (disregarding the lake Sevan area). However, there is no distinct separation of household, commercial, and industrial waste, so that, for example, a high proportion of mining waste strongly influences the results in the region of Syunik.

Table 3.4: Quantitative changes of waste occurrence in the regions (Marz) of the RA and the city Yerevan in tons, 2009 [ARMSTAT]

Region (Marz)	Waste received from other organizations	Waste generated during the year	Waste transmitted to other organizations	Waste processed and destroyed by organizations	Waste used by organizations	Waste transported to landfills (deposited) from organizations
1	*2*	*3*	*4*	*5*	*6*	*7*
Yerevan city	714.7	15058.9	5305.8	436.9	2148.6	7898.1
Aragatsotn	241.0	580.7	68.1	-	-	753.6
Ararat	1818.2	7.7	-	-	-	1390.5
Armavir	-	1131.7	7.1	4.0	0.8	1127.5
Gegharkunik	430.0	56.9	53.9	-	-	433.0
Lori	490.5	31644.6	22844.8	9.3	72.4	1779.1
Kotayk	1484.2	797.4	22.0	-	144.5	1641.4
Shirak	13056.0	4043.8	1.1	6.0	-	16532.5
Syunik*	9197.0	14711930.2	521.5	6.9	38.7	13303088.4
Vayots Dzor	137.6	707.2	4.0	-	-	833.6
Tavush	870.0	183.0	3.0	-	-	1050.0
Total RA	**28439.2**	**14766142.1**	**28831.3**	**463.1**	**2405.0**	**13336527.7**

*High proportion of mining waste by the biggest Armenian mines (Kajaran, Kapan, Agarak)

Table 3.5: Quantitative specific indicators of amount of waste generated from organizations in the regions of the RA and Yerevan city, 2009 [ARMSTAT, p. 50]

Region (Marz)	Generated waste		
	total (t)	per capita of region (marz) (kg)	Per square km of region surface (kg)
1	*2*	*3*	*4*
Yerevan city	15058.9	13.5	66338.8
Aratsotn	580.7	4.1	210.9
Ararat	7.7	0	3.7
Armavir	1131.7	4.0	911.2
Gegharkunik	56.9	0.2	13.9
Lori	31644.6	112.3	8351.7
Kotayk	797.4	2.9	381.7
Shirak	4043.8	14.4	1508.3
Syunik	14711930.2	96219.3	3264964.5
Vayots Dzor	707.2	12.7	306.4
Tavush	183.0	1.4	67.7
Total RA	**14766142.1**	**4552.3**	**518519.6**

Table 3.6: Quantitative distribution of annual amount of waste generated in organizations in the regions of the RA and Yerevan city in tons, 2004 – 2009 [ARMSTAT, p. 50]

Region (Marz)	2004	2005	2006	2007	2008	2009
1	*2*	*3*	*4*	*5*	*6*	*7*
Yerevan city	11004.4	16262.5	352272.4	31969.3	13933.3	15058.9
Aratsotn	259.0	346.9	596.3	434.1	243.4	580.7
Ararat	83.4	125.6	44.4	6156.9	6641.8	7.7
Armavir	337.5	208.5	142.2	6938.0	67.0	1131.7
Gegharkunik	83.0	-	-	84.5	71.9	56.9
Lori	30409.9	477.0	34772.5	38638.3	32106.3	31644.6
Kotayk	122.1	74.6	410.5	503.8	183.6	797.4
Shirak	514.6	282.5	648.4	2851.3	1407.0	4043.8
Syunik	17615251.0	11218598.0	12030857.6	13258053.0	11400317.5	14711930.2
Vayots Dzor	726.2	208.8	129.4	148.6	107.4	707.2
Tavush	1179.7	866.5	846.7	246.1	298.6	183.0
Total RA	**17659970.8**	**11237450.9**	**12420720.4**	**13346023.9**	**11455377.8**	**14766142.1**

Table 3.7: Annual quantity of waste generated in organizations in the regions of the RA and Yerevan city per inhabitant in kg, 2004 - 2009 [ARMSTAT, p. 51]

Region (Marz)	2004	2005	2006	2007	2008	2009
1	*2*	*3*	*4*	*5*	*6*	*7*
Yerevan city	10.0	14.7	319.0	28.9	12.6	13.5
Aratsotn	1.9	2.5	4.3	3.1	1.7	4.1
Ararat	0.3	0.5	0.2	22.3	24.0	0
Armavir	1.2	0.7	0.5	24.7	0.2	4.0
Gegharkunik	0.3	-	-	0.4	0.3	0.2
Lori	107.0	1.7	122.8	136.9	113.9	112.3
Kotayk	0.4	0.3	1.5	1.8	0.7	2.9
Shirak	1.8	1.0	2.3	10.1	5.0	14.4
Syunik	115132.4	73324.2	78684.5	86710.6	74576.7	96219.3
Vayots Dzor	13.0	3.7	2.3	2.7	1.9	12.7
Tavush	8.8	6.4	6.3	1.8	2.2	1.4
Total RA	**5494.7**	**3492.6**	**3856.0**	**4136.4**	**3542.1**	**4552.3**

Table 3.8: Annual quantity of waste generated in organizations in the regions of the by RA and Yerevan city per 1 km^2, 2004 - 2009
[ARMSTAT, p. 51]

Region (Marz)	2004	2005	2006	2007	2008	2009
1	*2*	*3*	*4*	*5*	*6*	*7*
Yerevan city	48477.5	71641.0	1551860.8	140833.9	61380.2	66338.8
Aratsotn	94.1	126.0	216.6	157.7	88.4	210.9
Ararat	39.8	59.9	21.2	2937.5	3168.8	3.7
Armavir	271.7	167.9	114.5	5586.2	53. 9	911.2
Gegharkunik	20.3	-	-	20.7	17.6	13.9
Lori	8025.8	125.9	9177.2	10197.5	8473.6	8351.7
Kotayk	58.4	35.7	196.5	241.2	87.9	381.7
Shirak	191.9	105.4	241.9	1063.5	524.8	1508.3
Syunik	3909287.8	2489702.2	2669964.0	2942310.9	2530030.5	3264964.5
Vayots Dzor	314.6	90.5	56.1	64.4	46.5	306.4
Tavush	436.3	320.5	313.1	91.0	110.4	67.7
Total RA	**619930.9**	**394446.0**	**436027.4**	**468567.6**	**402232.4**	**518519.6**

Table 3.9: Quantitative distribution of disposed of (deposited) waste from organizations in the regions of the RA and Yerevan city in tons, 2004 – 2009
[ARMSTAT, p 52]

Region (Marz)	2004	2005	2006	2007	2008	2009
1	3	4	5	6	7	*7*
Yerevan city	3764.5	7247.5	342722.0	18187.7	8060.9	7898.1
Aragatsotn	256.7	347.5	595.4	528.6	646.6	753.6
Ararat	710.4	621.0	952.4	1033.0	1834.0	1390.5
Armavir	328.5	124.3	102.2	166.7	63.7	1127.5
Gegharkunik	668.0	728.1	410.0	520.0	640.0	433.0
Lori	407.0	358.1	643.5	824.4	809.4	1779.1
Kotayk	543.0	956.5	1770.5	1374.7	1641.6	1641.4
Shirak	514.6	271.5	631.9	2756.3	888.6	16532.5
Syunik	17614384.0	11218305.4	12029877.0	13258053.0	11400000.0	13303088.4
Vyots Dzor	716.2	402.1	403.2	359.5	378.3	833.6
Tavush	910.8	812.0	634.5	894.9	890.6	1050.0
Total RA	**17623203.7**	**11230174.0**	**12378742.6**	**13284698.8**	**11415853.7**	**13336527.7**

As in the report "the Strategic management plan for waste collection in the city of Sevan" of the UN programme in the year 2009 the quantities of waste generated in 2010 that are listed in Tab. 3.10 have been determined from the statements of the waste producers.

Table 3.10: Quantity of municipal solid waste generated in Sevan [USAID1]

Waste generator	tons/year	m^3/year
Quantity of waste generated in the town, and of it from:	5339	18480
from population: municipal waste	3813	15253
of it department houses	2554.71	10219.51
of it single family houses	1258.29	5033.49
Quantity of recycled waste	1526	3227

These data do not include the considerable quantities of building waste and other wastes from private land. The waste disposal service provider only has contracts with the shops (shops, sales places). The contracts are concluded with only 80 of the currently 198 shops which is only 40, 4 %.

The total annual quantity of waste generated also includes the waste generated by tourists during the summer season. The population rises to 1.5 times the regular number of inhabitants with the summer tourists. The main disadvantage of the current or former practice in respect of the services based on contracts between private businesses and the disposal service provider under municipal control (municipal business) is that the relationships between the municipal authorities and the businesses are very strong and close. Principally the enterprises in the wider sense act as part of the municipal government. There are also bilateral relations between employees of the supervising authorities and the enterprises that also render monitoring and the control more difficult.

The rendering of services differs between different communities. These differences are connected with quality and form of government control by local authorities and do not depend on the form of ownership of the disposal enterprises.

In private conversations with the representatives of the local self-government (authorities) Members of the municipalities expressed different lines of thought in relation to ownership of the enterprises. Some municipalities are delighted that they have concluded a contract with a private company. Since there is no legal basis for the determination of fees for waste removal, it is necessary to conclude the contract between the waste producers and the waste collector.

Article 49 of the Law „On local self-government", says: "Obligatory authorisations of municipalities are carried out by the head of a municipality, the users of the state, commercial and non-commercial organisations (enterprises) ". This serves as the basis for authorisation of the private enterprises by the authority of the local municipality for performance of the disposal service.

Moreover, according to article 52 "the municipality may, for the purpose of realisation of authorisations for the disposal of wasted create the budgetary enterprises (users of the state budget), commercial and non-commercial organisations (enterprises)“.

3.2.7 Infrastructure of waste registration and collection

During use of the existing assets for waste processing the following issues exist:

- existing waste collection vehicles (lateral loaders) are mostly adapted for one Russian or Ukrainian technical system for waste collection (open conic

receptacles for gathering), the term of operation of the existing vehicles has expired in most cases (the only exception is Yerevan),

- many vehicles are not fit for this waste collection system, for example, dump truck with open body,
- maintenance and service of the equipment (though this was not studied in detail), presumably, also are outdated, are equipped by old technology,
- The number of containers is insufficient, the majority of containers is in bad condition. Containers fit only one of several systems and do not correspond to the minimum standards (for example, standard containers with a lid). The exceptions exist only in some city districts of Yerevan.

These thoughts lead to the conclusion that the existing technical equipment (equipment) cannot be generally used in future, as they are worn out or have become outdated, or do not correspond to the requirements of operation (for example, containers without a lid).

Tab. 3.11 shows the typical equipment of many waste collection. These vehicles are outdated and over-aged and cannot be used with full efficiency and frequently require repair.

Table 3.11: Technical equipment for waste collection

Type of the used technology	Type of fuel:	Capacity
SIL, KO-449-10, side loader	petrol	10.0 m^3
GAS-53, KO -413, side loader	natural gas	7.0 m^3
GAS-53-M, rear loader	natural gas	7*3 =21 m^3
Kamaz KO -415, side loader	diesel	10.0 m^3

The community (in this example Sevan) puts the focus for waste disposal on those areas that are close to the waterside and in possession of legal persons or private enterprises (see Tab. 3.12). For this purpose, separate tours were developed and additional collection vehicles were put into operation. In total the routes, distances and frequency of waste collection (collection rhythm) were planned for the whole town and the waterside areas.

Table 3.12: General technical parameters for collection of municipal solid waste in Sevan [USAID1]

Quantity of waste disposed in the landfill [m^3]	18480	Number of inhabitants per route	4000
Daily number of tours per waste collecting vehicle	2	Distance between landfill and the town [km]	10.0
Total number of tours	24	Empting frequency of the containers	Sevan: daily Gagarin: daily Camakaberde: twice a day Peninsula: daily
Average route length in (km)	20 - 30	Average duration of the handling (filling and emptying) of a container	Interval from 1 to 2 days
Average duration of a tour (h)	2.5 - 3.5	Average distance between the containers [m]	30 - 100

Now waste collection in PA is actually performed only in cities and only without preliminary sorting. Progress can be seen only in Yerevan where garbage containers are established on almost every street and in every court yard.

The waste collection rhythms are daily or every second day. Problems exist mostly in the summer months when unsanitary collection places and smells result from the high air temperature and late collection of waste. Many multi-family houses (apartment houses) are equipped with refuse chutes which freeze during the winter months and therefore further complicate collection. In the summer months they too can create unsanitary conditions on stairways in case of late waste collection.

In most rural settlements, there is no organised waste collection at all. The inhabitants who have no other possibilities for waste disposal either burn the waste or cover it with earth. The foliage and branches that fall in autumn are all burned.

It should be noted that the fees in those municipalities where the waste collection is performed in an orderly manner are unrealistic and can hardly cover the actual costs.

3.3 Education and trainings of the Armenian experts in Germany

To ensure reliable performance of the services to be rendered in the project by Armenian project partners, to map the knowledge head start and to transfer the client's know-how, as well as to achieve a sustainable effect in Armenia beyond the end of the project, 14 Armenian representatives from science and communities received intense further training on waste management theory and practice in a two-week seminar in Magdeburg from 9 to 23 February 2010.

Besides the transfer of theoretical knowledge a variety of visits to real installations of for waste management on widely varying principles was on the schedule. A particular focus was on the practical preparation for the performance of sorting analyses. For this purpose, a game that simulated the procedures in Armenia was designed and performed. (Fig. 3.15)

Figure 3.15: Preparation and realization of the game «household waste composition analysis» at Otto-von-Guericke-University Magdeburg

Besides the on-topic training many cultural and social events were organised, which were also used to further develop personal contact.

Integral Parts of the Theoretical Education

Derived from the many years of experience of the project participants of the Otto-von-Guerike Universität of Magdeburg in teaching and in similar research projects, a workshop program was designed which initially offers an overview of all the many aspects of the waste management industry and doesn't pose too high demands on participants with comparatively little prior knowledge.

Concluding the following particular points of interest were treated in illustrative presentations and discussions:

1. Legal framework conditions and basics of waste management.
2. Waste types, quantities, composition, analyses and forecasts
3. Waste collection, collection systems, waste containers
4. Vehicle technology, transportation and handling
5. Material recycling / thermal recycling
6. Landfilling and remediation of existing pollution
7. Waste management and, environmental/climate protection;

8. Evaluation and analysis of weak points of the current state of waste management in Armenia (together with Armenian colleagues).

All the teaching material was transferred to the employees of the State University of architecture and building of Yerevan in electronic form.

Visits to Waste Management Facilities

Besides the transfer of theoretical knowledge visiting of facilities of various principles of operation and of representative institutions of the community and contributed to forming an overall understanding and a picture of waste management in Germany. In particular the following facilities were visited (a Fig. 3.16):

1. Park of recycling of Wernigerode: waste sorting, composting

2. MHKW Rotenzee: thermal processing of waste,

3. Deponie GmbH Altmarkkreis Salzwedel: mechanical-biological pre-processing of waste,

4. City enterprise for management of waste of Magdeburg,

as well as the federal department on environmental protection in Dessau

Figure 3.16: Visits to waste management facilities (from the left to the right: Recycling park Wernigerode, Municipal waste management enterprise Magdeburg “Städtischer Abfallwirtschaftsbetrieb Magdeburg, dump site „Deponie GmbH„ Altmarkkreis Salzwedel: Mechanical-biological waste pre-treatment)

3.4 Sorting Analysis in Armenia

3.4.1 Methodology and Preparation of the Sorting Analyses

Considering the initially named specific aspects of the research region respectively experience of from projects as well as on site estimations of feasibility, the research scope was limited.

Choice of groups

Based on the results of previous studies (e. g. [FICHTNER]), the analyses were limited to 9 groups for sorting. In addition, were the small fraction (grain size <10 mm) and contrary to initial planning, middle fraction (grain size > 10, but <40мм) were sieved out.

The set-up of the sorting and the sorting groups ferrous and non-ferrous metals, cardboard/paper/cardboard packaging, glass, plastic, organic material, textiles, inert materials, leather/rubber, miscellaneous, middle grain and fine waste fractions are presented in Fig. 3.17.

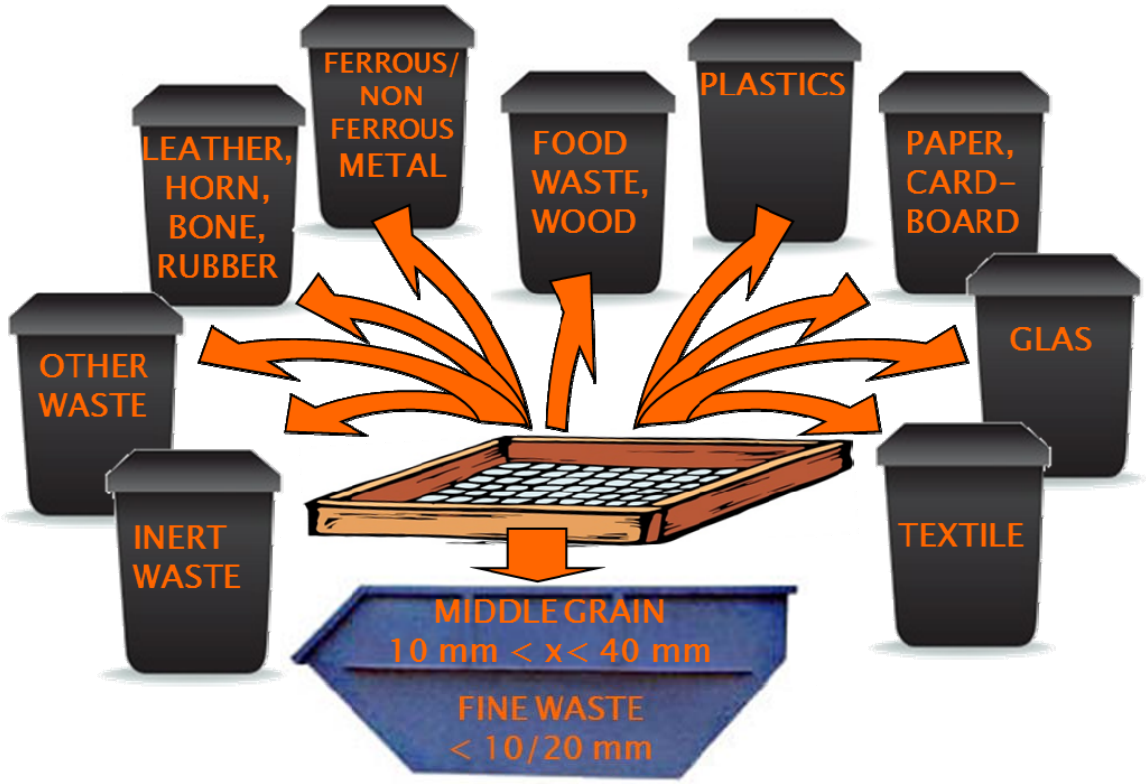


Figure 3.17: Layout and sorting groups for waste sorting campaigns in Armenia

Choice of Waste Collection Areas

As in [FICHTNER], the city area of Yerevan was already thoroughly investigated, a focus on the following places was determined in agreement with the Armenian partners and federal department of Environmental protection of Germany: Vanadzor, as a cities, Echmiadzin and Sevan, as middle sized towns, Talin, as a small town, and the village Mkhchyan. By these choices the different regional conditions are suitably represented.

Procedure of the Waste Composition Analyses

The performance of the sorting campaigns that were principally carried out in all 4 seasons according to identical procedures, began with accompanying of collection tours and in parallel with the emptying of the containers the collection of the number of inhabitants and living situations, the condition of the collection container/collection place as well as an estimation of the collected amount of waste, which, due to the non-uniformous availability of infrastructure (collection places, containers/garbage chutes/wild dumps varying and partially not reliably kept collection cycles), was difficult and calls generalisations in question.

Generally it must already be noted at this point that separate gathering of waste was not performed, but that the general waste contains a wide spectrum of waste components.

3.4.2 Performance of Sorting Campaigns

Waste Collection and Sorting

The important data and information on the description of the situation during the collection of the waste to be sorted are shown in Table 3.13 summarised at the example of the spring campaign. The sorting campaigns in the seasons summer, autumn, and winter were performed under similar conditions. On average an amount 10 m ³ was collected and sorted.

Table 3.13: Conditions of the waste collection in the researched areas at the example of the spring campaign

Town	Collection containers	MSFZ	Crew	Collection frequency and connected inhabitants	Collected waste volume
Vanadzor	500 and 700 l, garbage chute	Side loader Russian production	1 driver + 3 loaders	daily: 990 inhabitants, 3-times a day: 516 inhabitants, weekly: 72 inhabitants	15,7 m^3
Sevan	500 l, garbage chute	Side loader Russian production	1 driver + 3 loaders	daily: 3450 inhabitants	8,1 m^3
Echmiadzin	500 und 700 l	Side loader Russian production	1 driver + 3 loaders	2-3 times a day: 1500 inhabitants	9,33 m^3
Talin	no containers, unsanctioned dump sites at the roadside	Dump truck Russian production	1 driver + 3 loaders	2-3 times a week: 972 inhabitants	ca. 9 m^3
Mkhchyan	no waste containers, unsanctioned dump sites at the roadside	Dump truck Russian production	1 driver + 3 loaders	weekly: 1850 inhabitants	ca. 9 m^3

The situations of gathering of waste are explained based on the examples of the settlements Vanadzor, Talin and Mkhchyan.

The sorting personnel were provided by municipal facilities and provided with work protection by project means. Installation of sorting containers, weighing of the groups of waste, as well as data entry in the report were handled by employees of the State University of architecture and building of Yerevan.

The spring, summer and autumn campaigns were accompanied by the an employee of the Otto-von-Guerike Universität of Magdeburg. Coordination between employees of university of Yerevan and the municipalities' authorities was supported appreciably by the Union of communities of Armenia (CAA).

Waste Collecting at the Example of Vanadzor

Gathering of waste in Vanadzor was carried out by very out-of-date collection vehicles (MSFZ) of Russian production. The containers are of open build (without lid) with a capacity of 500 or 700 l. In consequence waste in the containers is not protected from water and frequently very wet causing rotting processes to begin very early.

The apartment houses (multi-story buildings) are frequently equipped with rubbish chutes. These refuse chutes don't always have no containers for storage which means that waste is frequently distributed in the shaft and then has to be manually shovelled into the MSFZ (a Fig. 3.18).

Figure 3.18: Waste collecting in the town Vanadzor
(left: waste collection containers, right: garbage chute)

It was also established that in the town, there is a lack of waste collection containers and the containers frequently overflow and the waste lies next to them. It can be concluded that inhabitants of side streets that aren't equipped with containers of their own, frequent the containers chosen for sorting as well. In addition, waste from a nearby market was also included. Waste from households, small businesses and public institutions is all collected together.

There is no differentiation of streams of waste. The situation concerning waste collection in the other towns Sevan and Emchiadzin is similar.

Waste Collection at the Examples of Talin and Mkhchyan

The town of Talin counts about 7,000 inhabitants and has a total of 40 systemless waste collection containers which are mostly located in public institutions and schools. These containers frequently have the form of a metal box of widely varying build, and the function of such containers consists of avoiding the dispersion of waste. Waste is also deposited at the side of roads by forming heaps of 5 to 7 m^3 (Fig. 3.19 on the right). Collection of waste happens once or twice a week by a dump truck of Russian build though the waste is loaded manually with shovels.

Figure 3.19: Waste collecting points (unsanctioned dump side at the roadside) (left: Talin, right: Mkhchyan)

The village Mkhchyan is not equipped with waste collection containers at all (Fig. 3.19 on the left). In streets, it is normal to see small heaps of waste and dumps on the roadside. Several households contribute to the collection of wastes in one heap. Frequently such heaps are disposed of by the villagers themselves by burning respectively reduced to inert leftovers. In these heaps bulk waste, garden cuttings and ashes as a consequence of the burning can be seen. The waste is collected by a dump truck once a week and is taken to the site of a former bus station. The local government (municipality) organizes and provides a dump truck for waste collection and inhabitants themselves are responsible for the loading of the vehicle after the driver signals readiness by sounding the horn.

Waste Sorting at the Example of Vanadzor

(Similarly good conditions in Talin)

Preparation and performance of the waste analyses in the towns of Vanadzor and Talin were organized by the personal effort of the mayor in a for Armenian conditions exemplary manner (Fig. 3.20).

Figure 3.20: Waste sorting place in Vanadzor

In Vanadzor, the sorting place was one side isle of a roofed hall. The place was also relatively well equipped with the necessary facilities. In Talin, a very large private hall was used. In both towns the employees were well equipped with protective clothing and worked very motivatedly.

Waste Sorting at the Example of Sevan

(Similar conditions in Mkhchyan, in of Talin where in partially roofed sorting area, pent roof).

In Sevan and Mkhchyan the waste sorting analyses in spring and summer took place outside without a hall (Fig. 3.21).

Figure 3.21: Sorting places (left: Sevan, right: Mkhchyan)

The wind and rain therefore made the unprotected work of the employees harder and influenced the results of sorting. In comparison with Sevan, employees in the cities of Echmiadzin and Mkhchyan were very well motivated nevertheless.

On the initiative and under the direction of the Union of communities of Armenia (CAA) makeshift roofs could be provided for the surveys in autumn and winter which allowed for the sorting to be performed protected from the influence of weather at least.

Regarding Echmiadzin, the sorting place was partially covered by a pent roof. In all three cases the employees were relatively well provided with protective clothing, however there were no sanitary facilities anywhere.

3.5 Evaluation of the research results of the waste sorting analyses

For each campaign and research location the determined waste compositions are separately represented in a diagram and always in reference to percentages of mass and volume in the appendix (see appendix A.1 - A.5).

In addition to the research program presented so far PET-bottles from the plastics group were sorted and weighed during the autumn and winter campaign. These results are shown in appendix A.6.

Also in the appendix the diagrams showing the results of the sorting campaigns for each separate location (also as comparison of percentages of mass and volume, see appendix A.7).

In the following sections 3.5.1 - 3.5.5, the results of the sorting campaigns are presented in diagrams as average values of all 4 campaigns. The results and deviations between seasons are explained.

3.5.1 City Vanadzor

The average results of the sorting analyses for all seasons (4 sorting analyses) in the city of Vanadzor show a high mass percentage of organic waste (27 %), plastic material/plastic (17 %), and cardboard/paper/cardboard packaging (10 %) (see Fig. 3.22). Volume percentages of this waste group are for organic waste (12 %), plastic material/plastic (33 %), cardboard/paper/cardboard packaging (28 %).

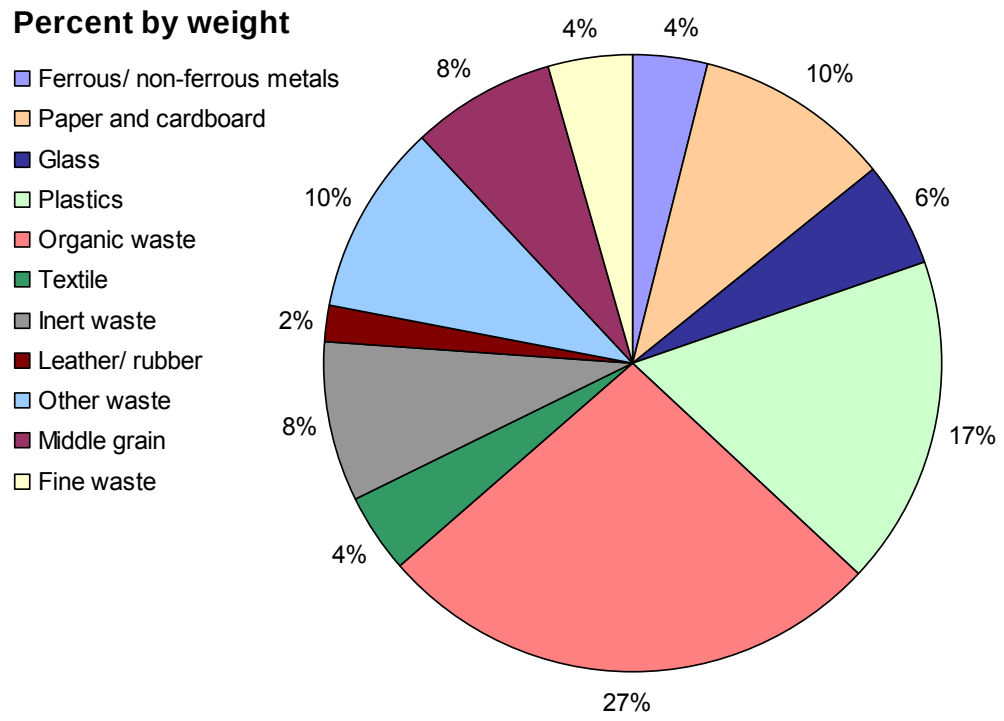
The percentage of plastics was abnormally large during spring in comparison with the other seasons (mass: 29 % and volume: 42 %), see appendix. A. 7.1 a) and b). Plastic shows a change: a reduction from 29 % in the spring to 11 % in the summer. This mass percentage of plastics remains almost constant at 11 % and 13 % in summer, autumn and winter. The large amount of plastics can be explained by wastes collected from small businesses (the weekly market, small shops). This group contains a very large share of PET-bottles and plastic composites. Appendix A. 6 delivers the information on the percentage of PET-bottles in autumn and winter.

The large mass percentage of cardboard/paper/cardboard packaging is caused by humidity and dirt because waste is collected in open conic containers. It is noticeable that the mass percentage of cardboard/paper/cardboard packaging is significantly higher in spring and autumn (13 % respectively 13 %) than in summer and winter (8 % and 6 %) (see appendix A 7.1 a)). The comparison of results between spring and summer shows a decrease of the proportion of cardboard/paper/cardboard packaging by 5% (mass) and simultaneously an increase of 8 % in respect to volume. This is likely a consequence of dry summer months.

Organic waste (mass percentage) rose from 13 % in spring to 38 % in summer and decreased again in autumn to 27 %. In winter an increase of organic material to 33 % is marked.

Inert wastes shows an increase from 2 % in the spring to about 10-13 % in the other seasons, likely the consequence of construction and household repairs (see Fig. 3.22 and appendix A 7.1).

a)



b)

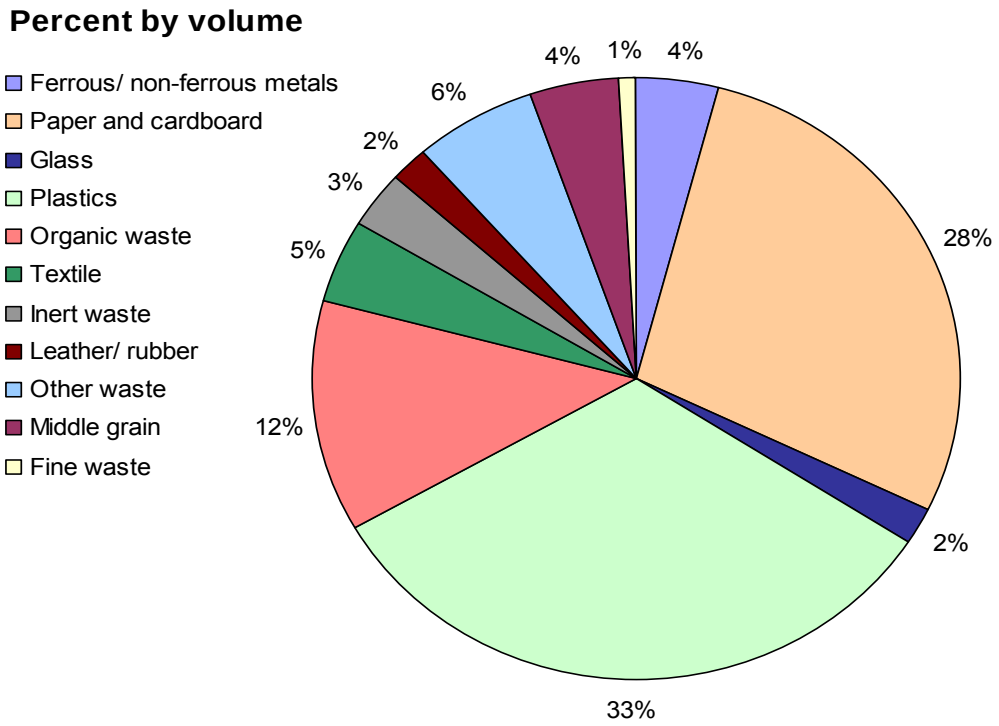


Figure 3.22: Results of the sorting campaigns in Vanadzor – average values for the whole year

3.5.2 Middle sized town Sevan

The largest waste groups in Sevan in mass are: organic material (32 %), inert waste (11 %), plastics (9 %), glass (7 %) and a cardboard/paper/cardboard packaging (5 %) (see Fig. 3.23 a)). The most important groups in volume are plastics (31 %), a cardboard / paper / cardboard packaging (19 %), organic materials (15 %), ferrous and nonferrous metals (7 %). The share of inert waste is 4 %.

The mass percentage of plastic materials/plastics increases in summer in time of the high season to 12 % (see appendix A 7.2 a)). This can be explained by the increased number of guests and tourists in the town.

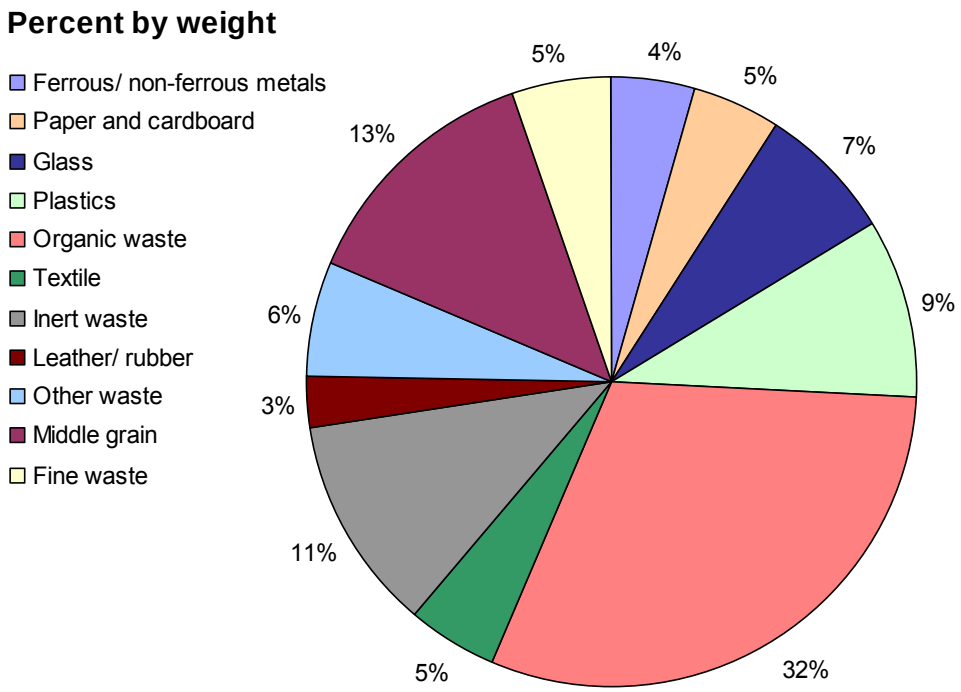
The mass percentage of cardboard/paper/cardboard packaging is considerably higher in the spring (7 %) and summer (61 %) than in autumn (3%) and winter (2 %) (see appendix A 7.2). This is also is valid for all volume percentage of this group.

The waste amount of organic waste is particularly high in summer (mass 41 %). This was probably caused by waste from restaurants. Besides that garden cuttings play an important role in the increase of organic waste. In the time without many visitors in the town and of the Sevan-lake (spring) the share of the organic waste is only 11%, which in comparison is significantly lower than during the other seasons.

The share of inert waste from construction, alteration or restoration work in households is particularly large in summer (22 %) (see appendix A 7.2 a)).

Due to rain the middle fraction is unusually high in spring 25 %. As a result of the rain the middle and fine fractions were very muddy and the further sorting of these groups turned out to be senseless.

a)



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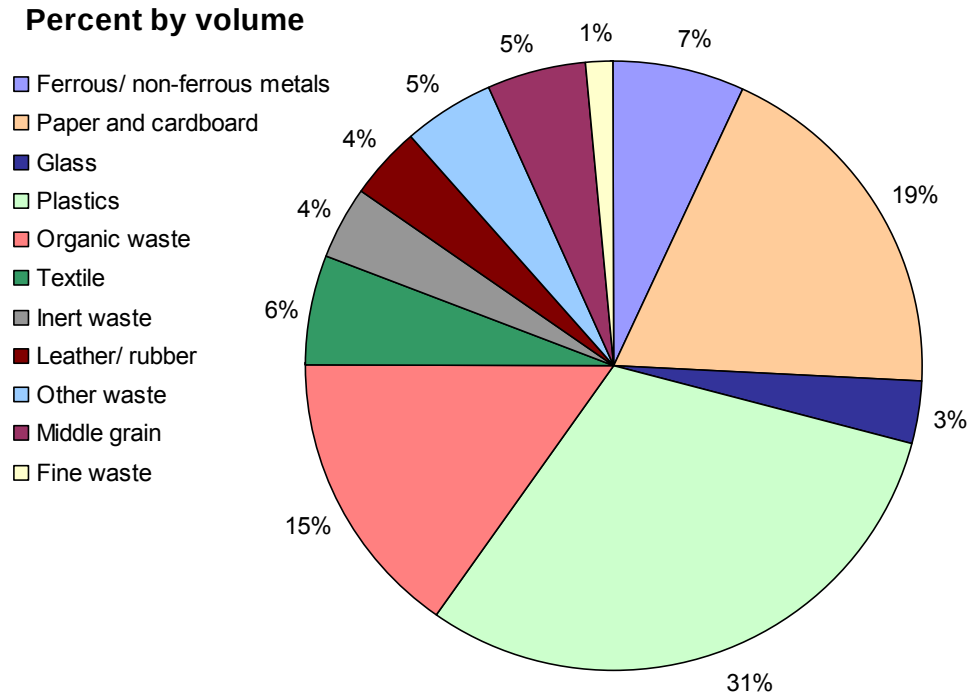


Figure 3.23: Results of the sorting analyses in Sevan – average values for the whole year

3.5.3 Town Echmiadzin

The largest waste group in mass on average of the whole year in the town Echmiadzin is organic material at 39 %, followed by plastics at 10 %, glass (9 %) and cardboard/paper/cardboard packaging at 6 %. In volume plastic materials/plastics (31 %) are at the top followed by cardboard/paper/cardboard packaging (20 %), organic material (18 %), and textiles (9 %) (see Fig. 3.24).

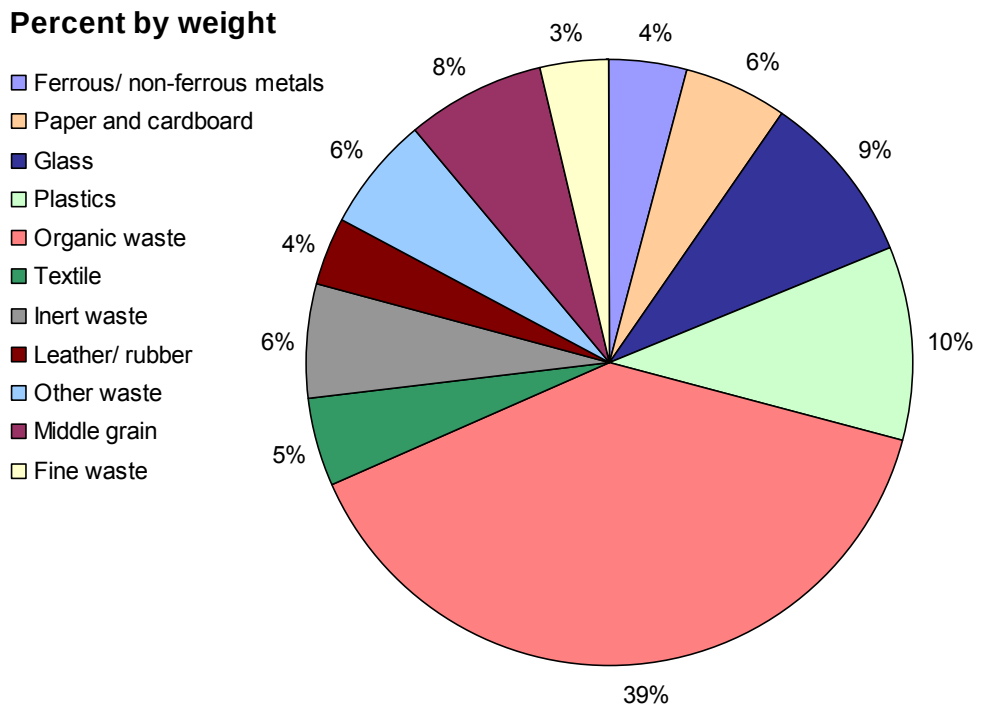
The mass percentages of plastics decreases from 12 % in the spring and 12 % in summer, to 9 % in autumn and 8 % in winter (see appendix A 7.3). In summer the share of plastics materials in volume reaches the largest value of37 % of the total amount (see appendix A 7.3 b)). This is significantly caused by the pilgrims in the town during the summer months. The town is known as an Armenian religious centre.

The volume percentage of cardboard/paper/cardboard packaging remains constant between 20% to 22 % in spring, summer and autumn without large fluctuations. In the winter it falls to 17 % (see appendix A 7.3 b)). The large mass percentages of 7% in spring and autumn are caused by humidity (waste containers without lids). This group, as in other regions of Armenia is very dirty and unsuitable for recycling.

The big share of organic waste is likely caused by waste from restaurants. Particularly in autumn the share of this group is very high at 44 % (high percentage of garden cuttings). Besides this is also the pilgrim high-season, and the number of visitors in the town increases.

An important waste group is glass. This group increases in mass from 5 % in spring via 9 % in summer and autumn to 13,56 % in winter. The group consists mainly of empty bottles and glasses, little broken glass. The development in the glass group has the same reasons as for organic waste and plastics.

a)



b)

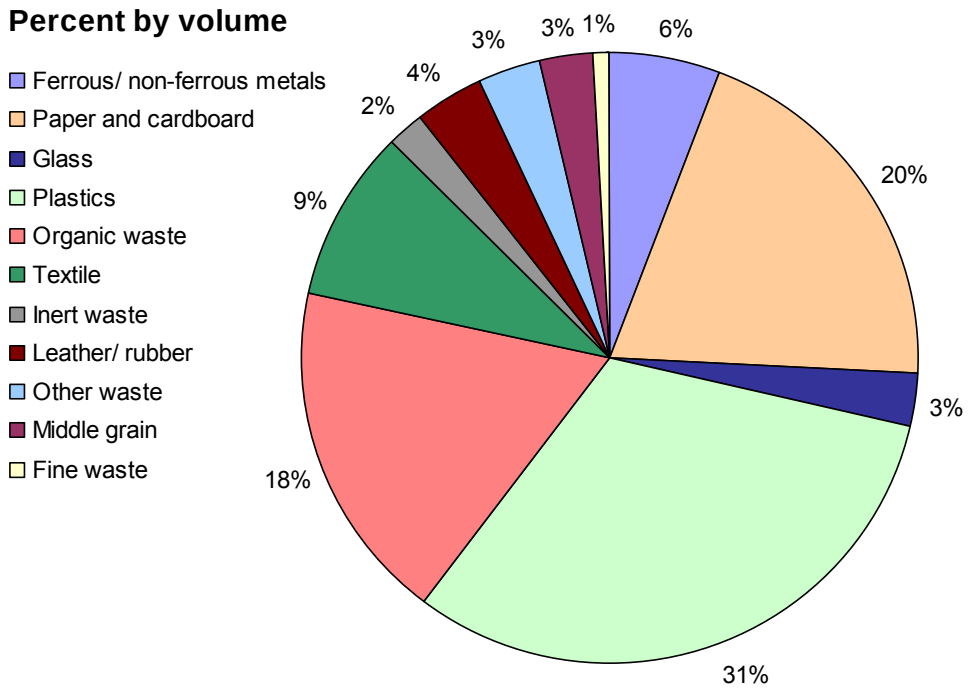


Figure 3.24: Results of the sorting analyses in Echmiadzin – average values for the whole year

3.5.4 Small Town Talin

The analysis of the composition of waste in all four seasons in the small town Talin showed that the greatest mass percentage is organic waste at 29 % (see Fig. 3.25 a)). The second-largest group is plastics at 13 %, the third-largest groups are cardboard/paper/cardboard packaging and other waste at 9 % each. Inert waste makes up a percentage of 7 % of the total amount of waste generated.

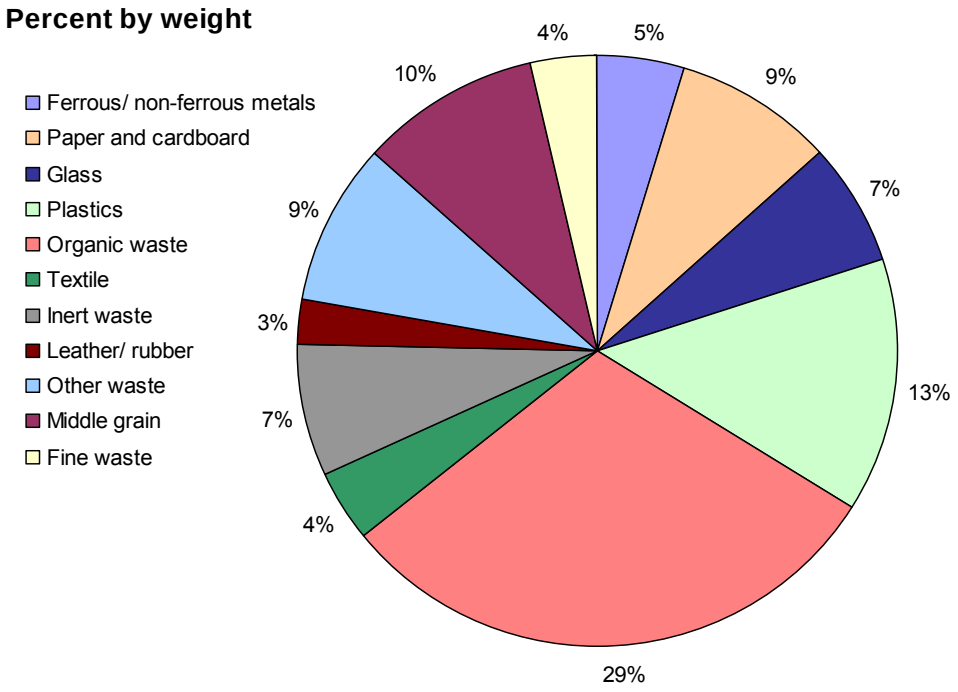
In volume plastics are in the first place at 33 % (see Fig. 3.25 b)). Cardboard/paper/cardboard packaging makes 24 % of the total amount of waste generated, organic waste 14 %, ferrous and nonferrous metals 7 % of the total amount of waste generated.

From the comparison of the results of the analysis of the composition of waste during all four seasons (see appendix A. 7.4) an increase in the group of plastics is noticeable in the summer months in comparison with the other seasons, that means 18 % in mass and 36 % in volume are plastics. The share of this fraction is lower in spring and is 11 % of the total mass and 28 % of the total volume.

Cardboard/paper/cardboard packaging remain almost constant: in spring (9, 30 %), autumn (9, 23 %) and winter (9, 04 %). In summer this fraction even decreases to 7 % (see appendix A 7.4 a)).

Comparison of the results of sorting throughout the four seasons shows a strong increase in the mass share of the organic material group during the summer months compared with the other seasons to 40 % respectively concerning volume 16 %.

a)



b)

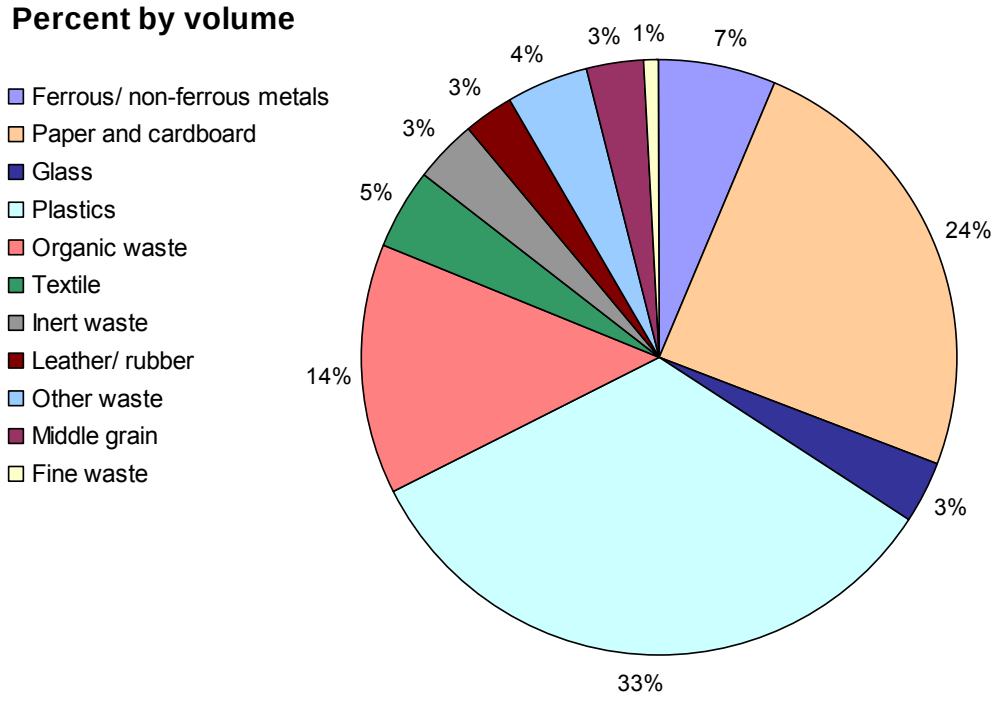


Figure 3.25: Results of the sorting analysis in Talin – average values for the whole year

3.5.5 Village Mkhchyan

The result of the analysis of the composition of waste in Mkhchyan shows a very high percentage of fine waste of 26 % of mass. It is however only 2 % in volume (see Figure 3.25). This group consists largely of earth from greenhouses (autumn campaign). A similar statement can be made concerning the middle fraction (15 % of mass and 6 % of volume). Inert and organic waste makes up a mass percentage of 15 % each.

The analysis on the composition of waste in the village of Mkhchyan shows a very high mass percentage of glass of 15 % in spring (see appendix A 7.5 a)). This group consists mostly of flat glass splinters from greenhouses.

Ferrous and nonferrous metals also make a large percentage of 16% of mass in spring. This group consists of scrap metal and metal containing bulk waste. Comparing summer with spring the group of ferrous and non-ferrous metals shows a reduction from 17% to 1% in summer (see appendix A 7.5 a)). Later this group grow again in autumn to 4 % and in winter to almost 5 %.

The share of organic material of 13 % of the mass in spring and summer consists mostly of garden cuttings and hay. Unfortunately, in autumn, the cuttings from greenhouses were not collected for analysis and remained by the roadside (5 %). In winter the percentage of organic waste was particularly high and at 32 %. As a reason it must be suspected that dried cuttings from autumn were colleted with the rest.

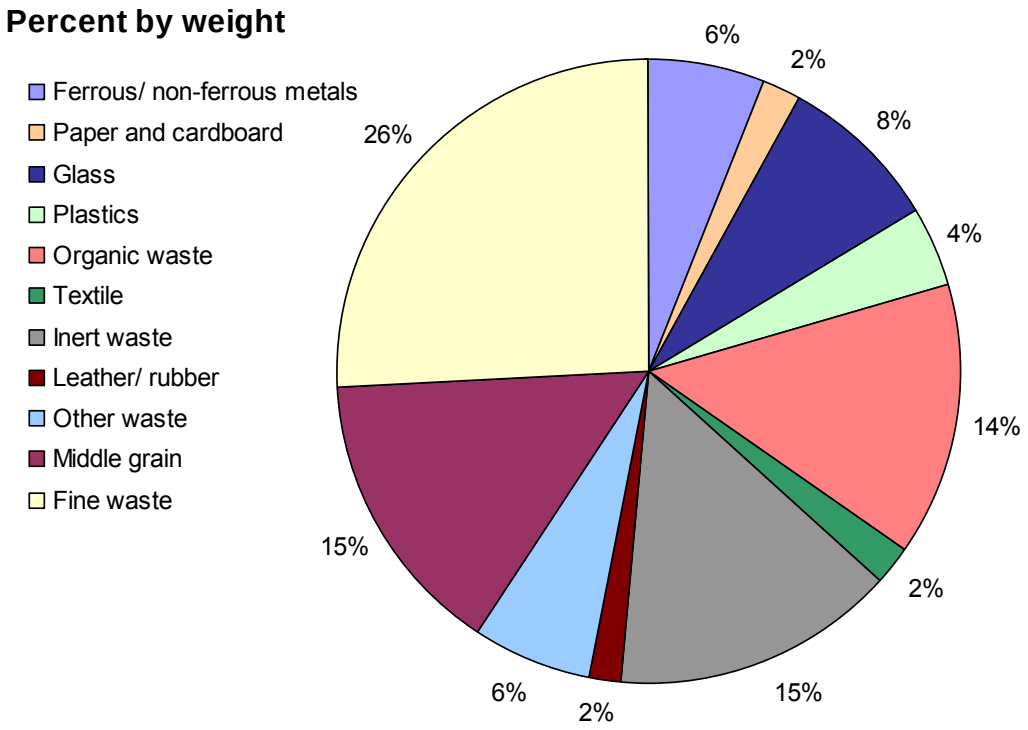
The portion of glass also shrunk from 15% in spring to 4% in summer. After that it rose again in autumn to 7% and in winter to 9 %. The amount of glass generated came mostly from building elements of the greenhouses. Annual fluctuations are connected with the seasonality of vegetables grown in greenhouses (sowing and harvest) (see appendix A 7.5 a)).

The share of inert waste has increased considerably from 7 % in spring to 24% in autumn (re-construction and renovation of houses).

In spring, the ash in the collection places wasn't included in the analysis even though ash was in considerable quantity at the collection points. The fine waste increased strongly from 6% spring to 34% in summer because at that time the ash at the collection points was also included. Also, the share of fine waste increased to 41 % in autumn. The reason for this is the earth collected from greenhouses.

The biggest problem for the execution of a precise waste analysis is also the way of waste collection and disposal on site. This also has a negative impact on the significance of the results gained from four analyses. For example, ashes were not collected regularly and cuttings were spread out for drying.

a)



b)

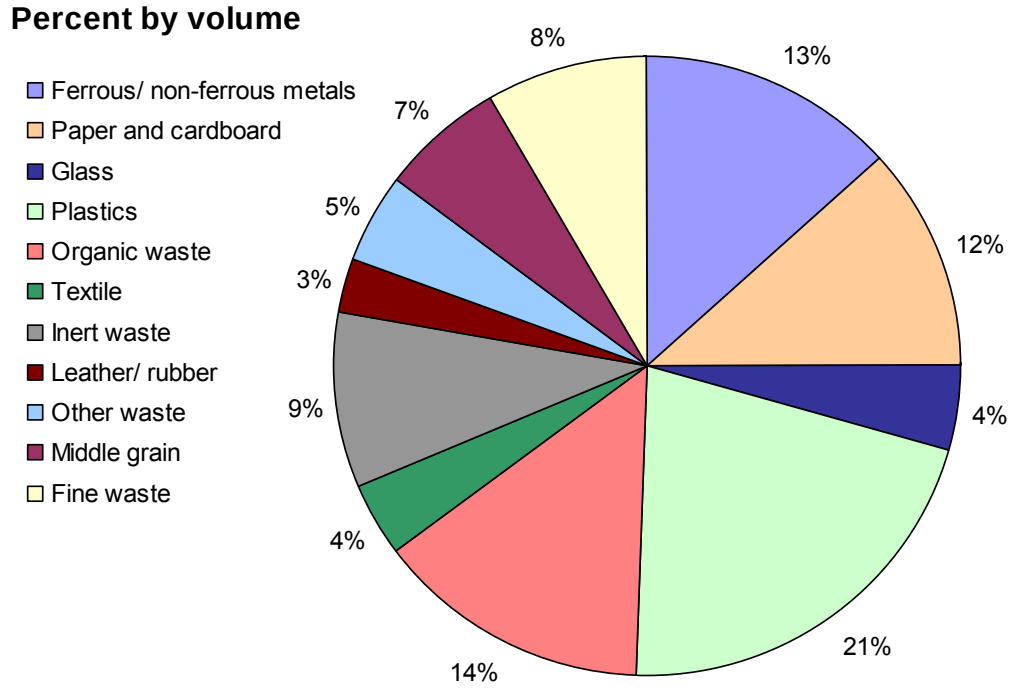


Figure 3.26: Results of the waste sorting analyses in Mkhchyan – average values for the whole year

3.6 Extrapolation of the Amount of Waste Generated

The extrapolation of the amount of waste generated for the settlements in Armenia where the analysis on the composition of waste was carried out are presented in Tab. 3.14. The table contains data on number of inhabitants included in the analysis, the collected quantity of waste in [kg], volumes of waste collected in [l] (estimated) as well as volumes of waste at sorting in [l] (measured). Based on these starting data the amount of waste generated per inhabitant and day was calculated.

For the calculation of amounts of waste generated [l] per inhabitant and day [l / (E*d)] the measured amount of waste at sorting was used as a basis. In the development of waste management concepts in the sorting places, in particular in respect of the determination of the volume of waste to be expected and the required amount of containers as well as the required capacity of the waste collection containers the actual volume of the amount of waste generated must be determined. That means this amount of waste generated must be multiplied by an relief factor (see tab. 3.15). In addition, a safety factor must be included so be able to cope with possible future quantitative fluctuations.

With Tab. 3.14 and Fig. 3.27 considerable seasonal deviations of the amount of waste generated in individual settlements can be determined. In addition the amounts of waste generated in different sorting places vary widely. One reason for this is the determination and attribution of the population size at sorting. The number of inhabitants was generalised. In addition, the attribution of these inhabitants to concrete collection containers is a big problem

Waste from households is collected together with waste from businesses. The situation on location is aggravated by the shortage of receptacles. Due to this passers by from other parts of the town, who most likely have no access to waste collection containers of their own, take waste to the few existing waste collection containers (for example: Vanadzor, Sevan and Echmiadzin). In the small town of Talin and the village Mkhchyan, waste was collected from the practically anonymous garbage heaps making an exact attribution to inhabitants impossible.

An additional problem with the extrapolation of amounts of waste generated is the rhythm of waste collection which is not regulated by fixed schedules. Waste not always collected on a fixed schedule, but for example according to requirement (for example, because of complaints and applications of citizens). Additional difficulties for extrapolation were created by the fact that the gathering of waste for the sorting campaigns was from the same street, but from different collection points.

These facts hint at a limited reliability of the data on the amount of waste generated for further planning in spite of the fact that sorting of waste according to groups has been performed very properly.

Due to the above reasons, an exact extrapolation of the generation of waste and recyclable materials for all Armenia was forgone. The procedure for an extrapolation is explained in the following. A rough estimation of the potentials for Armenia based on it is presented in appendix A.9.

An extrapolation should be performed in the following manner. According to the data of [ARMSTAT1], the Republic of Armenia had a population of 3.249.500 total inhabitants in 2010. Of these, 2.081.000 inhabitants (64, 04 %) are urban population and 1.168.500 (35, 96 %) rural population. In the capital, Yerevan, live 1.116.000 inhabitants or 34, 34 % of the overall population of Armenia.

Table 3.14: Waste generation amounts in sorting places of Armenia

	Spring	Summer	Autumn	Winter	Average value
Vanadzor					
Number of inhabitants	1.578	1.590	1.020	1.560	
Waste amount [kg]	2.028,90	1.753,00	1.216,10	1.205,20	
Waste volume-collecting [l]	15.170,00	11.620,00	10.360,00	9.980,00	
Waste volume-sorting [l]	12.998,40	12.786,00	11.070,00	9.450,00	
Waste generation amount [l/(cap/d)]	5,61	13,07	17,09	12,12	**11,97**
Waste generation amount [kg/(cap/d)]	1,02	1,63	1,76	1,63	**1,51**
Sevan					
Number of inhabitants	3.490	3.490	3.190	2.740	
Waste amount [kg]	1.628,20	2.434,00	1.633,00	1.700,00	
Waste volume-collecting [l]	11.100,00	15.006,00	10.450,00	10.450,00	
Waste volume -sorting [l]	9.834,00	15.006,00	8.802,00	10.656,00	
Waste generation amount [l/(cap/d)]	2,82	4,30	2,76	7,78	**4,42**
Waste generation amount [kg/(cap/d)]	0,53	0,70	0,61	1,22	**0,77**
Echmiadzin					
Number of inhabitants	1.500	1.600	1.600	1.500	
Waste amount [kg]	1.273,30	1.993,00	1.984,30	1.147,90	
Waste volume-collecting [l]	9.390,00	10.900,00	10.370,00	8.310,00	
Waste volume-sorting [l]	8.324,40	12.948,00	13.032,00	8.028,00	
Waste generation amount [l/(cap/d)]	11,10	20,27	16,29	10,70	**14,59**
Waste generation amount [kg/(cap/d)]	1,92	2,63	1,97	1,58	**2,03**
Talin					
Number of inhabitants	972	972	1.185	1.185	
Waste amount [kg]	1.858,50	1.722,40	1.635,20	1.408,20	
Waste volume-collecting [l]					
Waste volume-sorting [l]	11.803,20	11.466,00	10.512,00	9.931,20	
Waste generation amount [l/(cap/d)]	4,05	3,93	4,44	4,19	**4,15**
Waste generation amount [kg/(cap/d)]	0,64	0,59	0,69	0,59	**0,63**
Mkhchyan					
Number of inhabitants	1.850	765	220	1.200	
Waste amount [kg]	1.650,60	1.514,50	2.898,10	1.558,90	
Waste volume-collecting [l]					
Waste volume -sorting [l]	8.310,00	5.232,00	8.796,00	7.272,00	
Waste generation amount [l/(cap/d)]	4,49	6,84	39,98	2,02	**13,33**
Waste generation amount [kg/(cap/d)]	0,89	1,98	13,17	0,43	**4,12**

At the example of the city Vanadzor the amount of waste generated in cities in Armenia (more than 100.000 inhabitants) is to be explained. Armenia has 3 cities (Yerevan, Gyumry and Vanadzor) with a total number of 1.417.100 inhabitants or 43, 61 % of the total population. The results of the sorting analyses in Echmiadzin are used as the basis for towns of a size of 50.000 to 100.000 inhabitants. There are only two cities of this size with a total number of 110.700 inhabitants (3, 41 %). The example of Sevan is used for towns with a population of 10.000-50.000 inhabitants (in total 502.400 inhabitants or 15, 46 %). The small city of Talin represents towns with up to 10.000 inhabitants (in total 104.700 inhabitants or 3, 22 %). The village Mkhchyan represents the whole rural population (in total 1.168.500 inhabitants or 35, 96 %).

The outliers of the specific amount in the village Mkhchyan in summer and in particular in autumn (see Tab. 3.22 and a Fig. 3.27) can be explained by a considerable quantity of earth and ash from burned waste (also see Appendix A 5.3 and. 5.4).

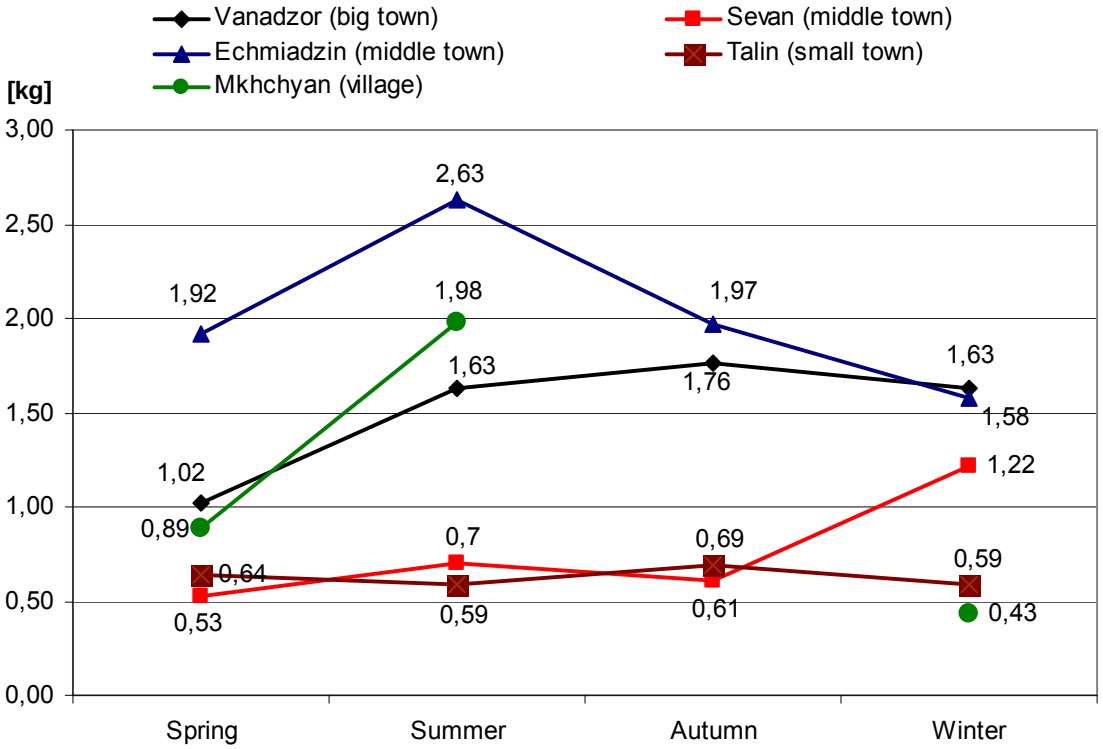


Figure 3.27: Waste generation amounts per capita and day [kg/cap/d)] according to the sorting places and settlement structure

Fig. 3.27 provides an overview of the development of the amounts of waste generated per inhabitant and day for the sorting places and their settlement structure. The curve behaviour shows some unexpected values. For example the amount of waste generated in Sevan is higher in winter than in all other seasons, despite the fact that the high season for tourists is in the summer months. Also noticeable is the large amount of waste generated in the village Mkhchyan in summer. The reason for the value of the waste generation amount being determined to be this high is in the attribution of the registered number of inhabitants and in the irregular of rhythm of waste collection. The amount of waste generated in the small town of Talin remains almost constant without large fluctuations throughout the year.

Tab. 3.15 gives data of the specific parameters of the conducted research: density of waste on the basis of the estimated volumes of waste at collection and of the measured volume of waste after sorting. At the same time the interrelations of these two core parameters were determined.

Table 3.15: Specific parameters: waste density and relation of the waste density at waste collection and after sorting

	Spring	Summer	Autumn	Winter	Average value
Vanadzor					
Waste density collection $\rho_{Sam.}$ [t/m³]	0,13	0,15	0,12	0,12	0,13
Waste density from sorting $\rho_{Sort.}$ [t/m³]	0,16	0,14	0,11	0,13	0,13
Relation $\rho_{Sam.}/\rho_{Sort.}$	0,86	1,10	1,07	0,95	0,99
Relation $\rho_{Sort.}/\rho_{Sam}$	1,17	0,91	0,94	1,06	1,02
Sevan					
Waste density collection $\rho_{Sam.}$ [t/m³]	0,15	0,16	0,16	0,16	0,16
Waste density from sorting $\rho_{Sort.}$ [t/m³]	0,17	0,16	0,19	0,16	0,17
Relation $\rho_{Sam.}/\rho_{Sort.}$	0,89	1,00	0,84	1,02	0,94
Relation $\rho_{Sort.}/\rho_{Sam}$	1,13	1,00	1,19	0,98	1,07
Echmiadzin					
Waste density collection $\rho_{Sam.}$ [t/m³]	0,14	0,18	0,19	0,14	0,16
Waste density from sorting $\rho_{Sort.}$ [t/m³]	0,15	0,15	0,15	0,14	0,15
Relation $\rho_{Sam.}/\rho_{Sort.}$	0,89	1,19	1,26	0,97	1,07
Relation $\rho_{Sort.}/\rho_{Sam}$	1,13	0,84	0,80	1,04	0,95
Talin					
Waste density collection $\rho_{Sam.}$ [t/m³]	Collection of bulk waste				
Waste density from sorting $\rho_{Sort.}$ [t/m³]	0,16	0,15	0,16	0,14	0,15
Relation $\rho_{Sam.}/\rho_{Sort.}$					
Relation $\rho_{Sort.}/\rho_{Sam}$					
Mkhchyan					
Waste density collection $\rho_{Sam.}$ [t/m³]	Collection of bulk waste				
Waste density from sorting $\rho_{Sort.}$ [t/m³]	0,20	0,29	0,33	0,21	0,26
Relation $\rho_{Sam.}/\rho_{Sort.}$					
Relation $\rho_{Sort.}/\rho_{Sam}$					

In Tab. 3.16 it was attempted to calculate the total amount of waste generated, even though the data are not fully reliable. The quantity of the population according to [ARMSTAT1] refers to the year 2010. Amount of waste generated in m^3/a was calculated with the waste density after sorting. At development of the concepts for waste management and calculation of the actual amount of waste generated it is necessary to multiply by the relief factor which is determined from the relationship of the two densities of waste. This influences definition of the necessary number of waste collection containers most of all.

Table 3.16: Waste generation amounts according to settlements

Place:	Number of inhabitants	Waste generation amount [kg/capita/d]	Waste generation amount kg/capita/a]	Waste generation amount [l/capita/d]	Waste generation amount [m^3/capita/a]	Waste generation amount [t/a]	Waste generation amount [m^3/a]
Vanadzor	104.800	1,51	551,15	11,97	4,37	57.760,52	457.972,07
Sevan	23.200	0,77	279,23	4,42	1,61	6.478,02	37.386,22
Echmiadzin	57.500	2,03	739,13	14,59	5,33	42.499,69	306.207,63
Talin	5.700	0,63	229,04	4,15	1,52	1.305,97	8.642,31
Mkhchyan	5.100	4,12	1.502,89	4,12	1,50	7.664,73	7.664,73

Table 3.17: Density of single waste fractions in [t/m^3]

Place and season	**Waste fractions:**										
	Ferrous/ non-ferrous metals	Cardboard/paper/cardboard packaging	Glass	Plastics	Organic materials	Textiles	Inert waste	Leather/ rubber	Other waste	Middle grain	Fine fraction
Vanadzor											
Spring	0,16	0,12	0,42	0,11	0,28	0,14	0,37	0,22	0,22	0,17	0,55
Summer	0,11	0,04	0,41	0,05	0,32	0,11	0,34	0,11	0,12	0,43	0,63
Autumn	0,11	0,03	0,40	0,04	0,35	0,16	0,36	0,13	0,25	0,27	0,89
Winter	0,9	0,03	0,13	0,06	0,21	0,11	0,40	0,11	0,31	0,33	0,63
Average	***0,12***	***0,06***	***0,34***	***0,07***	***0,29***	***0,13***	***0,37***	***0,14***	***0,23***	***0,30***	***0,67***
Sevan											
Spring	0,09	0,05	0,037	0,06	0,34	0,13	0,69	0,10	0,28	0,45	0,72
Summer	0,14	0,05	0,043	0,04	0,37	0,11	0,34	0,14	0,19	0,49	0,85
Autumn	0,10	0,04	0,12	0,08	0,33	0,16	0,67	0,08	0,11	0,36	0,49
Winter	0,09	0,03	0,56	0,05	0,29	0,14	0,46	0,13	0,28	0,49	0,45
Average	***0,10***	***0,04***	***0,37***	***0,05***	***0,33***	***0,14***	***0,54***	***0,11***	***0,22***	***0,41***	***0,63***
Echmiadzin											
Spring	0,08	0,06	0,39	0,06	0,28	0,13	0,64	0,20	0,27	0,38	0,51
Summer	0,12	0,04	0,53	0,05	0,38	0,12	0,47	0,16	0,25	0,55	0,84
Autumn	0,13	0,05	0,55	0,05	0,38	0,05	0,38	016	0,25	0,47	0,71
Winter	0,10	0,02	0,46	0,04	0,25	0,06	0,42	0,15	0,28	0,29	0,41
Average	***0,11***	***0,04***	***0,48***	***0,05***	***0,32***	***0,09***	***0,48***	***0,17***	***0,26***	***0,42***	***0,62***
Talin											
Spring	0,09	0,06	0,25	0,06	0,25	0,14	0,71	0,18	0,37	0,60	0,63
Summer	0,11	0,04	0,33	0,07	0,39	0,10	0,26	0,12	0,22	0,45	0,65
Autumn	0,12	0,05	0,46	0,06	0,39	0,14	0,34	0,14	0,27	0,44	0,71
Winter	0,13	0,05	0,33	0,06	0,33	0,11	0,32	0,13	0,24	0,40	0,61
Average	***0,11***	***0,05***	***0,34***	***0,06***	***0,34***	***0,12***	***0,41***	***0,15***	***0,28***	***0,47***	***0,65***
Mkhchyan											
Spring	0,11	0,06	0,56	0,06	0,32	0,18	0,35	0,17	0,38	0,48	0,46
Summer	0,07	0,03	0,40	0,04	0,17	0,09	0,59	0,11	0,34	0,56	0,75
Autumn	0,14	0,04	0,55	0,05	0,33	0,14	0,35	0,14	0,31	0,71	0,90
Winter	0,12	0,03	0,39	0,04	0,27	0,13	0,38	0,14	0,26	0,41	0,76
Average	***0,11***	***0,04***	***0,47***	***0,05***	***0,27***	***0,13***	***0,42***	***0,14***	***0,32***	***0,54***	***0,72***

Table 3.18: Density of PET and Rest Plastics fraction in [t/m^3]

	Autumn	Winter	*Average*
Vanadzor			
Density-PET bottles	0,037	0,036	***0,036***
Density-Rest Plastics	0,049	0,075	***0,062***
Sevan			
Density-PET bottles	0,033	0,036	***0,035***
Density-Rest Plastics	0,119	0,050	***0,084***
Echmiadzin			
Density-PET bottles	0,032	0,029	***0,030***
Density-Rest Plastics	0,055	0,060	***0,058***
Talin			
Density-PET bottles	0,036	0,031	***0,034***
Density-Rest Plastics	0,070	0,086	***0,078***
Mkhchyan			
Density-PET bottles	0,047	0,024	***0,035***
Density-Rest Plastics	0,058	0,069	***0,064***

3.7 Recommendations of actions for Armenian waste management

3.7.1 State of Armenian waste management in international comparison

An international comparison of the state of development of waste management is sensible to define weaknesses and bottlenecks of waste management in countries with a transition economy and to avoid further bad planning in waste management. As an example for international comparison the pioneering role of Germany in waste management was used. Comparison between Germany and Armenia is performed based on the catalogue of criteria developed in the dissertation of Mr. Jovanovic. The country of Serbia was also researched in the scope of this dissertation and served as country of comparison.

The comparative criteria are subdivided into main criteria and sub criteria of target level 1 and target level 2 (see Tab. 3.19). Process of evaluation is performed in two steps. First, the countries are evaluated directly and quantitatively by points and then by utility analysis.

Reasons for the attribution of points are included in Tab. 3.20. The evaluation was performed by the brainstorming method together by employees of in the logistics department of the Otto-von-Guerike Universität and the Armenian experts in the scope of the intensive course "waste management" in Magdeburg.

During this the employees of OvGU presented each evaluation criterion separately and explained the evaluation at the examples of Germany and Serbia. Then the discussion and determination of the level of fulfilment of the goal for their own country was performed by the Armenian experts. The employees of the OvGU served as moderators during this.

The evaluation criterions were divided under the chapters legal framework, indicators, technical implementation and organisational implementation (target level 0), main objectives (target level 1) and secondary objectives (target level 2).

Table 3.19: Country comparison / Benchmarking: Germany – Serbia – Armenia (Point evaluation) [JOVA]

Scale:	Degree of fulfilment of the criteria				
Verbal scale	not at all	initial	low	advanced	as far as possible
Point scale		•	••	•••	••••

Evaluation criteria							Counrty		
Target level 0		Target level 1		Target level 2		Orientation	Germany	Serbia	Armenia
1.	Legal framework	1.1	Legislative introduction of waste hierarchy	1.1.1	Reduction of waste production	as far as possible	••••	•••	
				1.1.2	Preparation for the reuse	as far as possible	•••	••	
				1.1.3	Material utilisation (recycling) of remaining waste	best possible	•••	••	
				1.1.4	Energy recovery from remaining waste	best possible	••••	••	
				1.1.5	Disposal of remaining waste	environmentally friendly	••••	••	••
		1.2	Juridical implementation	1.2.1	Judiciary implementation	effective	••••	•	•
				1.2.2	Executive implementation	effective	••••	•	•
				1.2.3	Statute rules - development	usage-based	••••	•	•
2.	Indicators	2.1	Characteristics of waste	2.1.1	Waste amount	as far as possible	••	•	
				2.1.2	Separate waste material collection	as far as possible	••••	•	•
				2.1.3	Residual waste	as far as possible	•••	•	
		2.2	Avoiding the negative environmental impacts	2.2.1	via air pathway	as far as possible	••••		
				2.2.2	via water pathway	as far as possible	•••		
				2.2.3	in energy balace - substitution of fossil fuels	as far as possible	•••	•	
3.	Technical implementation	3.1	Effective waste treatment methods	3.1.1	Sorting and treatment process incl. MBT and composting	effective	•••		
				3.1.2	Energy recovery from waste	environmentally friendly	•••	•	
				3.1.3	Thermic waste disposal	environmentally friendly	••••	•	
				3.1.4	Landfilling, dump sites	environmentally friendly	••••	•	
		3.2	Suitable waste disposal logistics systems	3.2.1	Waste container and waste collection systems	effective	••••	••	•
				3.2.2	Equipment for waste collection, handling and transportation	effective	••••	••	•
				3.2.3	Information and communication technology (tour planning and identsystems)	effective, efficient	•••	•	•
4.	Organizational implementation	4.1	Personal qualifications	4.1.1	Education	established, needs based	•••	•	•
				4.1.2	Know how and work experience	widely developed	••••	••	•
		4.2	Development of cooperations	4.2.1	Administration units (purpose associations)	existing, effective	•••	•	•
				4.2.2	Organization for protection of interests	existing, effective	•••	•	•
		4.3	Need development of the markets	4.3.1	Secondary raw materials markets -development	existing, effective	•••	••	•
				4.3.2	Energy markets - development	existing, effective	•••	•	
Σ			Achived score				93	34	14
			Maximum score according to the today's state of the knowledge and technology				108	108	108

Table 3.20: Reasons for evaluation of waste management development level in Armenia [JOVA, p. 78]

Nr.	Evaluation criteria	Points	Reasons	%
1.1.1	Reduction of waste production		Armenian waste legislation does not consider a waste hierarchy in waste management (for example like in the EU). No separation of waste groups in the statistic. No exact definition of the term waste s.	9,31
1.1.2	Preparation for reuse			6,98
1.1.3	Recycling of remaining waste			4,66
1.1.4	Energy recovery from remaining waste			2,33
1.1.5	Disposal of remaining waste	●●	Waste disposal in case of large amounts (towns and cities) is legally regulated, but unfortunately not in an environmentally friendly way	1,23
1.2.1	Legal implementation	●	Criminal law and certified courts are not sufficiently developed for the prosecution of the criminal offences in the environmental area. (no implementation regulations in detail)	3,15
1.2.2	Executive implementation	●	Police and controlling bodies are not specialised enough in questions of the environmental protection (no implementation regulations in detail)	3,15
1.2.3	Statute rules - development	●	No sufficient authority for the development of statute rules at local municipal level (no implementation regulations in detail)	4,20
2.1.1	Waste amount		Strategies and measures do not exist.	1,00
2.1.2	Differentiated material collection	●	Separate collection of metal, paper, PET bottles and glass by waste pickers (unorganised)	6,00
2.1.3	Residual waste		Strategies and measures do not exist.	3,00
2.2.1	via air pathway		Strategies and measures do not exist: CH_4-emissions from dumps, burning dumps, Beginning of landfill gas extraction.	3,50
2.2.2	via water pathway		Strategies and measures do not exist: Leachate from unauthorized dump sites	3,50
2.2.3	In energy balance – substitution of fossil fuels		Strategies and measures do not exist:	3,00
3.1.1	Sorting and treatment process incl. MBT and composting		Facilities do not exist	6,75
3.1.2	Energy recovery from waste		Facilities do not exist	4,50
3.1.3	Thermic waste disposal		Facilities do not exist	2,25
3.1.4	Depositing		Orderly landfills do not exist	1,50
3.2.1	Waste containers and waste collection systems	●	Waste bins without wheels, number of waste bins and area coverage is insufficient	4,00
3.2.2	Collection, handling and transport equipment	●	Waste collection vehicles from Soviet time are out of date, crew of waste collection vehicles is to large (3-4 men), no handling and long distance transport technologies exist	4,00
3.2.3	Information and communications technology (tour planning and identsystems)	●	Only defined waste collecting tours or areas without of tour optimisation Identsystems do not exist	2,00
4.1.1	Training	●	Waste management and environmental protection ate taught at the universities	3,00
4.1.2	Know-how and experience	●	Only in waste collection, lately landfill gas extraction	3,00
4.2.1	Purpose associations - development	●	First initiatives for cooperation exist	2,00
4.2.2	Organizations for protection of interests	●	There are a few organisations (for example CAA), further strengthening required	2,00
4.3.1	Secondary raw material markets - development	●	Market exists only partly for scrap metal and plastics	7,00
4.3.2	Energy market – development		Does not exist	3,00
Achieved score		**14**	total weighting	**100**
Maximum score		**108**		

The result of the comparison shows the big distance in the numbers of points for the condition of development of waste management between Germany on the one hand and Serbia, Armenia on the other hand (see Fig. 3.28).

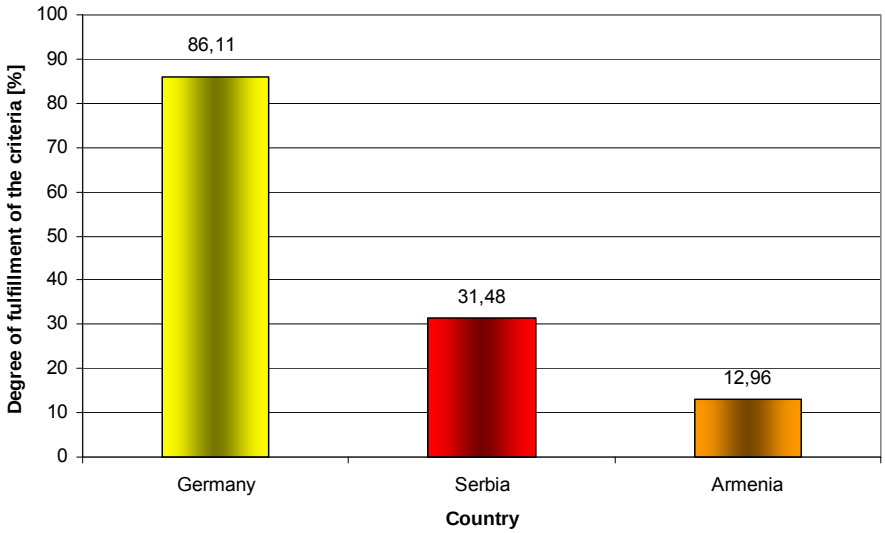


Figure 3.28: Degree of fulfilment of the criteria in [%] according to the today's state of knowledge: Germany - Serbia – Armenia [JOVA]

Serbia reached only 34 points out of the maximum of 108 points. From this comparison it can be determined that Serbia reaches only 31, 48 % of the goals of waste management in comparison with Germany which reaches 86, 11 % according to today's state of knowledge. Armenia is far lower on the evaluation scale with 14 points and 12, 96 % of goals of waste management reached.

The evaluation of the utility analysis and graphic representation of the results allow a look at the separate components of waste management in comparing the countries. In comparison with Germany at 346, 61 utility points only 138, 06 utility points were determined for.

To enable precise analysis of current state of the waste management and to identify the weaknesses a utility analysis was carried out. After weighting of criterion system (100 % are split in the matrix procedure on the criteria) the fulfilment of the secondary objectives is from evaluation by points adopted (maximum 4 points) and with weighting percentages multiplies. The maximum of utility values (points) is 400.

Armenia shows a great distance from both countries with only 45, 95 utility points. The waste management goals at the current state of knowledge are fulfilled at a quota of 86,65% in Germany while in Serbia –a quota of 34, 51 % and Armenia of 11, 48 % were reached. The results of the utility calculation show no big deviations from the results of the quantitative evaluation of points.

From the graphic comparison of utility values of the main criteria and evaluation criteria at level 1 (Fig. 3.29 and 3.30) the great deficits of the Armenian legislation on waste is clearly visible. A hierarchy of waste management and definition of the term waste as in the EU countries are unknown in Armenian legislation. Modernisation of the Armenian legal framework conditions is an important prerequisite for future development of waste management. This tendency of low utility is also shown in the results of the other evaluation criteria.

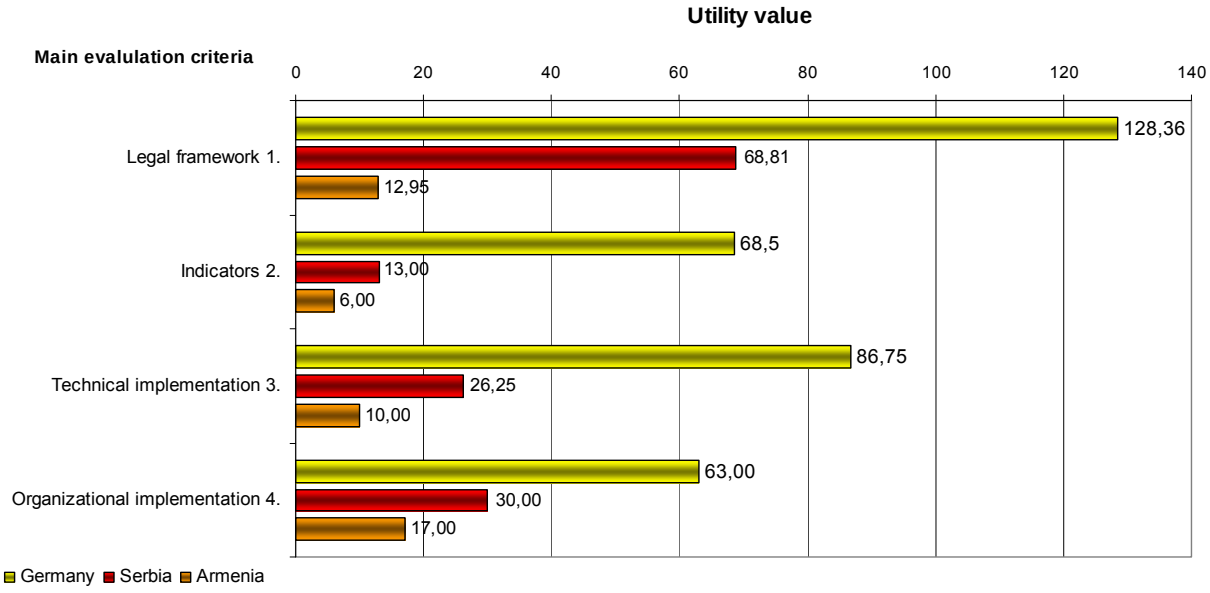


Figure 3.29: Comparison of the main evaluation criteria [JOVA, p. 82]

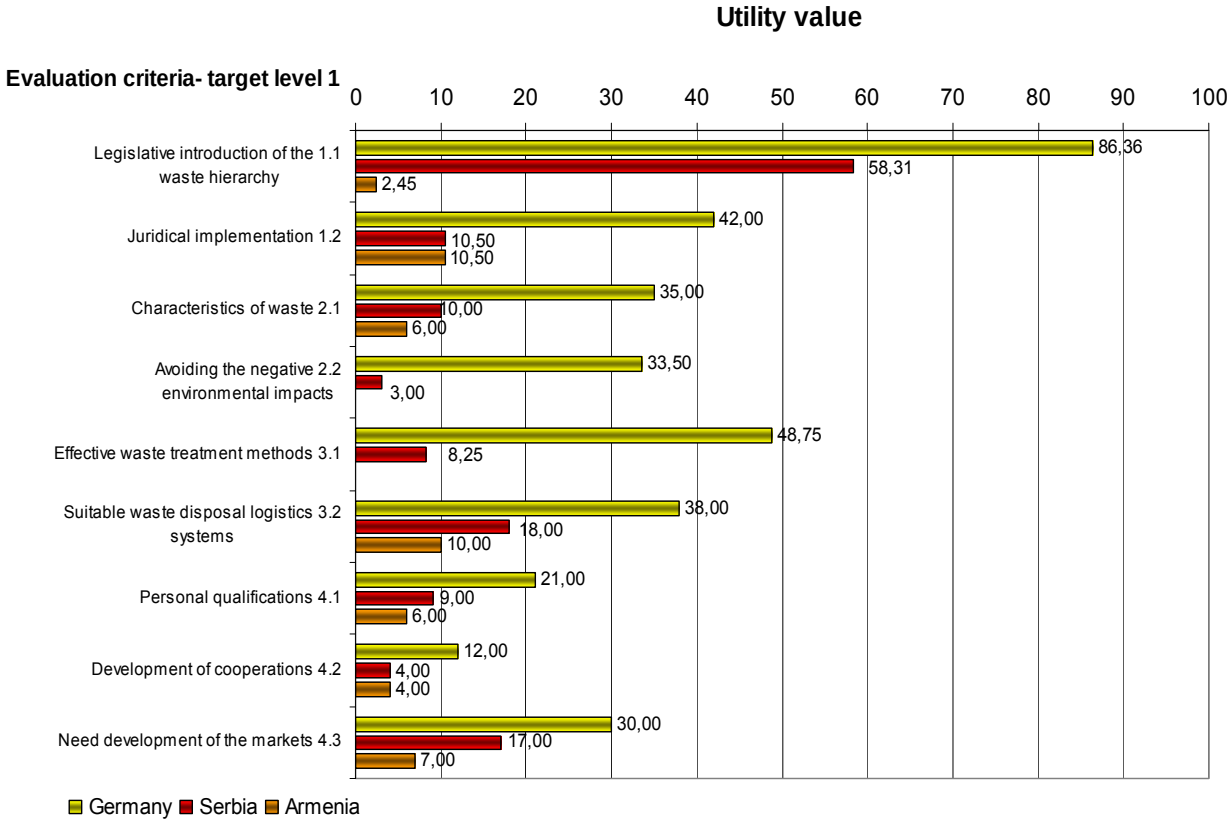


Figure 3.30: Comparison of evaluation criteria– target level 1 [JOVA, p. 83]

The basic problem for the future development of waste management in Armenia is the absence of waste legislation and corresponding legal framework conditions. The Armenian legislation on waste does not know and standards comparable to those of the EU countries. The definitions of the term waste do not conform to EU regulations.

Besides, the legal and executive embodiment as well as sufficient development of the authorisation right are also missing. For development of a modern waste management in Armenia the Armenian legislator should create adequate legal framework conditions. The EU waste framework directive could serve as an example.

The indicators of the state of development of waste management, such as characteristics of waste and the avoidance of negative influences on the environment show the very difficult the situation. Differentiated collection of materials in Armenia exists only in the form of separate collection of metal and scrap metal, paper, PET-bottles, and glass by waste pickers. The negative influences on the environment could be significantly reduced by rationalisation of waste management and construction orderly landfills.

Modern, efficient waste processing processes in the form of preparation, composting, energy recycling and thermal disposal as well as landfilling are completely foreign to the country. Lately garbage gas processing has begun in the landfill Nubareshen in Yerevan thanks to the efforts of the Japanese enterprise "Shimzu.

The technical application of effective processes and appropriate disposal-logistical systems is strongly hindered by a lack of suitable equipment. Containers and collection systems are mostly from the Soviet period and outdated. Almost all waste collection containers are in the form of a metal box without a lid (capacities of 400, 500 and 700 l). The waste is therefore exposed to climatic influences.

In most towns, there is major lack of containers. Possibilities for improvement are primarily in the organisation of waste collection covering the whole area with differentiated collection of materials and equipment of the collection sites with a sufficient number of containers for all citizens with access to waste collection.

The organizational performance the waste management should be better supported by the qualification of personnel (training), development of cooperation of municipalities, and development of secondary raw material and power markets.

Due to the comparison between the countries concrete starting points for the further development processes of waste management in Armenia could be defined. The purpose should be not only to follow and complete all stages of development one after another, but to shorten them as well as possible based on the comparison of countries on the way to an organised waste management respectively to partially perform them in parallel where possible. [JOVA, S. 87 ff].

3.7.2 Activity recommendations at the example of the small town of Talin

From Fig. 3.31 and 3.32 it can be derived that the most important waste groups are organic substances, plastics, cardboard/paper/cardboard packaging, and ferrous/nonferrous metals. There is already a market for these materials in Armenia. Therefore, possible revenues from the recyclable proportion of these groups are checked.

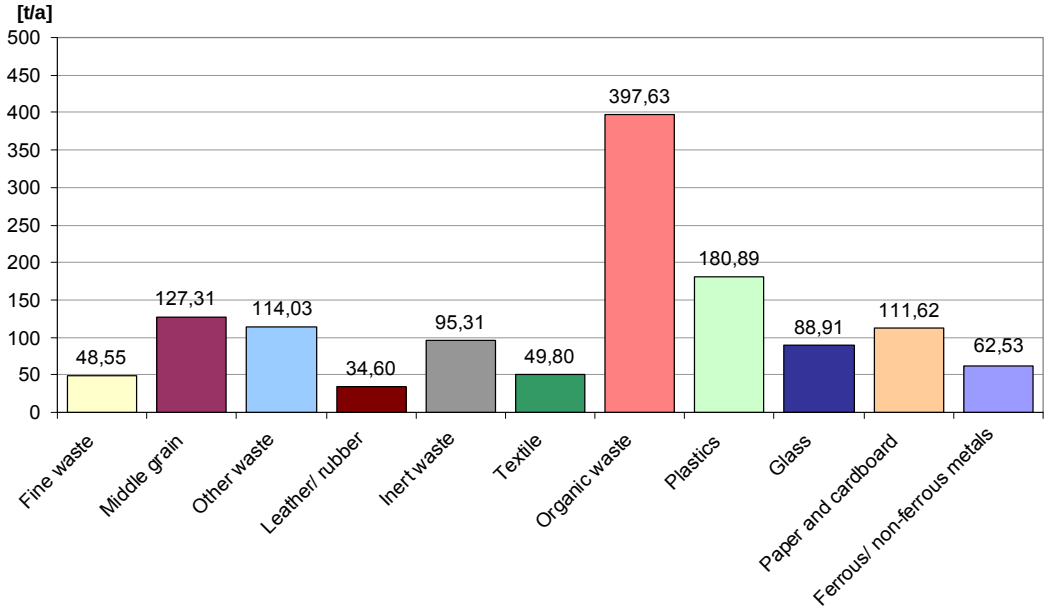


Figure 3.31: Annual waste generation amounts of particular waste groups in the town Talin [t/a]

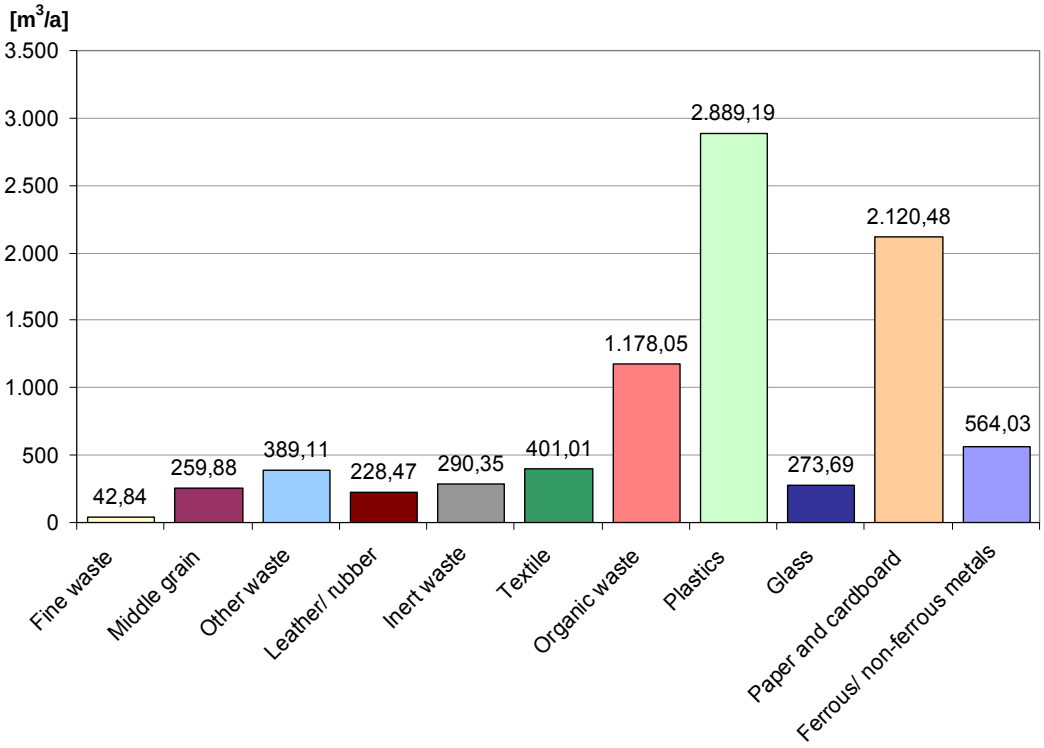


Figure 3.32: Annual waste generation amounts of particular waste groups in the town Talin [m³/a]

To derive the recommendations for measures of waste management in the small town Talin, three possible scenarios of introduction of ordered gathering and systematic collection were formed:

Scenario 1: introduction of only one container for residual waste (grey container)

Scenario 2: introduction of the container for residual waste (grey container) and the container for recyclable waste (yellow container)

Scenario 3: introduction of the container for residual waste (grey container), the container for recycling (yellow container) and the bio-container (brown container)

The waste management measures primarily refer to the determination of the required quantities of containers, waste collection vehicles and personnel for waste collection. Besides the most suitable type of large waste container (MBG) and the collection system (Hol - or Bring - system) for each group of waste will be analysed and suitable waste collection rhythms recommended to safe logistics expenses where possible. As the basic parameter to perform the logistic design of the waste collection processes and determine the necessary technical equipment (collection vehicles, MGB) the waste density at the collection point and after compression in the collection vehicle are determined as well.

Here it is necessary to emphasise that the starting values from the sorting analyses must be critically questioned and definitely require validation via further sorting analyses with orderly waste collection. Therefore, a modellised check of the procedure in a limited intake area - as suggested for Talin here - is recommended. The theoretical calculations performed in the following can give a starting point for planning and can be as a recipe for optimisation with corrected initial data.

Waste density in waste the collection vehicle

The density of waste in the collection vehicle can be defined at the example of the city Vanadzor from the first sorting (spring). During waste collection the collection vehicle was filled completely. It has a loading capacity of 7 m^3. For the first analysis of waste composition a total of 12, 99 m^3 of waste was collected. The waste was condensed from 156, 08 kg/m^3 in the collection containers to 289, 84 kg/m^3 in the collection vehicles. This way condensing by 185, 69 % was achieved.

3.7.2.1 Scenario 1: Implementation of only one residual waste bin (gray bin)

The purpose of the introduction of only one residual waste bin is to create an orderly waste disposal and dust free collection of waste. In this scenario all waste generated is considered residual waste. Tab. 3.21 provides an overview of all three scenarios. According to Mister Gabriel Avetisjana (the vice-mayor of the town Talin) 3.902 inhabitants (68 %) live in single-family houses and 1.800 (32 %) inhabitants in apartment houses. For apartment houses the 1,1 m^3 containers should be suggested and for households in single-family houses MGBs with a capacity of 120 l or 240 l.

Table 3.21: Scenarios of introduction of a orderly waste collection and systematic removal

	Number of inhabitants	Waste amount - unit generation rate [m^3]	Residual waste[m^3]	Bio-waste [m^3]	Dray recycling bin [m^3] Plastics+Paper and cardboard+Ferreous/non-ferreous metals	Number of container (pre collection facilities)						Number of waste collection vehicles	Necessary staff (crew)
						Residual waste			Bio-waste		Recycling bin		
						1.100 l	240 l (once in 14 days)	120 l (once weekly)	1.100 l	240 l	1.100 l		
Scenario 1: only residual waste (100%) – gray bin													
Single houses	3902	5910,55	5910,6	-	-	-	950	950	-	-	-	1	1+2
Apartment buildings	1800	2726,55	2726,6	-	-	48	-	-	-	-	-		
Scenario 2: dray recycling bin (collection rate 60 %)													
Single houses	3902	5910,55	3486,5	-	2424,09	-	870	870	-	-	42	1	1+2
Apartment buildings	1800	2726,55	1608,3	-	1118,24	29	-	-	-	-	20		
Scenario 3: bio-waste bin + dray recycling bin (collection rate 60 %)													
Single houses	3902	5910,55	3012,6	473,9	2424,1	25	870	870			42	1	1+2
Apartment buildings	1800	2726,55	118,24	218,61	1118,2						20		

The inhabitants of the single-family houses produce a predicted yearly waste generation amount of 5.910 m^3 of waste and the inhabitants of apartment houses 2.727 m^3. To collect these amounts of waste based on a weekly waste collection rhythm, 48 containers with capacity of 1, 1 m^3 are required for apartment houses and 870 containers with a volume of 120 l or 240 l for single-family houses are necessary. It is estimated that a family has an average of 4,5 members (that's about 870 households), that means it is necessary to distribute 870 waste collection containers of the sizes 120 or 240l to the households in single-family houses so that each household can use its own collection container.

According to own calculations theoretically about 950 of the size 240 l are required for a collection rhythm of every 14 days, or about 950 containers of 120 l for a weekly collection rhythm to collect the total amount of waste generated. Some households produce more waste and therefore more available container capacity should be provided. Here further planning and optimisation on site are required such as for example the combination of two of the named container types when distributing them to the population and the determination of fixed time rhythms of waste collection.

According to calculation it results that at weekly waste collection and 5 day work per weeks a waste volume of 33,21 m^3 per day must be collected. Inside the collection the waste is condensed from 157, 46 kg/ m to 289, 84 kg/m^3 (condensing by 1, 84 times). This condensing refers to the current state where the waste collection is performed with the collection vehicles of Russian production.

With the introduction of modern vehicles, which is already planned in Talin, the density of waste in the collection vehicle is increased from 300 kg/m^3 to 550 kg/m^3 [BRUNNER]. The volume of 33, 21 m^3 is currently (Russian vehicles) reduced to 18, 04 m^3 in the collection vehicle. This is the capacity of one collection vehicle with a volume capacity of 10 m^3 for 2 tours per shift and day. The required personnel for this consists of 1 driver and 2 waste loaders.

3.7.2.2 Scenario 2: Introduction of residual waste bin (gray bin) and recycling bin (yellow bin)

In the second scenario simultaneously to the introduction of orderly disposal of residual waste separate collection of recyclable materials is considered. The introduction of a dry container for recyclable waste is suggested for this in which the groups plastic, glass, cardboard/paper/cardboard packaging, and ferrous/nonferrous metals are collected together. Afterwards these groups have to be separated and marketed. It is assumed that a collection quota of 60% for the recyclable materials is reachable. For the principle dry recyclable materials container the introduction of a combined Hol-/Bring-system with 1,1 m^3 containers is the favourite. Here several lots are attributed to one collection point. This solution appears sensible as it will save costs for acquisition of depositing containers and the corresponding collection vehicles with a loading crane. The collection of residual waste is carried out as in scenario 1 by means of containers with a volume of 1, 1 m^3 for apartment houses and containers of 240 l – or 120 l – for single family houses.

The recycling potential of the estimated amount of 60 % of the total amount of recyclable waste generated which can be siphoned off amounts to 3.542 m^3/a. Of this, 2.424 m^3/a comes from single-family houses and 1.118 m^3/a from apartment houses. This reduces the residual waste from 8.637 m^3/a by about 41 % to 5.095 m^3/a.

Tab. 3.22 visualises the amounts of individual groups of waste generated, and, in accordance with Tab. 3.3, possible revenues according to the current state. In this the expenses for collection and separation of the recyclable materials are not considered. With introduction of orderly collection of recyclable materials a better quality of recyclable waste and higher prices on the market can also be achieved. This assumption needs to be verified on location.

Table 3.22: Recycling potential in Talin

Recyclable material	Amount of waste generated [kg/a]	Price of recyclable material [AMD/kg]	Revenues [AMD]	Revenues [Euro]
Ferrous/ non-ferrous metals	37.516,4			
Cardboard/Paper/cardboard packaging	66.969,0	20 – 30	1.339.380,0 – 2.009.070,0	2.550,26 – 3.825,39
Glass	53.347,2			
Plastics	108.535,0	75 – 100	8.140.125,0 – 10.853.500,0	15.499,3 – 20.665,7

Exchange rate on 3/23/2011: OANDA http://www.oanda.com/lang/de/currency/converter/;

60% of the potential of recyclable material can be collected

According to the performed theoretical calculation 42 containers of a volume of 1, 1 m^3 for single-family homes and 20 containers for apartment houses (in total 62 containers) are required to collect recyclable materials at a weekly collection rhythm. Besides this the required quantity of containers of a volume of 1, 1 m^3 for residual waste in apartment houses is then 29 (weekly collection rhythm). For the collection of residual waste in single-family houses 870 waste containers with a capacity of 120 l are required at a weekly collection rhythm, or 870 waste containers with a capacity of 240 l at a collection rhythm of every 14 days. With both types of containers and the mentioned collection rhythms about 45 % of the capacity of the containers remains

unused. As each household should have its own waste container, it would be mathematically possible to empty the 120 l with a collection rhythm of every 11 days. Here the 14-day collection is recommendable, which should be optimised further based on initial experiences.

The volumes of 19, 6 m^3 of residual waste and for 13, 62 m^3 of recyclable materials are to be gathered per day. At a 5-day working week one collection vehicle with a capacity of 10 m^3 can perform this at 2 trips per shift and day (theoretically one tour for residual waste and one for recyclable materials). The required personnel for collection consists of 1 driver and 2 waste loaders.

3.7.2.3 Scenario 3: Introduction of residual waste bin (gray bin), recycling bin (yellow bin) and bio-waste bin (brown bin)

The scenario 3 represents an addition to scenario 2. Parallel to the introduction of the dry container for recyclable materials for the groups plastics, glass, cardboard/ paper/cardboard packaging and ferrous/nonferrous metals, bio-containers (brown container) for organic waste are also considered. Here as well a collection quota of 60 % each for recyclable materials and organic materials is assumed. As Armenia is a mountainous country, organic waste could be well used in the form of compost for improvement of soil quality. For the dry recyclable materials container as well as the bio container a combined Hol-/Bring-system based on containers with a capacity of 1, 1 m^3 each is considered. The 1, 1 m^3-MGB for recyclable materials and organic waste can be offered together in islets for waste to which several households are connected. This system for organic waste appears sensible for Armenian conditions because it generates fewer costs for the purchase of the containers and container management. The collection of residual waste is performed, as described in scenario 1 and 2 with 1,1 m^3 containers for apartment houses and 240 l or 120 l waste containers for single-family houses.

The potential of recyclable materials at the amount of 60% of the total amount of recyclable material generated, and remains unchanged as in scenario 2 and amounts to a predicted 3 542 m^3/a. Of this, 2,424 m^3/a comes from single-family houses and 1,118 m^3/a m3 from apartment houses. The expected volumes of organic waste generated also at an expected value of 60 % of the total amount of organic waste generated amount to 707 m^3/a. These two separately collected groups reduce the amount of residual waste from 8,637 m^3/a by about 49%, to 4,402 m^3/a and would significantly relieve landfills and decrease biological activity in landfills.

The required quantity of containers for gathering of recyclable waste remains the same as presented in scenario 2. For single-family houses 42 containers of the size 1, 1 m^3 are required and for apartment houses require 20 containers at a weekly collection rhythm, to collect the recyclable materials, that means 62 containers are required for the whole town. Besides them, 13 additional 1, 1 m^3 containers need to be positioned at suitable points to provide access to the containers for all citizens. Alternatively it is recommended to collect organic wasted at the same locations as recyclable materials. For this the 62 recyclable materials islets have to be equipped with one 240 l container each which offer about 774 m^3/a capacity (10% reserve).

The collection of residual waste in apartment houses requires 25 1, 1 m^3 containers at a weekly collection rhythm. For the collection of residual waste, according to the quantity of houses (single-family homes), 870 containers of the size 120 l are required at a weekly collection rhythm or 870 containers of the size 240 l at a collection rhythm of every 14-days. This solution is however not ideal because a

volume of1,026 m^3 or about 23 % of the waste containers remains empty and is not fully used. Therefore, it is necessary to optimise the collection rhythm. Purely theoretically, it would be sensible to empty the 120 l containers for residual waste at collection intervals of every 13- days. Here the first practical results will have to be evaluated.

To guarantee reliability of the system, it is necessary to collect volumes of 17 m^3 of residual waste, 2, 66 m^3 of organic waste, and 13, 62 m^3 recyclable materials per day. In a 5-day working week, a collection vehicle with a capacity of 10 m^3 manages this volume in 2 tours per shift and day. The necessary collection personnel consists of one driver and 2 waste loaders.

3.7.3 General recommendations for Armenia

All recommendations are based upon the results of the analyses of waste sorting conducted in the five places and in four seasons. For this reason our main findings will be summarized by way of introduction.

The specific amounts of documented household waste generated (and the included documented commercial waste) ranges with its averaged values from the 4 campaigns between 229 kg/(E*a) for Talin and 1504 kg/(E*a) for Mkhchyan. If one standardises the outlier value of the autumn campaign in Mkhchyan to the average value of spring, summer and winter, the value relativises to 401 kg/(E*a) and Echmiadzin shows the highest specific amount at 741 kg/(E*a). As the average of all examined settlements an amount of 661 resp. 493 kg/(E*a) if one standardises the value of Mkhchyan results.

The amount of waste generated is shown as minimum, average and maximum value of the examined towns, averaged through all campaigns and in comparison with the town of Talin in Fig. 3.33.

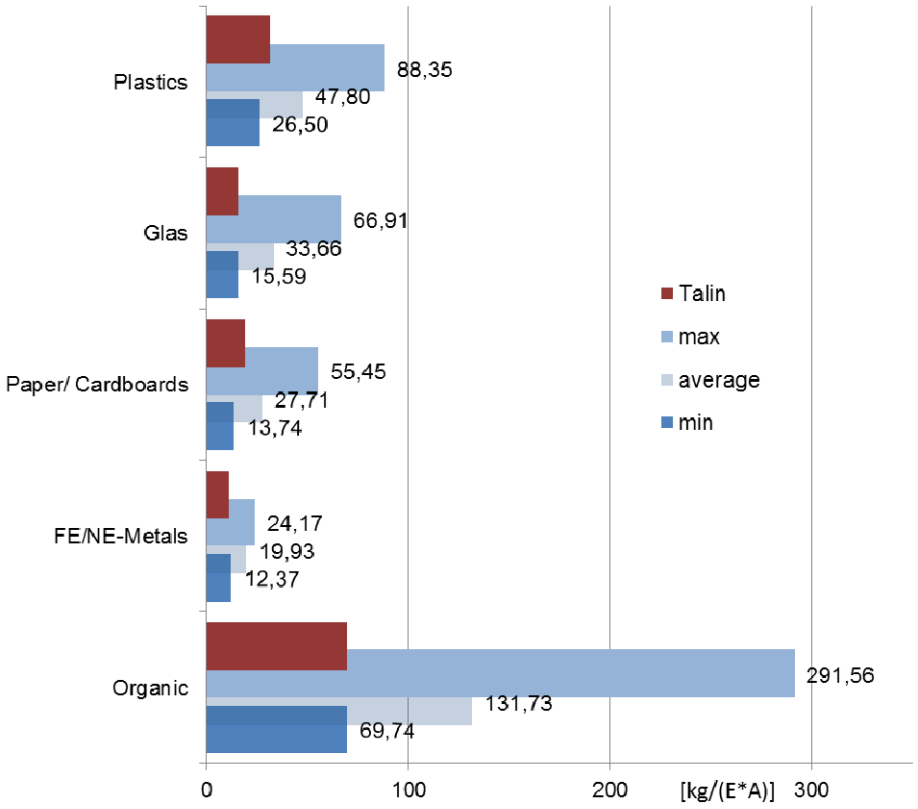


Figure 3.33: Specific amount of waste generation as maximum, minimum and average value, for comparison the values of the town of Talin [kg/(E*a)]

The strong fluctuations in the amounts of recyclable materials and other groups in different towns (see Fig. 3.33) and during different seasons (see appendix A.7) can be explained not only by different behaviour patterns of the citizens in different settlement structures, but also show the considerable influence of the share of commercial waste (market of Vanadzor, greenhouses in Mkchyan) as well as the uncertainties of a systemless and in part entirely containerless collection (impossibility of allocation to waste producers, weather influences affect material properties) and irregular collection rhythms.

3.7.3.1 Legal framework conditions

The primary main goal for modernising Armenia's waste management should be the establishment of waste law framework conditions.

Here the European environmental and waste management legalisation can supply aid and ideas. The national laws of Armenia should however consider the regional, sociological and economical conditions of the country. From the experience gained via the project three main focus points can be derived:

1. The introduction of a hierarchic handling of waste (avoiding *before* recycling *before* disposing) to reduce the amount of waste and to lead towards a recycling industry and away from deposit (landfills) in terms of material flow. The governance (state ministries and also municipal administrations) should encourage the implementation of this hierarchy by statutory regulations. This can be achieved by commands and prohibitions as well as by constraints, taxes and subsidies.
2. In addition to this hierarchy a waste management act must on the governmental level provide a precise definition of waste that can differentiate various kinds of waste according to their origin (and responsibilities) and depending on the characteristics of the waste (risk potential, treatment of waste, intrinsic value). An undifferentiated classification of all sorts of waste (as used in Fig. 3.5 to 3.9) is not suitable for waste management planning that goes beyond mere landfilling.
3. With the help of a federalistic organisational principle a part of the responsibility for household waste can be transferred to local governments. The refinancing of costs should be regulated by those administrations with the help of waste/waste fee schedules. Interest groups (like the community of municipalities of Armenia) can assist by the preparation of constitution-templates.

Legal frameworks should ensure the feasibility and the realisability (efficiency) of the political aims of an eco-friendly(er) waste management policy. For an efficient implementation of operative services (collection, sorting, and marketing of recycled products) private service providers can be commissioned as is already a standard praxis in Armenia.

3.7.3.2 Waste capture and collection

Even if all waste can be disposed, the present way of capturing and collecting waste does not represent an approach at orderly waste management. Apart from very few exceptions for Eriwan and other larger cities, there are no container systems and the waste is stored loosely along roadsides. Statistics of rural areas indicate that there waste is often not even carried to (half-way) orderly landfills or dumps, but rather burned or dumped arbitrarily at the roadside.

For the capturing of recyclable material and the associated relief of landfills a container system with covers (lid) is necessary, if only to guarantee the highest possible quality of the recyclable material. For the citizen the use of system containers for residual waste and recyclable material will improve the hygienic conditions and raise interest in responsible handling of waste. The container systems are the basis of orderly waste management which also avoids daily drives to the collection points and an efficient organisation of route planning, deployment of personnel and equipment.

In [FICHTNER2] modern collection systems were compared economically with the present Russian-Ukrainian system (existing) of the city of Eriwan. Considering the costs of containers, vehicles and staff, there are similar specific collecting costs when using modern technology more efficiently (Fig. 3.34)

Figure 3.34: Comparison of specific collection costs of different collecting systems by [FICHTNER2]

3.7.3.3 Waste pre-treatment

When sorting waste/recyclable material one can begin with a relatively simple standard of pre-treatment (manual sorting and if necessary further processing by filtering, shredding, parting and baling of metals). Unfortunately the expenses of pre-treatment do correspond with the revenue achievable of the market (purity level). Separated capturing of recyclable material in the recommended dry recyclable materials container will already considerably increase the quality of the present standard. To what extent of waste capture it will be possible to have access to the potential of recyclable material that has been determined by the sorting analyses is difficult to estimate and depends largely on effective public representation and reward systems. The calculations for the town of Talin are based on an assumed level of 60 % of waste capture.

Organic waste (organics) can be kept within the economic cycle through composting for soil improvement and subtracted from landfill.

Residual waste can optionally be led through a mechanical-biological treatment during which high-caloric materials can function as a substitute fuel in the cement industry and low-caloric materials offers only substances of low reactivity for the landfill.

The last two procedures of pre-treatment mentioned above can be gradually or optionally and after having examined the progress that has previously been made implemented.

The method of thermic waste pre-treatment is not considered to be a recommendable solution for Armenia in the short and medium term for financial reasons.

3.7.3.4 Orderly Landfilling

In the first step existing landfills should be improved by truck scales, compactors and landfill gas extraction. To reduce biological activity of wastes to be deposited and methane emissions, it is recommended for Armenia to in the first step test simple and inexpensive procedures such as a landfill with the flue draught method of Spillmann/Collins [BILIT].

In a step-by-step approach rural areas too should be connected to orderly waste collection and waste disposal. Despite the fact that through the proposed waste pre-treatment amounts of waste are subtracted from landfilling, it must be tested whether available capacities of landfill areas are sufficient in the medium- and long-term. Possibly, for example, in case geological and hydrogeological requirements are not fulfilled, insufficient landfill locations my have to be replaced by new sanitary landfills.

High-quality facilities often require minimum capacities to work efficiently. Therefore the installation of capacities for waste treatment (pre-treatment and landfilling) requires preliminary regional planning. Responsibilities e.g. in the Marzes are to be legally regulated.

From the presently operated landfills vast effects for environmental conditions can exist due to insufficient sealing measures. For the protection of the environment it must be checked which old landfills should be included in a remediation program and at what priority.

3.7.3.5 Economical considerations

Even if revenues are to be expected from marketing of recyclable material, they cannot cover all the costs residual waste collection and disposal as well (cross-subsidisation). An orderly waste management that starts with collecting must still be financed by the producer of waste (citizen). This can be realised indirectly via taxes. Direct waste collection fees - charged based on producer and performance - can however also serve as stimulation people to separate waste.

The costs of a modernised waste management

At the example of the town of Talin an economic consideration of different scenarios with different grades of waste pre-treatment is to be demonstrated.

Scenario 1 is considered a comparison option without separate collection of recyclable material but with modernised landfilling.

Scenario 2 captures the recyclable materials as shown in Fig. 3.21 metals, waste paper, plastics and additionally waste glass which are sorted in a mechanical treatment facility and prepared for recycling. As a variation in 2a no and in 2b one additional mechanical-biological pre-treatment for remaining residual waste is calculated. The pre-treatment aims to extract high-caloric material as a substitute fuel (we do not assume that revenues are achievable here) and to reduce the biological activity of low-caloric material for landfilling. Primarily by drying processes the weight of the waste is simultaneously reduced so that only approx. 35 % of the facility input finally reaches the landfill.

Scenario 3 captures organic waste (organics) that is composted in addition to the recyclable material of scenario 2. Here as well two sub-variations with and without mechanical-biological pre-treatment are considered.

All of the described scenarios that are used as starting points for economical considerations are compared in Fig. 3.35.

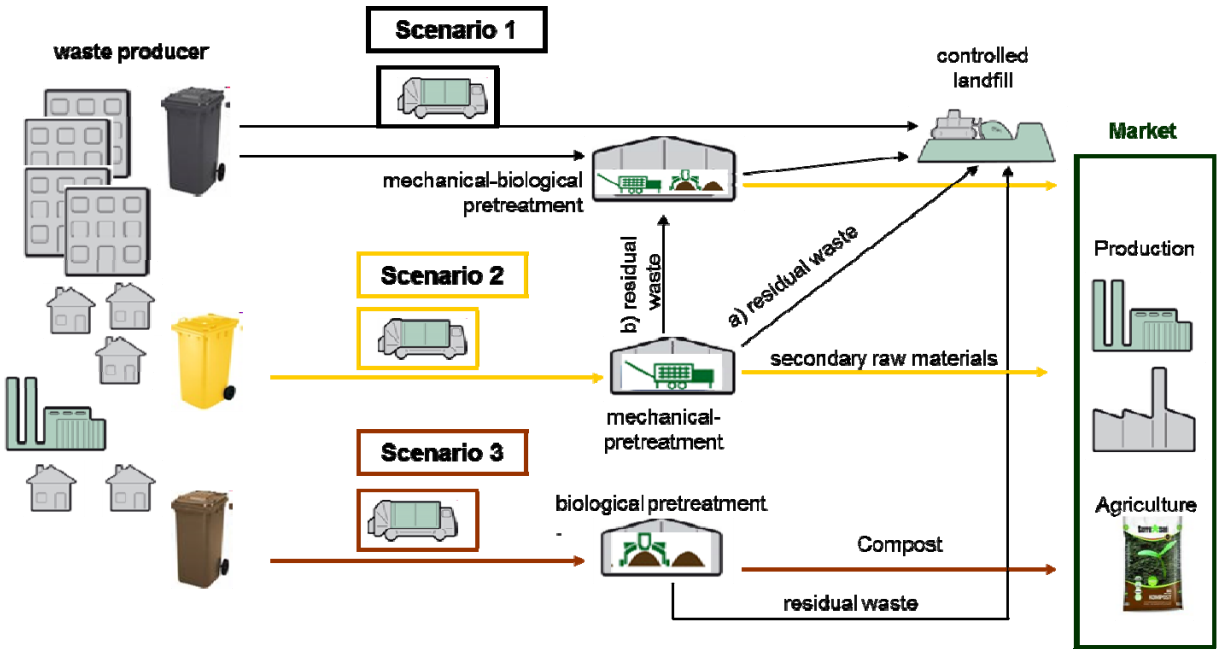


Figure 3.35: Scenarios of waste capture and pre-treatment for economical comparison

Specific arrangements of a separated waste capture for different scenarios have already been examined in chapter 3.7.2. In the following those values are illustrated by economical identification numbers.

For this the cost rates that have been defined in [FICHNTER2] for Yerevan are used. They can provide a first orientation and should be checked in the scope of a pilot project / a test region for other non-city settlement structures (also see chapter 3.7.3.6). From the cost ranges mentioned in [FICHTNER2] one cost range was chosen in Table 3.23 and converted to Euro.

Table 3.23: Costs according to [FICHTNER2] and specification of cost rates for sample calculation

term	cost range [AMD/t]	selected cost rate [€/t]
collection	10.500 to 11.000	20,00
mechanical pre-treatment	12.000 to 15.000	25,00
biological pre-treatment	18.000 to 20.000	35,00
mechanical-biological pre-treatment *	30.000 to 40.000	65,00
(orderly) landfilling	12.000 to 15.000	25,00

Rate of exchange of 23.03.2011: OANDA http://www.oanda.com/lang/de/currency/converter/;
* costs of the mechanical-biological pre-treatment including clean-up costs of the low-caloric group of the landfill

There will be only minor differences of collection costs between the scenarios because the total amount of waste to be collected does not change. Additional costs may be caused by new investments of recyclable materials containers or more expensive routes that must be driven. Even though additional use of containers for recyclable material and organic waste reduces the required number of containers for residual waste, these costs will be calculated in Table 3.24 and also to some extent taken into account in Table 3.25.

Table 3.24: Container costs of the waste collection

recyclable material	waste amount Talin [t/a]	average density [t/m³]	waste amount Talin [m³/a]	number of containers [#]		costs [€/a] ***
				1,1 m³	0,24 m³	
FE/NE-metals	38	0,11	345	70*		2.240
cardboard/paper / cardboard packaging	70	0,05	1.400			
glass	53	0,34	156			
plastics	108	0,06	1.800			
organics	228	0,34	671		70**	784

60 % of the potential of recyclable material can be captured

* because unlike in Fig. 3.21 glass is also captured here so that exactly 65 containers are necessary

** an organic waste container is added next to every recycling container, approx. 30 % reserve of capacity

*** assumptions: 200 € per 1,1 m³ container and 70 € per 240-l-bin, 10 years depreciation, 8 % interest, 2% for investment costs for maintenance

Table 3.25: Costs of waste management exemplified by the town of Talin considering different scenarios

scenario			1	2a	2b	3a	3b
		unit	residual waste container (3.7.2.1)	residual and dry waste container (3.7.2.2)		residual, dry and organic waste container (3.7.2.3)	
sub-variations				with mbp	without mbp	without mbp	with mbp
amounts	residual waste	t/a	1.311	1.042		814	
	recyclable material		-	269		269	
	organics		-	-		228	
costs	collection*	€/a	26.220	28.460		29.244	
	mechanical pre-treatment		0	6.725		6.725	
	biological pre-treatment		0	0		7.980	
	mechanical-biological pre-treatment ** (mbV)		0	0	67.730	0	52.910
	(ordered) landfilling		32.775	26.050	0	20.350	0
	total		58.995	61.235	102.915	64.299	96.859

Cost rates from Fig. 3.23 [FICHTNER2]; 60 % of the potential of recyclable material can be captured,

* for scenario 2 and 3 additional container costs have been taken into account according to Fig. 3.24

**costs of the mechanical-biological pre-treatment (mbp) including disposal costs of he low-caloric fraction of the landfill

An additionally limiting factor for the development of waste management in Armenia are the comparatively high acquisition costs for large waste containers (MGB) and other technical equipment. According to our own request a 240-l-bin has a price of

approx. 200 US $ in Armenia (which is almost 6 times the German price). These prices are caused by high transport costs and import duty.

Therefore it would be sensible to check and create possibilities for producing large waste containers in the country and. This way new jobs can be created in the country as well.

As he separate collection of recyclable material with mechanical pre-treatment (here the processing of separately collected recyclable material) shows similar cost rates in comparison to orderly landfilling scenario 1 and scenario 2a show only minor differences in costs while the regained recyclable material (269 t/a of waste which is subtracted from the landfill) of scenario 2a produce some additional revenue.

The separate collection of organic waste again reduces the amount of waste that needs to be landfilled by 228 t/a. From an economic point of view higher collecting and treatment costs that are assumed higher than the costs of landfilling only make this option a sensible choice if revenues could be generated from composting.

A mechanical-biological pre-treatment of residual waste is ecologically sensible and as an alternative to thermal waste treatment under certain conditions cheaper. Like residual waste incineration this method is only considered suitable Armenia in the medium to long-term run however.

Revenues from recyclable material

The prices that were calculated according to information of USAID in table 3.3 represent acquisition costs of the named companies and must be verified critically. Up to now recyclable material is picked up by waste pickers from deposited waste and is regularly very dirty. At better quality of recyclable material and self-marketing by municipal collecting and sorting companies the revenue situation shows a better outline than it is assumed in Table 3.22 and can finance investments in waste management measures.

In table 3.26 the values of Table 3.22 (average values) are compared with costs of recyclable material on the German market although there have been wide fluctuations and turbulences after the financial crisis of 2009 here as well. The assumptions of Table 3.26 were calculated from the prices that are mentioned in [GIB]. They can serve for orientation or can be updated with newer market prices. It should be noted that the given values are acquisition costs of the processing industry and require pre-treatment (such as baling, shredding or granulating)

Table 3.26: Revenues from sales of recyclable material at the example of the town of Talin

recyclable material		after [USAID]		after [GIS]	
	Waste amount Talin [t/a]	costs of recyclable material [€/t]	revenues [€/a]	costs of recyclable material [€/t]*	revenues [€/a]
FE/NE-metals	38	120	4.560	200	7.600
cardboard/paper/cardboard packaging	70	50	3.500	100	7.000
glass	53		no data	25	1.325
plastics	108	175	18.900	200	21.600
		Total:	26.960	Total:	37.525

* data based on the price level of 2008; 60 % of the potential of recyclable material can be captured

In Germany the capture of organic waste has to be considered rather critically from the point of view of revenues. The revenues of composting (quality-dependently) do not cover the costs of handling. In case of rising energy prices, the fermentation of organic waste possibly in addition to other biomasses may have a chance in future. Organic waste is not considered in terms of costs any further here.

For transfer of the costs and revenues to all five examined regions scenario 2a which shows the lowest costs compared to a good revenue situation will be used.

Calculation of waste collection fees

In [FICHTNER2], p. 17 average fees of 137,5 AMD per inhabitant and month were calculated for Yerevan in the year 2008. The Fichtner study calculates a fee of 320 to 480 AMD per citizen and month and a fee of 15.500 to 22.400 AMD per bin for companies that are necessary in the scope of a reform of tariffs for financing of a modern waste management.

Following the approach that was used for the town of Talin Fig. 3.35 shows the costs (scenario 2a) and revenues for the other regions based on the specific composition of waste in the region. The calculation approach as well as the interim results can be taken from attachment A.8. The estimation results in fees in the range between approx. 230 to 920 AMD per citizen and month for households and 10.700 to 18.350 AMD per bin for companies. This corresponds to costs of 0,42 to 1,71 Euros per citizen and month for households and 20 to 34 Euros per bin for companies when converted to Euros.

The broad spread of fees reflects the uncertainty of the data that has already been indicated several times.

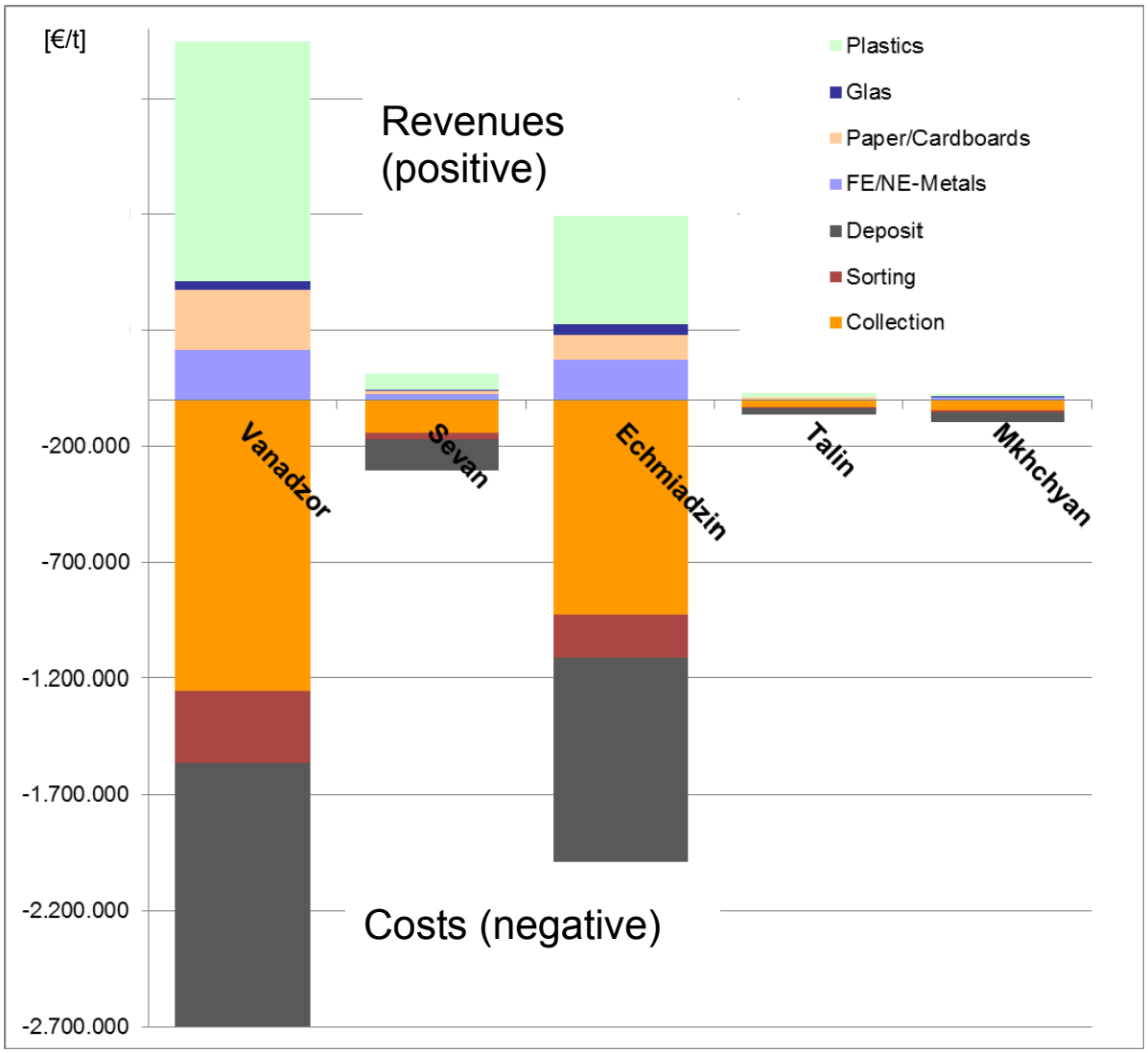


Figure 3.36: Estimation of costs and revenues of a modernised Armenian waste management

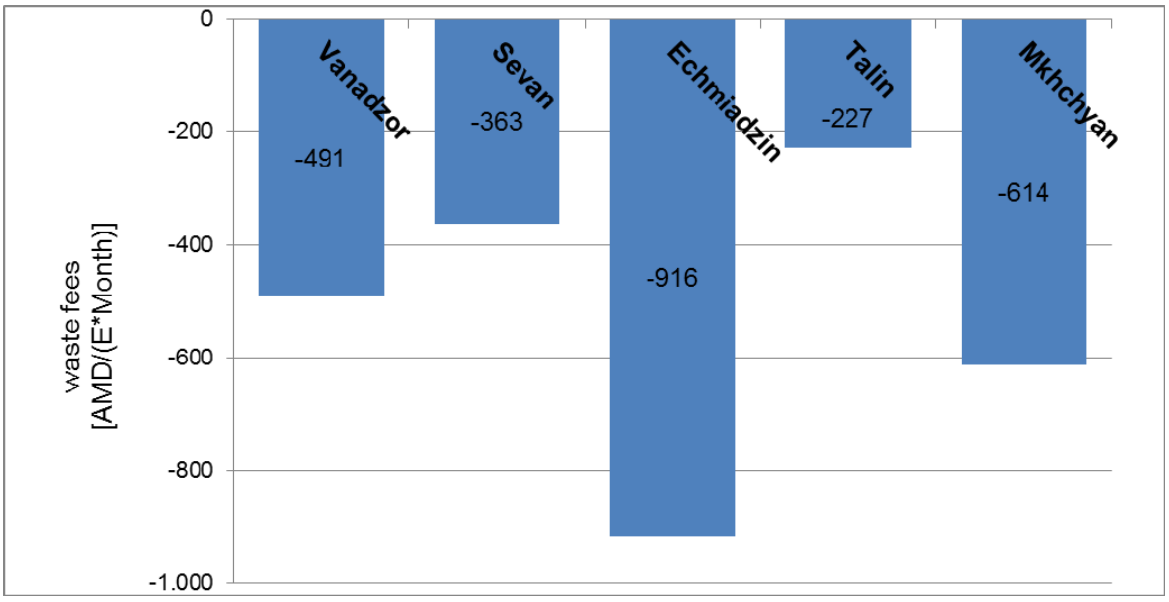


Figure 3.37: Estimation of waste disposal fees of a modernised Armenian waste management

3.7.3.6 Model region as a pilot project

The documented procedure cannot be realised immediately for the whole country of Armenia even based only on economical reasons. The values determined in the project for waste composition and characteristics show high fluctuations resulting primarily from the extremely different situations of unsystematic provision of waste. What changes and consolidations of values may result from the implementation of orderly waste collection should be determined before its transfer by use of a limited model region. At the example of the town of Talin in addition to the concrete measures that were stated in chapter 3.7.2 generalisable approaches are to be discussed.

The town Talin could without any particularly high expenses be turned into a model region for testing of waste management concepts for all of Armenia. Wirth the support of the Union of Communities of Armenia (CAA) and the Yerevan State University of Architecture and Construction (YSUAC) the example of Talin could after a successful pilot phase be used as a good practical example for training of the responsible persons in other communities and towns in Armenia.

A basic procedure for the introduction of orderly collection – as it is described at the example of Talin – should begin with systematic collection of residual waste in the emptying system familiarise the inhabitants with the new containers, sites and collection rhythms. The required number of containers can be reduced if necessary, if it is possible to connect several households/ single-family houses to one MGB (240 or 1.100 l). A weekly collection rhythm is suggested. By step by step introduction of collection of recyclable waste and organic waste the collection of residual waste can then be stretched to every 14 days and be performed alternatingly with the collection of recyclable waste.

To achieve the goals described in scenarios 2 and 3 a lot of publication work is required. The education of the population on separate waste collection via newspapers, other media and particularly in schools plays an important part in motivating citizens to separate recyclable waste. Especially via the motivation of children for responsible treatment of the valuable resources parents can be reached as well and the youngest citizens are conditioned early on.

These measures should prepare the population for new behaviour patterns in dealing with waste and communicate that waste is more than just undesirable leftovers of anthropogeneous action, but can be a valuable resource as well.

Besides the presented solution proposals for education and motivation of citizens financial stimulations play a large part in furthering separate waste collection. Here two ways are suggested which can be adopted together or alternatively, or one after another. It should also be suggested to test this procedure on a model region and evaluate its successes/results afterwards.

Introduction of system of fees for waste collection that is adapted to local conditions has priority to for example achieve that citizens pay less for smaller amounts of residual waste generated and more separated materials. This goal can, for example, be reached by lower fees for smaller residual waste containers or by an extension of the collection rhythm (for example instead of weekly collection every 14-days).

Regarding waste paper, metal, used glass a revival of the old SERO-system of the GDR should be looked into. In the GDR SERO stood for a tight network of points of reception for secondary raw materials where secondary raw materials of a high degree of capturing and cleanliness and then passed them on to recycling. Here as well children and youths could be the drivers of the system and collect waste of high quality and hand it in at collection points for a small compensation. The adults may still remember the novel "Timur and his Troop" by the Russian author Arkadi Gaidar from their childhood.

From the point of view of the project members it is recommendable to conduct another analysis of the composition of waste in the town Talin after introduction of the orderly waste collection. Here the named structures of settlements (single-family and apartment houses) and the seasons should be considered in carrying out of the sorting analyses. This way the waste generating citizens can be attributed to the corresponding waste collection containers which will enable precise extrapolation of the data on amounts of waste generated and their structure for the town with conclusions for all of Armenia.

The town of Talin which was considered as model settlement represents a relatively small municipality in Armenia. For reduction of waste management expenses the town Talin should develop a regional waste management concept together with other, neighbouring municipalities. This way resources not only for collection of residual waste can be used more economically and synergies be used. In particular the collection, sorting and marketing of waste can be exercised more profitably and marketably. The regional centres for recyclable materials can be implemented for sorting, separation and marketing. The centres for recyclable materials could offer citizens the option to sell their recyclable materials for a small compensation (analogue to SERO-system, see above).

Looking into and aiming for rationalisation of waste management is recommendable for all of Armenia. Currently there are 915 municipalities in Armenia that are responsible for waste disposal. Here is - not only from the point of view of waste disposal - an organisational reorganisation towards larger administration areas would be desirable, or at least a cooperation of municipalities. The municipal association of Armenia can play an important coordinating role in the formation of regional cooperations. Through these waste disposal communities and waste utility unions regional sanitary landfills can be financed more easily to provide an eco-friendly disposal of the remaining residual waste.

A change away from wild waste disposal towards orderly waste management will enable Armenia to protect the environment, save natural resources and create new jobs in waste management.

4 Evaluation of the project course, the results and the long-term impact by the receiver of the consultation achievement (A. Sergoyan, YSUAC)

4.1 Basic problems of establishment of control system of firm household waste

To ensure effective work of the system it is necessary to establish a general basis of information on solid waste in the region. This basis of information must include data about its quantity, composition, density, humidity and about physical and biological features. Data about businesses that generate large quantities of waste as well as the rules effecting changes of the main parameters of waste generation for a weekly, monthly and annual intervals are required as well.

At the preliminary stage the following questions must be answered completely:

- Type and quantity of processed waste,
- Development of waste generation,
- Type and weight of the recyclable materials contained in the solid municipal waste,
- Characteristics of the recyclable solid municipal waste,
- Rules of change of these characteristics depending on time,
- Influence of these characteristics on process of recycling,
- The characteristics of the efficiency of solid municipal waste,
- the optimal model of recycling under the circumstances,
- the financial assets required for introduction of waste management systems,
- Smooth transition from the short-term programs, demanding comparatively little input, to long-term programs, demanding big input

The program performed by us, has designed to supply answers to these questions.

4.2. Conclusions and Recommendations

From the results of the research performed in the municipalities, it can be concluded that necessity of solutions after effective management of solid municipal waste in the Republic of Armenia is very important and from the point of view of environmental safety has big risks. The delay in these questions can lead to serious consequences in the near future because the waste collected in the numerous legal and illegal landfills over many years is polluting the air and damaging the ground water. This ground water feeds the majority of underground wells and renders them unsuitable for the further use of large territories in our country, which already has few natural resources.

From the results of the research it becomes clear that individual components such as polymers, paper, cardboard, metals, glass, are contained in the municipal waste and can be utilized. The qualitative characteristics of these wastes (such as paper and cardboard) are unsuitable due to the mixing/dirtying during waste collection and transport to landfills. For this reason undoubtedly separate waste collection should be implemented.

Currently there are collection places and enterprises for processing of the components mentioned above, but their quantity, geographical location and production capacities are still unsatisfactory.

The investigated waste composition in the settlements is very diverse. For example in urban areas share of packaging materials (paper, cardboard, polymers) dominates with rather low density. At the same time in the village Mkhchyan where humidity and density are higher organic wastes (vegetables, fruits, rests of plants, etc.) prevail. The factors mentioned above are decisive for further processing. For example damp organic materials are not suitable for subsequent burning and are composted.

For an efficient waste management informing of the population and its motivation for the realization of the tasks is not less important. It determines the willingness of the population to sort waste and then transport it to the sites as well as to pay for the rendered service.

It is impossible to imagine efficient waste management without existence of a flexible and praxis oriented legal basis which includes the passing of laws and the standardising documents concerning the area in question.

The prevailing part of responsibilities of area in question in the RA rests on the shoulders of local self-government which renders the services in question to the population by means of communal or private enterprises though frequently the professionalism of the experts working in these enterprises does not meet the requirements and negatively affects the quality of the services.

Very frequently the shortage of financial and technological means is felt, as part of the population does not pay for waste collection and the low fee does not provide full rendering of service.

In the situation described the competent authorities ignore the amount of dangerous problems which frequently arise as a result of wrong management and negatively influence the health of people and the environment.

In the course of the implementation of a waste management system one should focus on the following points:

- Improvement legal situation,
- informing of the population, participation in management, performing of education measures,
- training programs for the experts,
- Cooperation of all participants of the management and bilateral work (organ of governmental administration – organ of local self-government – the recycling associations and enterprises),
- raise interest of potential investors,
- creation of processing industrial facilities,
- Expansion of the network of collection points for recyclable materials, give financial incentive to population.

In the scope of training programs and the improvement of public awareness raising the following activities should be focussed on:

- performance of seminars, round tables, scientific conferences in the circle of several social classes and especially in educational institutions,
- Educational cooperation of local universities with European universities: for the purpose of training of experts for processing of the solid municipal waste and preservation of the environment, according to the international standards,
- Creation of a fund for scholarships that is financed by the respective studying programs,
- Integration of the individual elements of waste management with other sciences: jurisprudence, engineering sciences, economy, etc.
- In the course of the education of the generation the importance of reasonable management of municipal waste should be emphasised.

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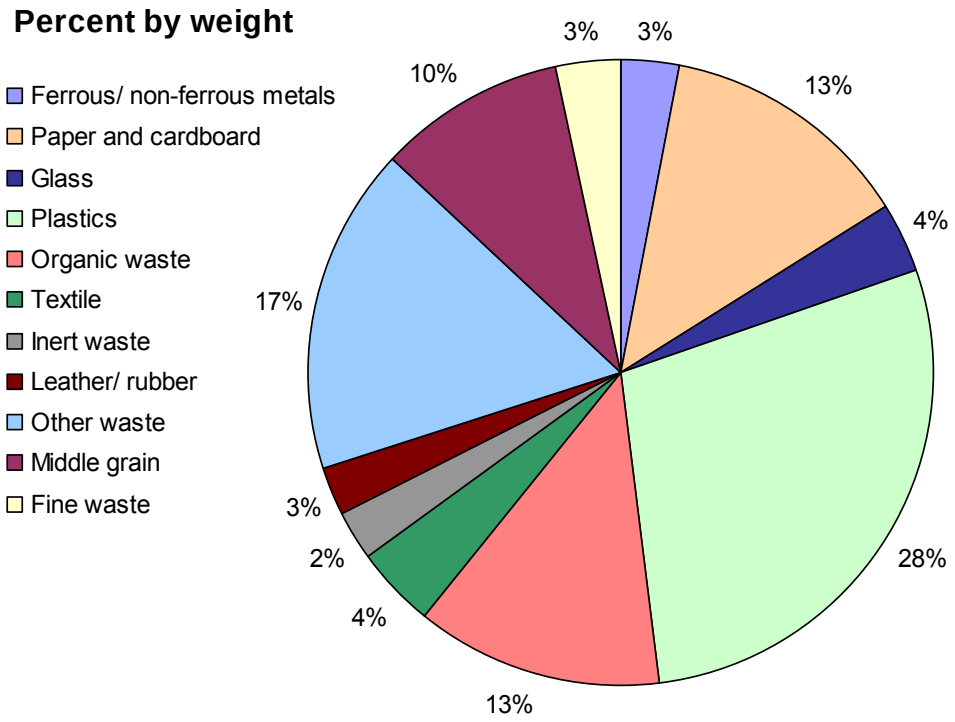
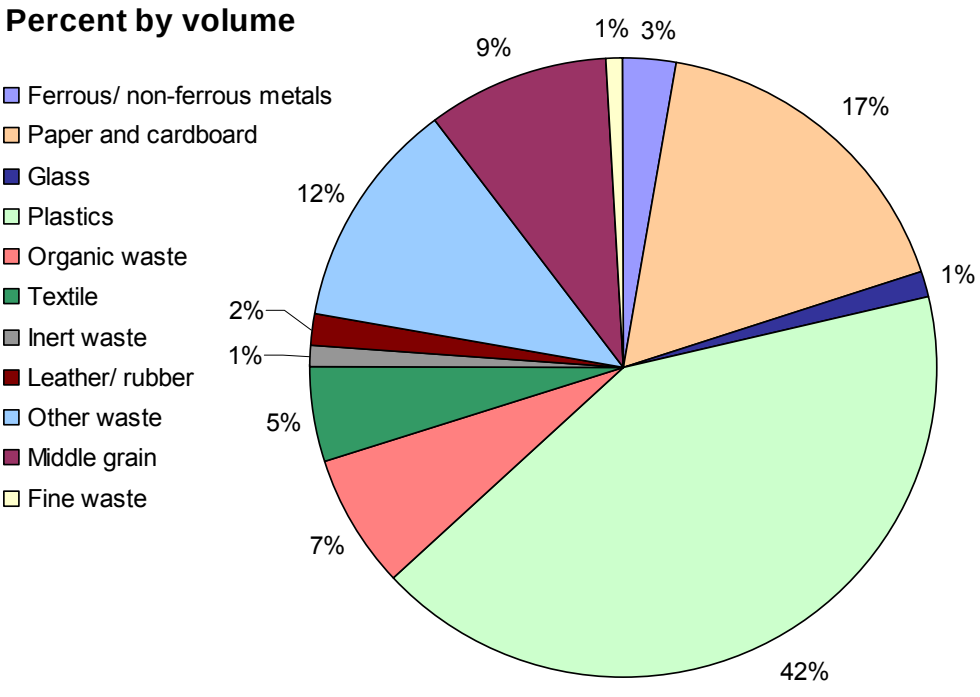
A Annex

A. 1 Waste Morphology in city Vanadzor (urban area)

A. 1.1 Spring

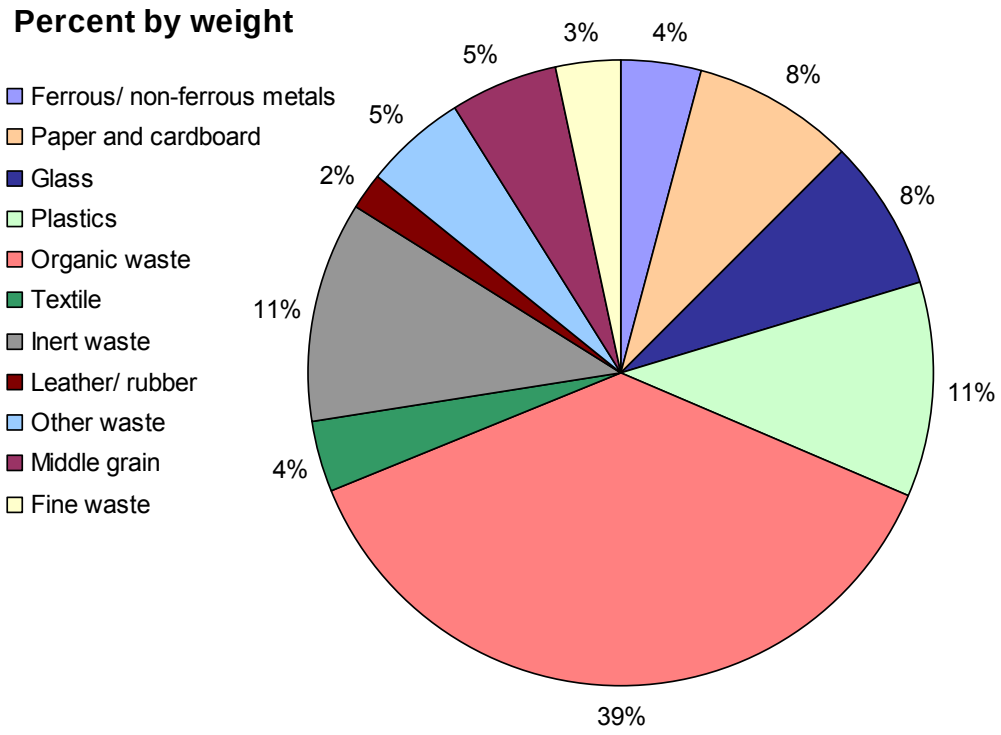
Examined waste amount: 13 m³ and 2,03 t; Number of inhabitants: 1578

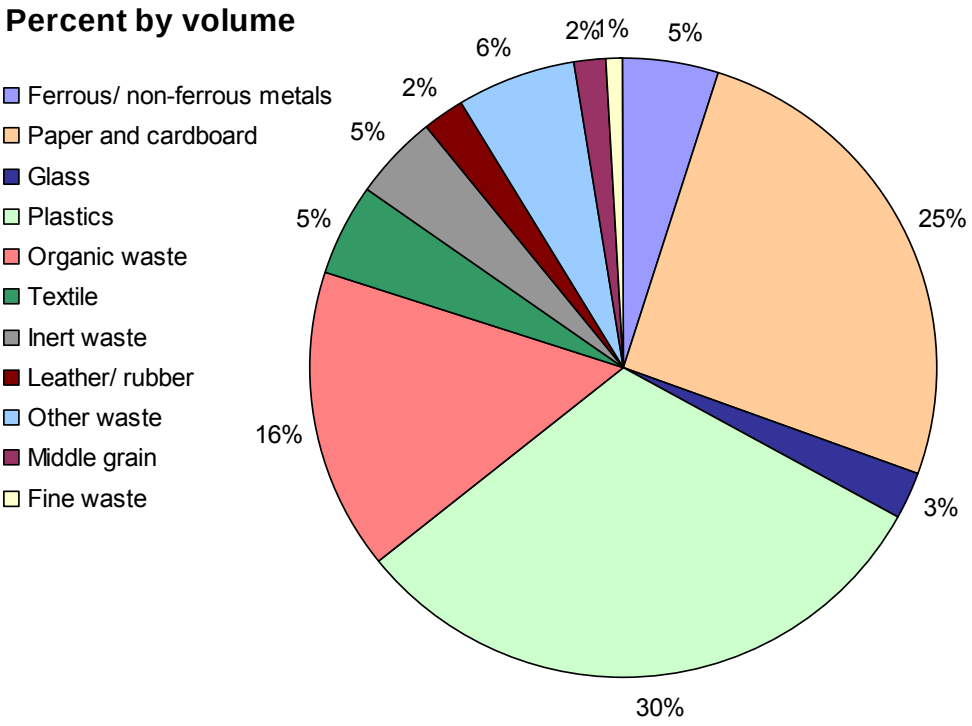




A. 1.2 Summer

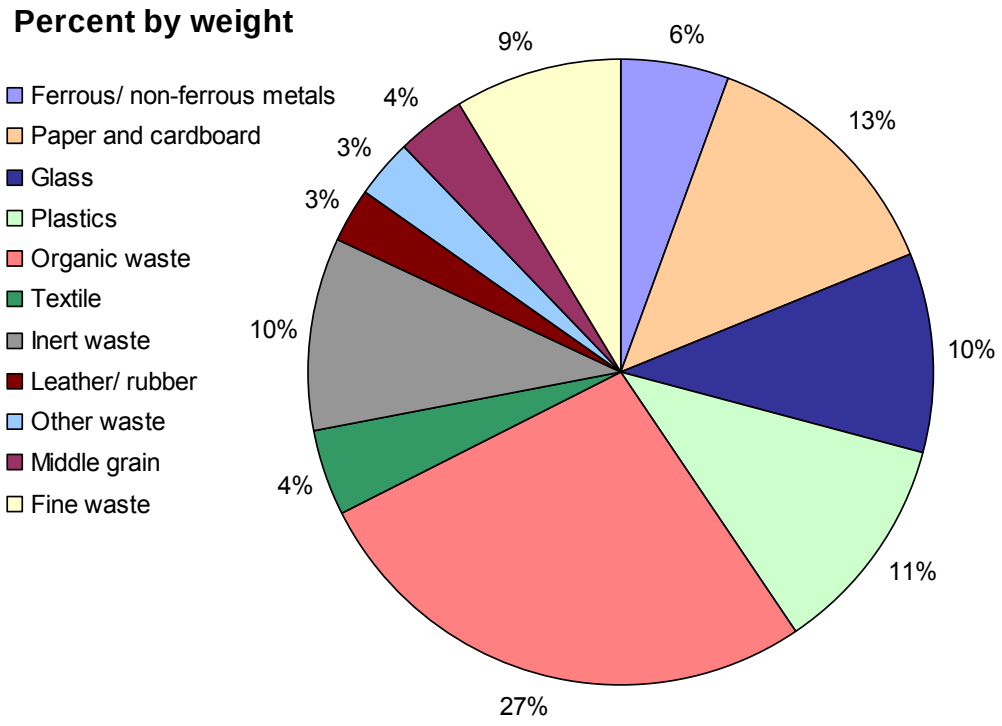
Waste amount: 12,78 m^3 and 1,75 t; Number of inhabitants: 1590

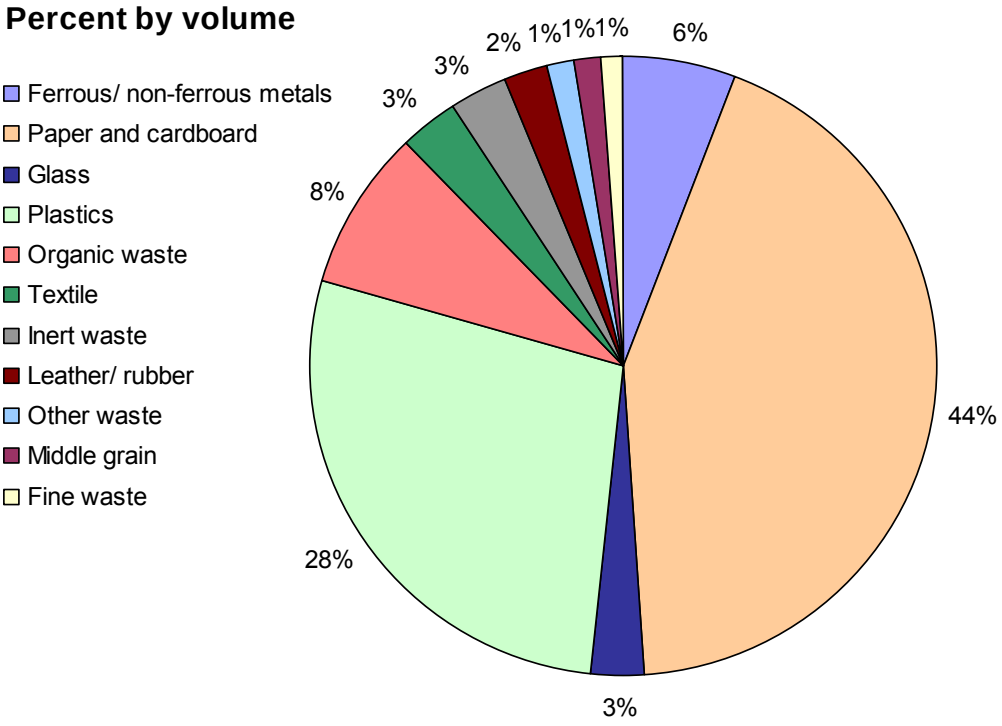




A. 1.3 Autumn

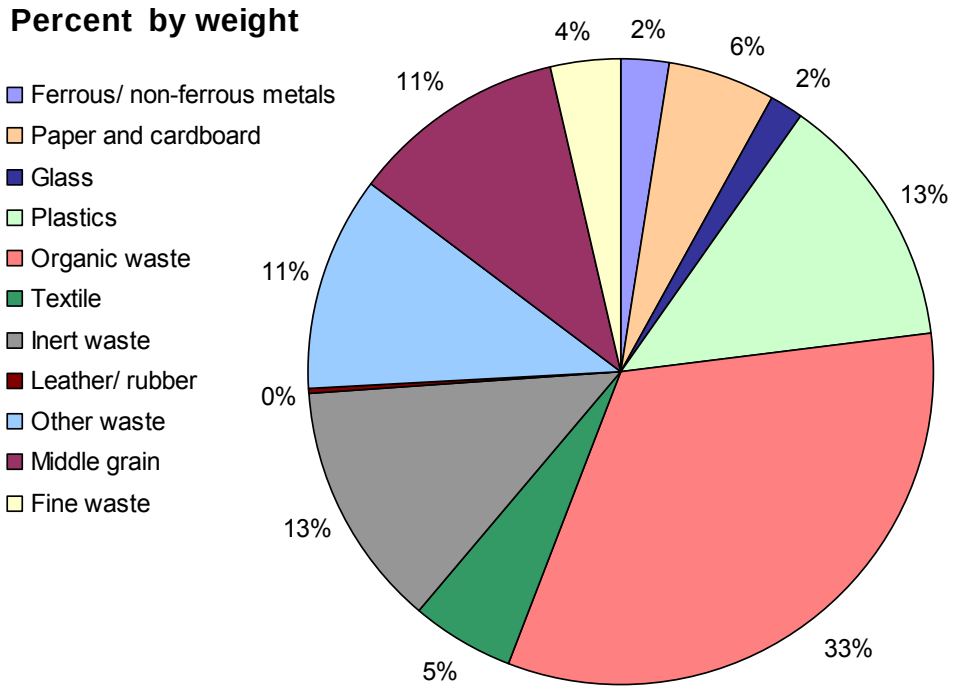
Waste amount: 11,07 m^3 and 1,22 t; Number of Inhabitants: 1020

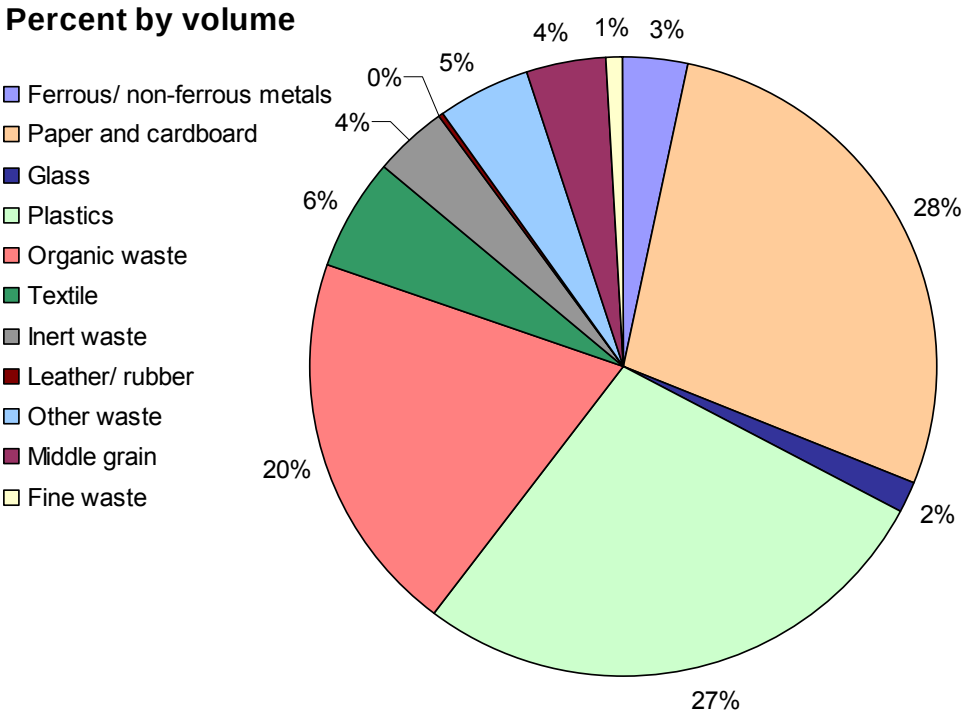

Percent by weight
Ferrous/ non-ferrous metals
Paper and cardboard
Glass
Plastics
Organic waste
Textile
Inert waste
Leather/ rubber
Other waste
Middle grain
Fine waste
6%
13%
10%
11%
27%
4%
10%
3%
3%
4%
9%


Percent by volume
Ferrous/ non-ferrous metals
Paper and cardboard
Glass
Plastics
Organic waste
Textile
Inert waste
Leather/ rubber
Other waste
Middle grain
Fine waste
6%
44%
3%
28%
8%
3%
3%
2%
1%
1%
1%

A. 1.4 Winter

Waste amount: 9,45 m^3 and 1,2 t; Number of Inhabitants: 1560

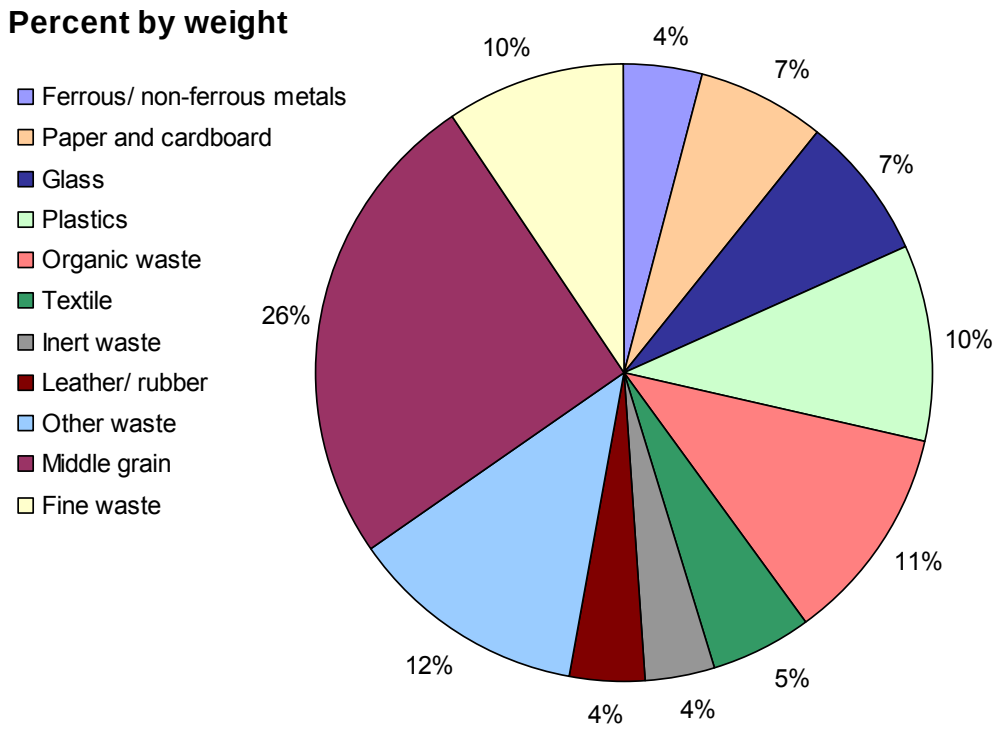


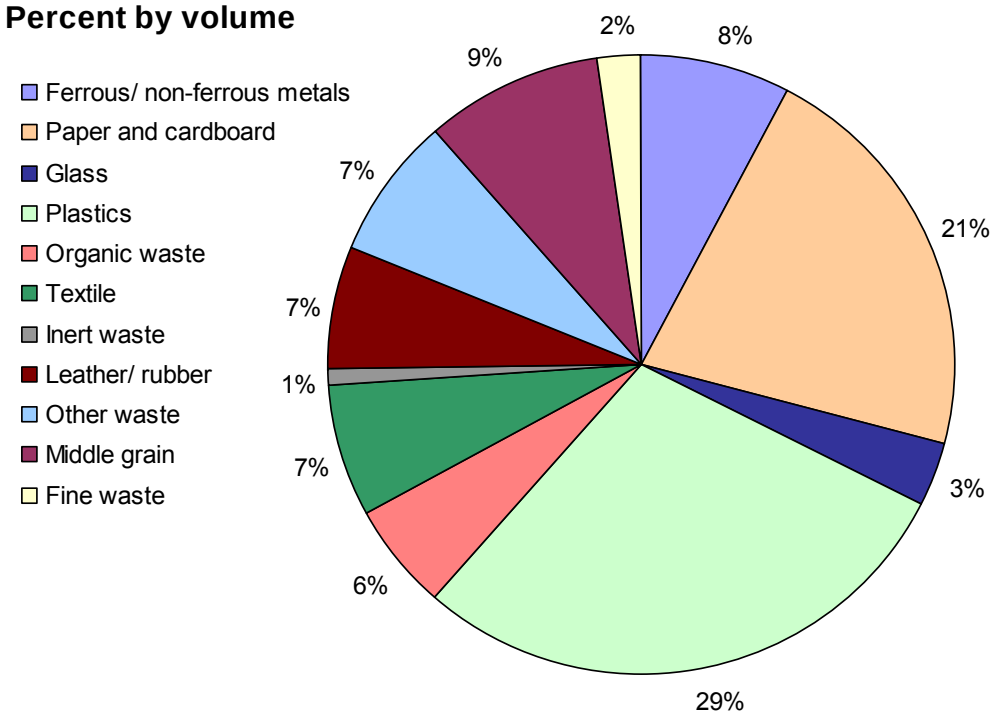


A. 2 Waste Morphology in town Sevan (urban area)

A. 2.1 Spring

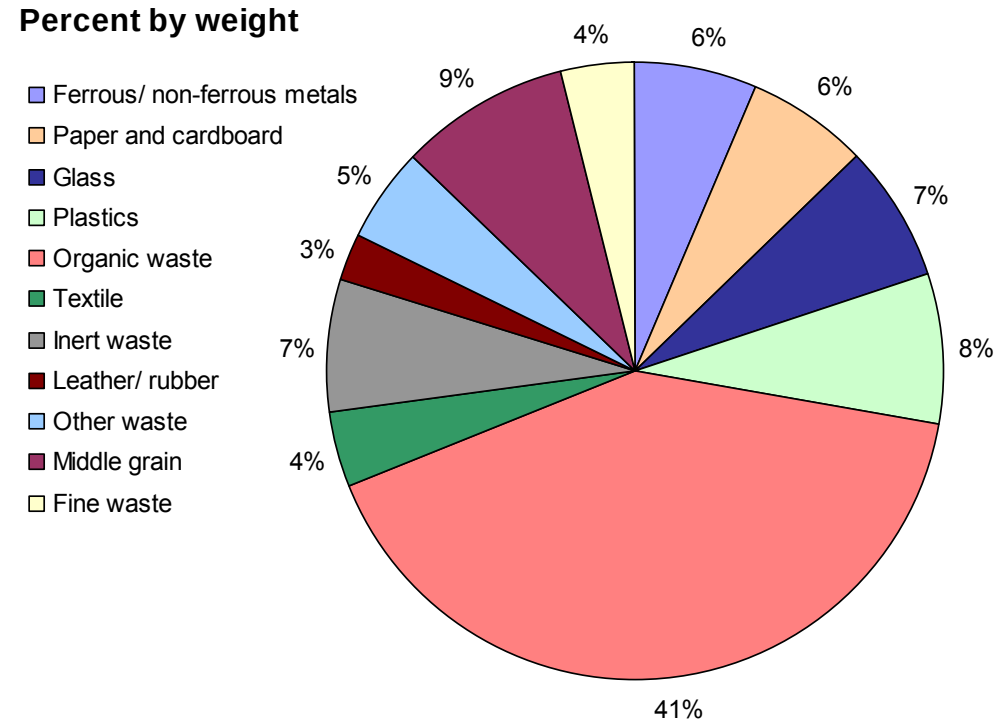
Waste amount: 9,83 m^3 and 1,63 t; Number of inhabitants: 3490

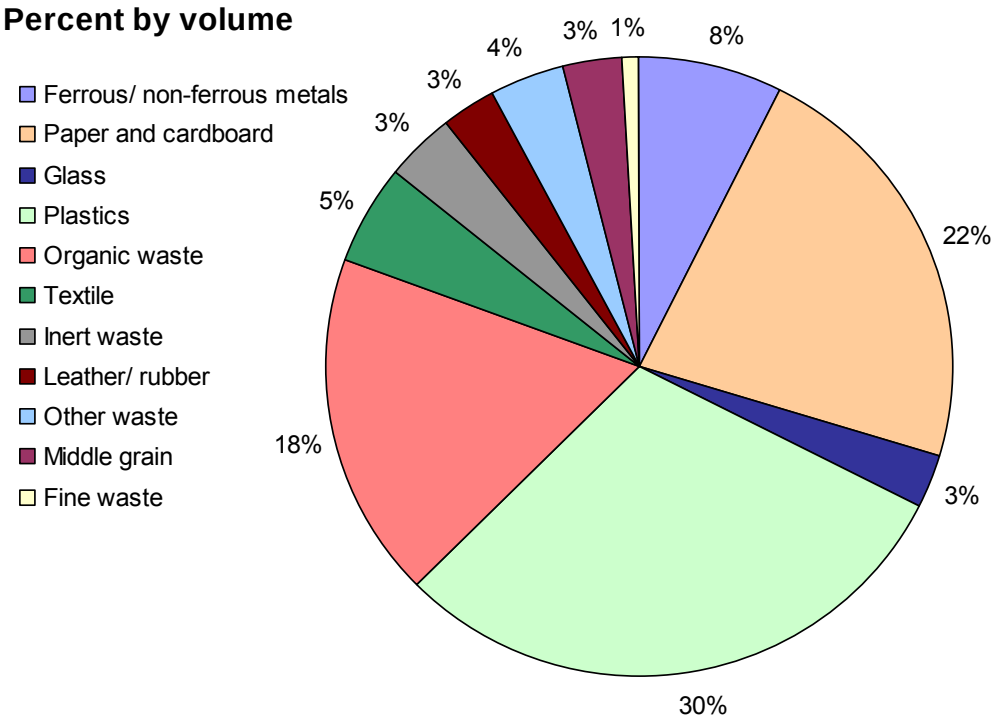




A. 2.2 Summer

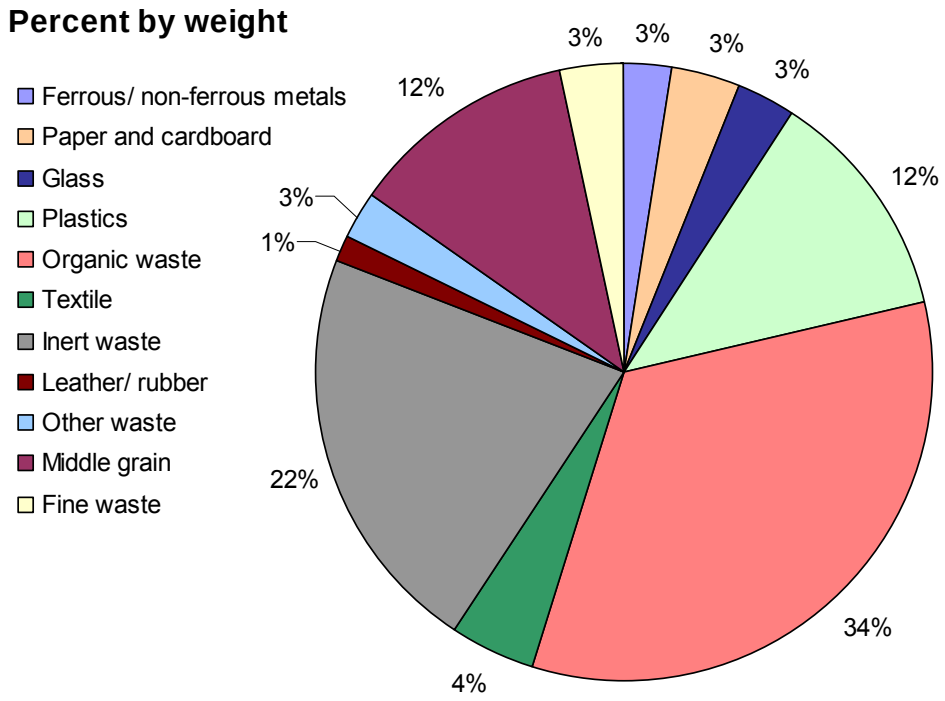
Waste amount: 15 m^3 and 2,43 t; Number of inhabitants: 3490

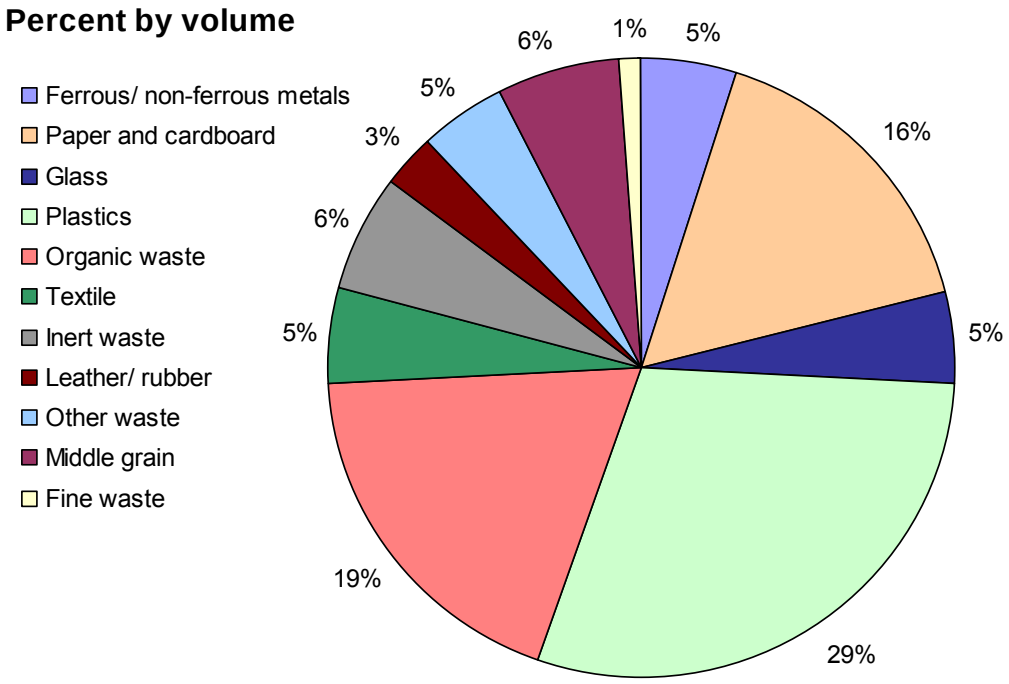




A. 2.3 Autumn

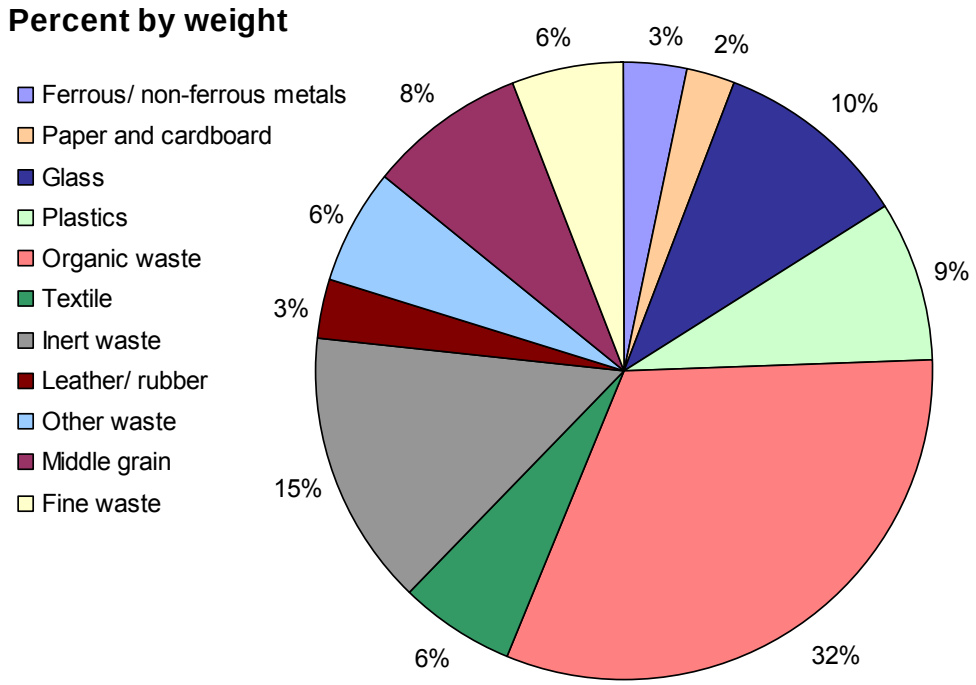
Waste amount: 8,8 m^3 and 1,63 t; Number of Inhabitants: 3190

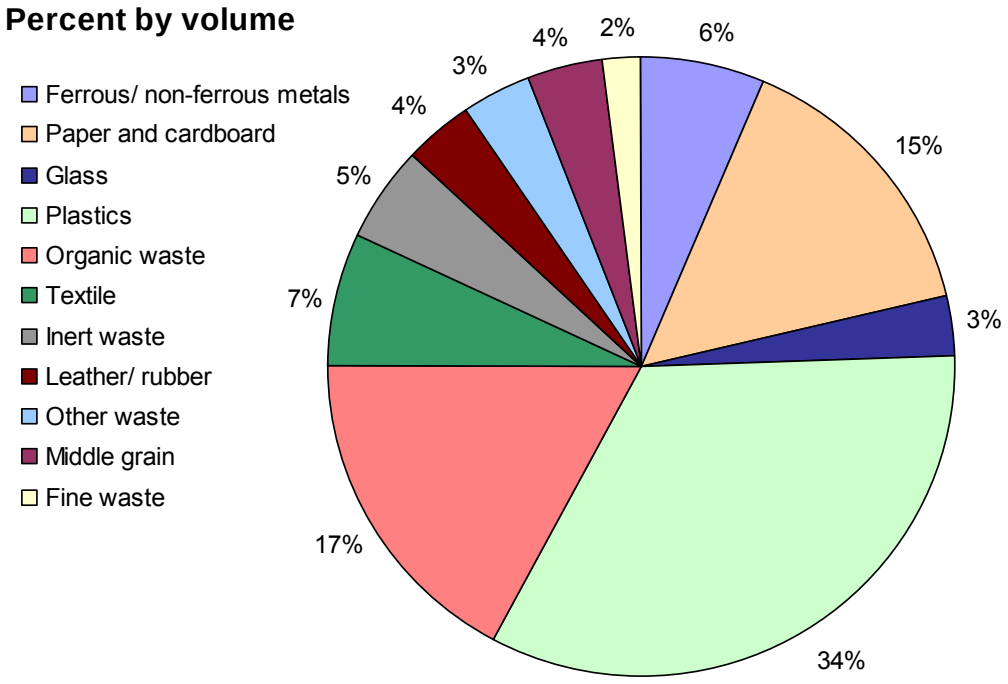




A. 2.4 Winter

Waste amount: 10,65 m^3 and 1,7 t; Number of inhabitants: 2740

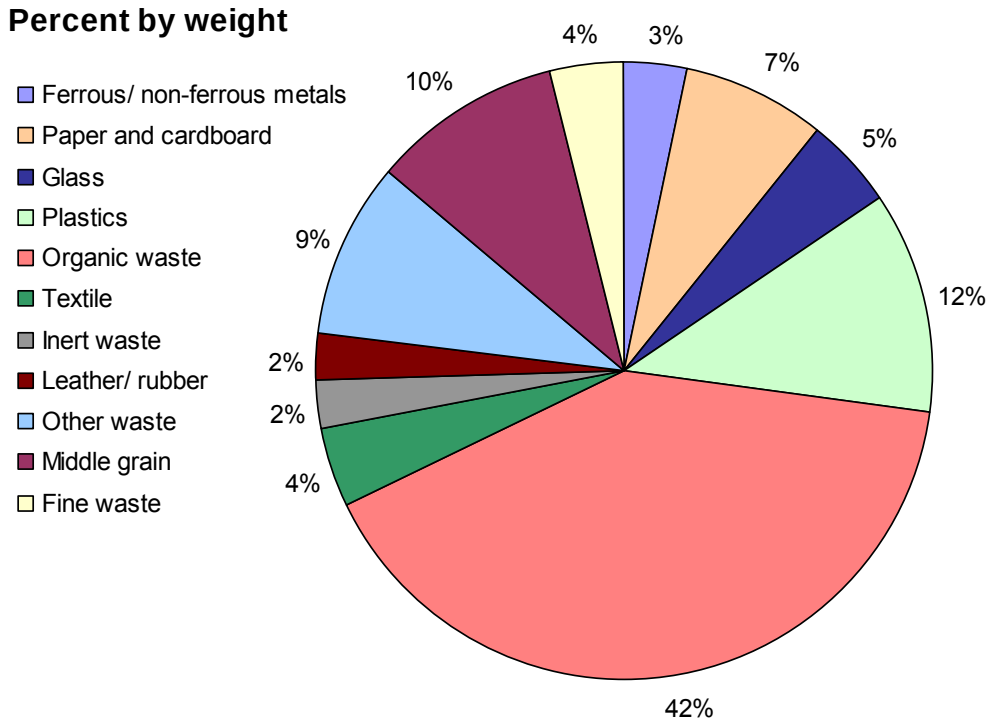


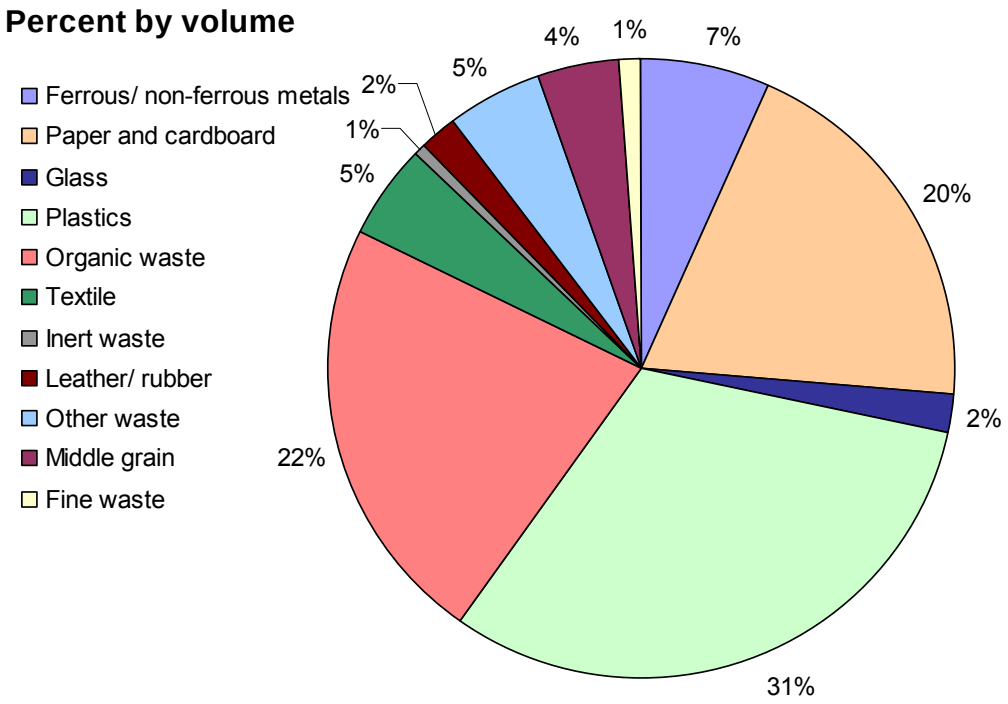


A. 3 Waste Morphology in the middle Town Echmiadzin (urban area)

A. 3.1 Spring

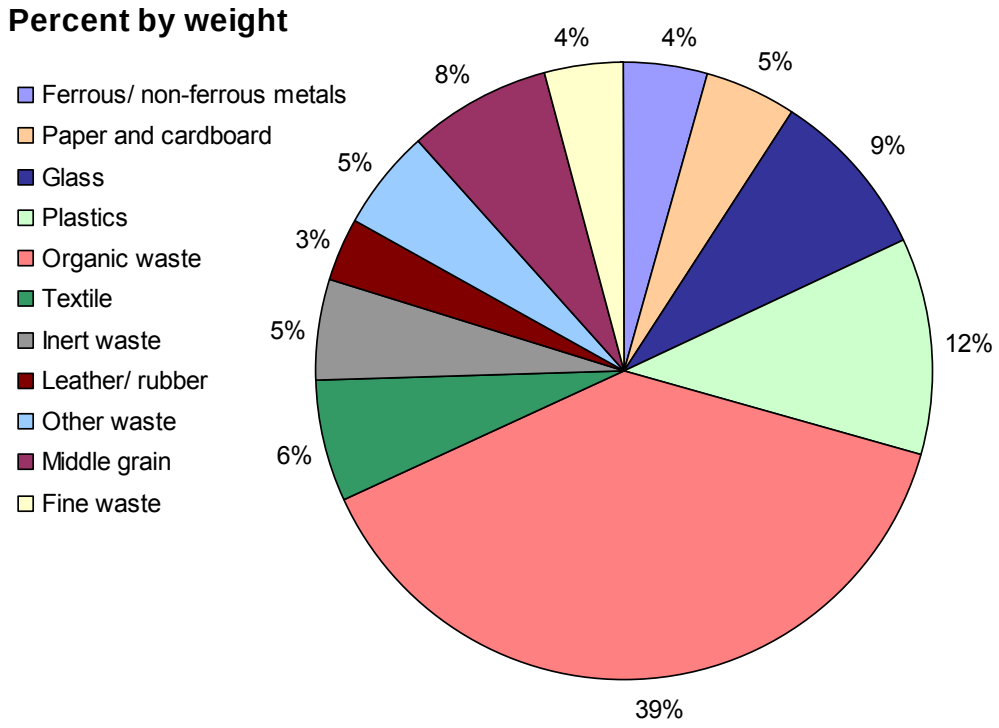
Waste amount: 8,32 m^3 and 1,27 t; Number of inhabitants: 1500

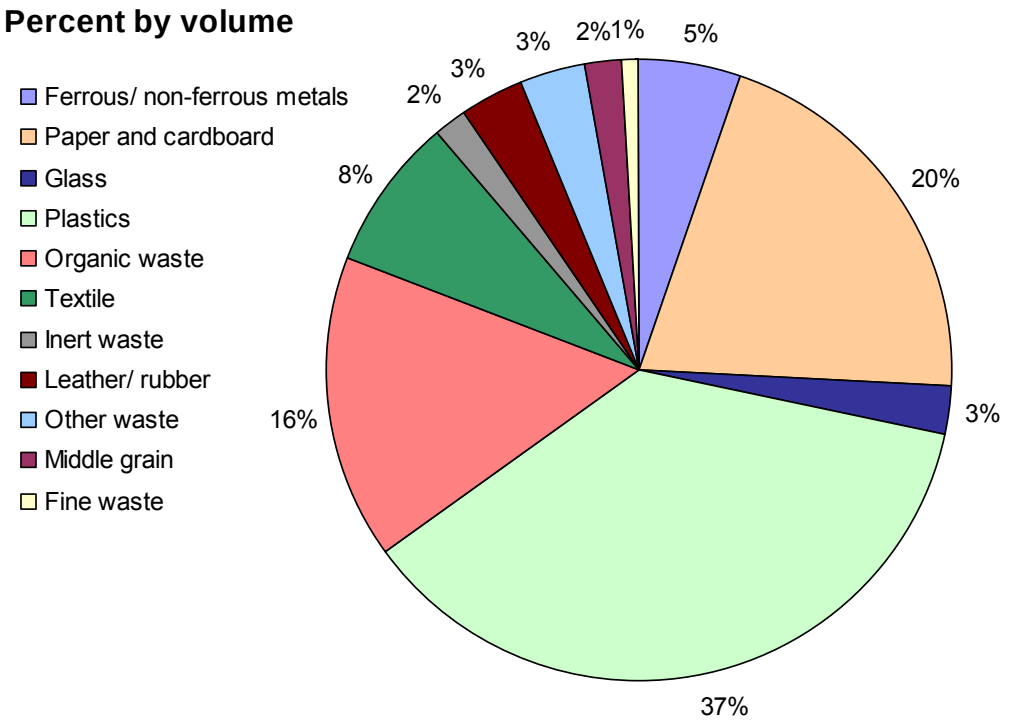




A. 3.2 Summer

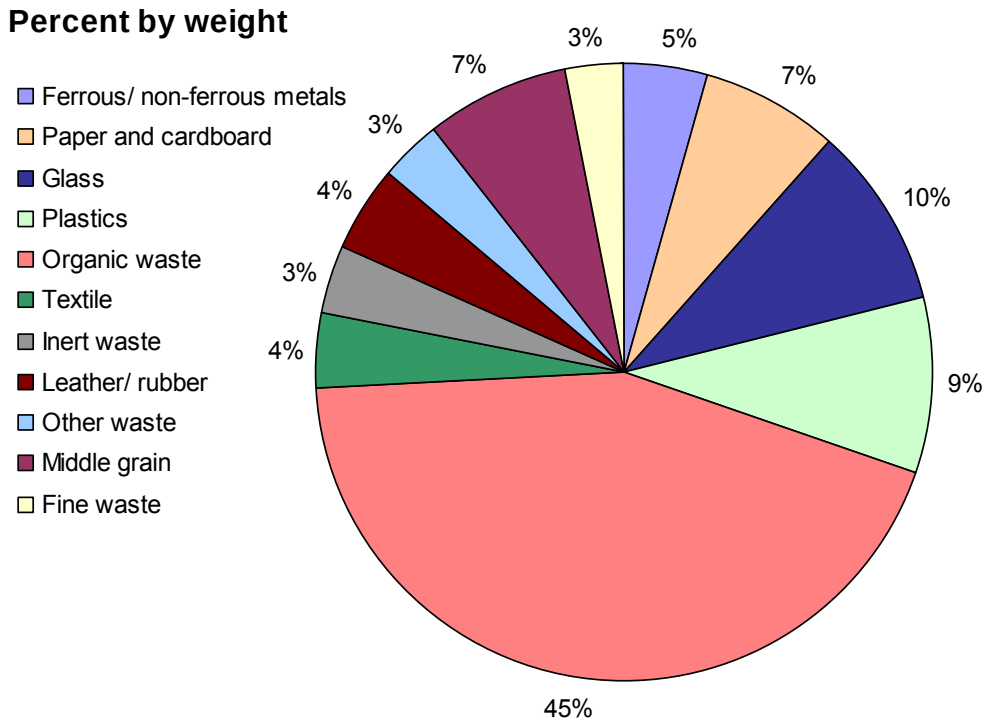
Waste amount: 12,95 m^3 and 2 t; Number of inhabitants: 1600

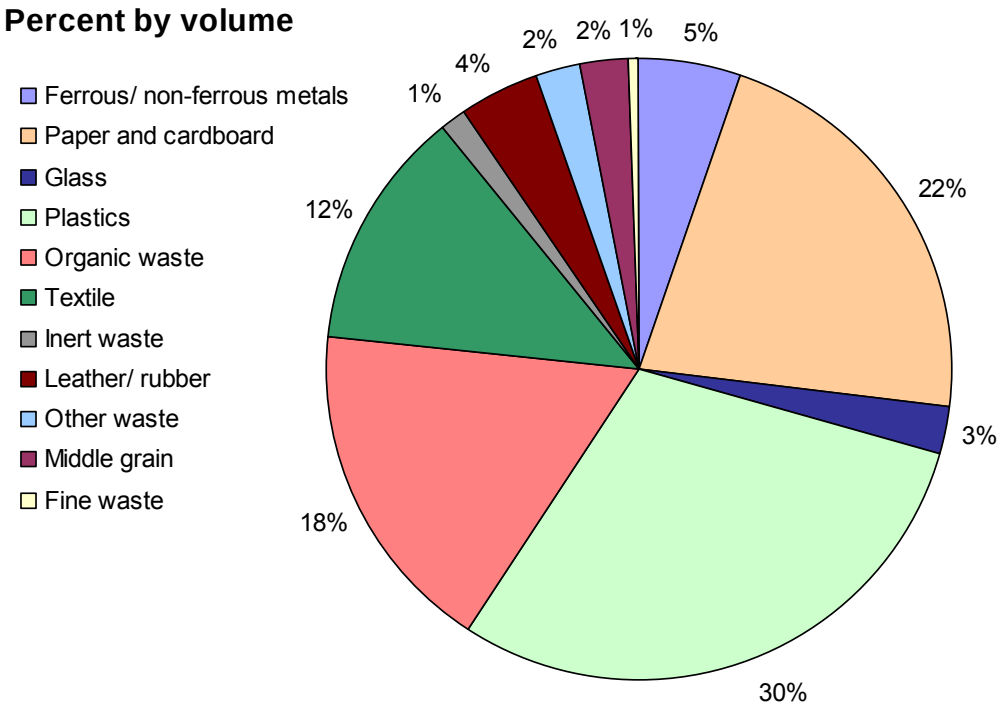




A. 3.3 Autumn

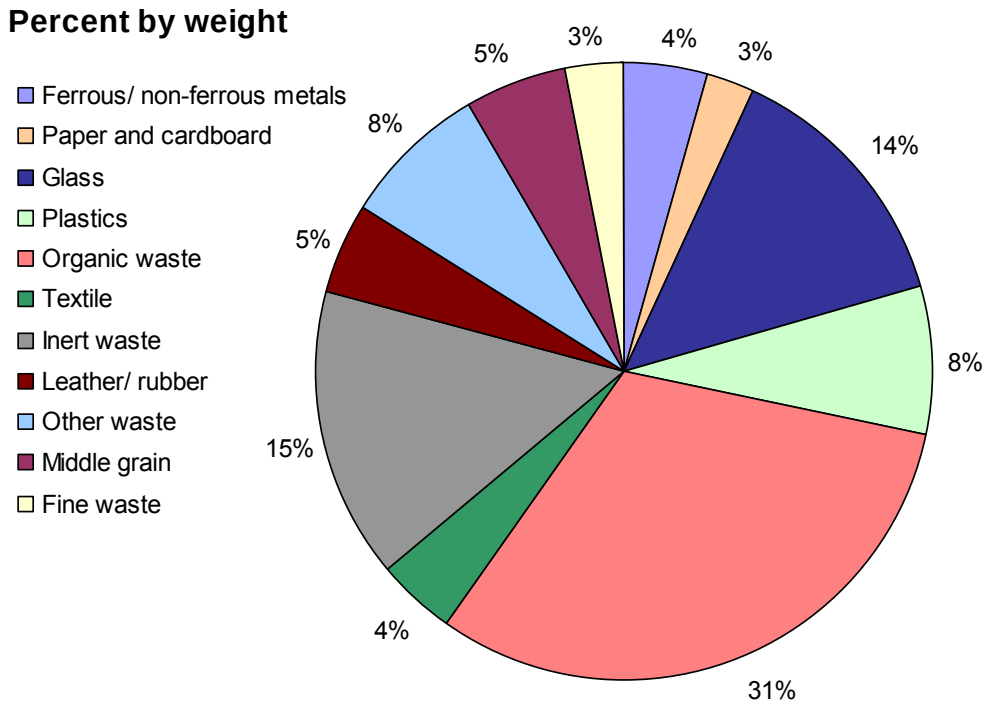
Waste amount: 13 m^3 and 2 t; Number of inhabitants: 1600

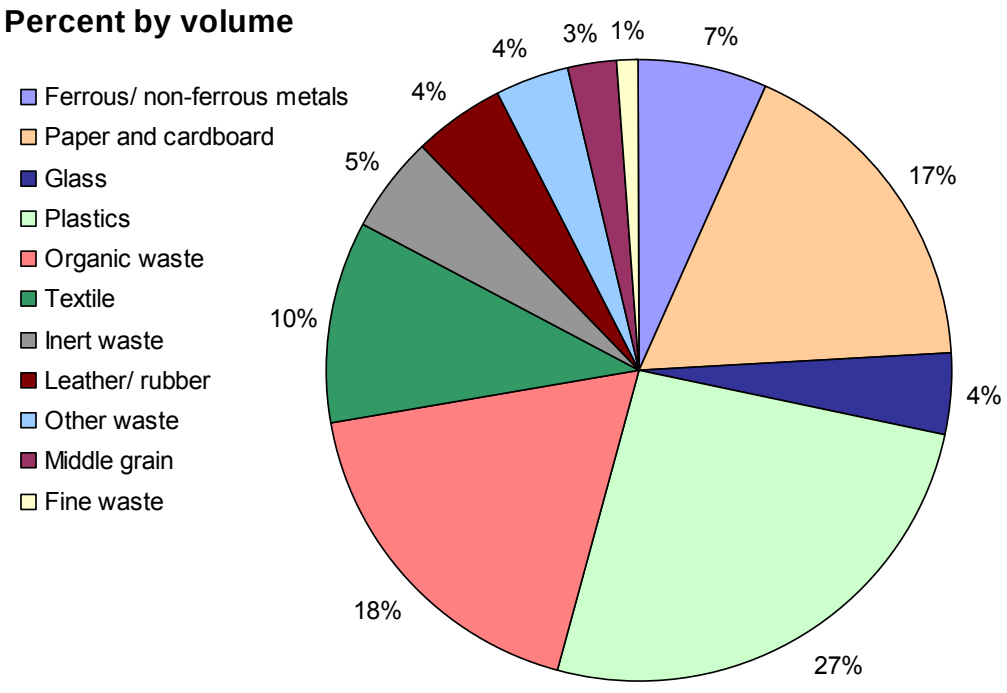




A. 3.4 Winter

Waste amount: 8,03 m^3 and 1,15 t; Number of inhabitants: 1500

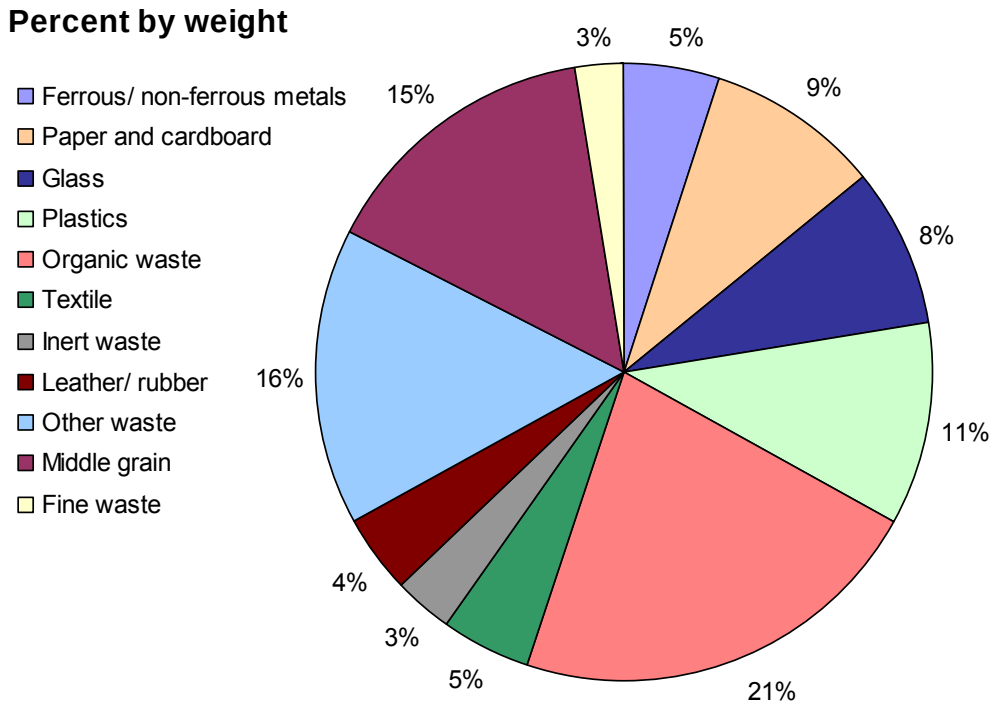


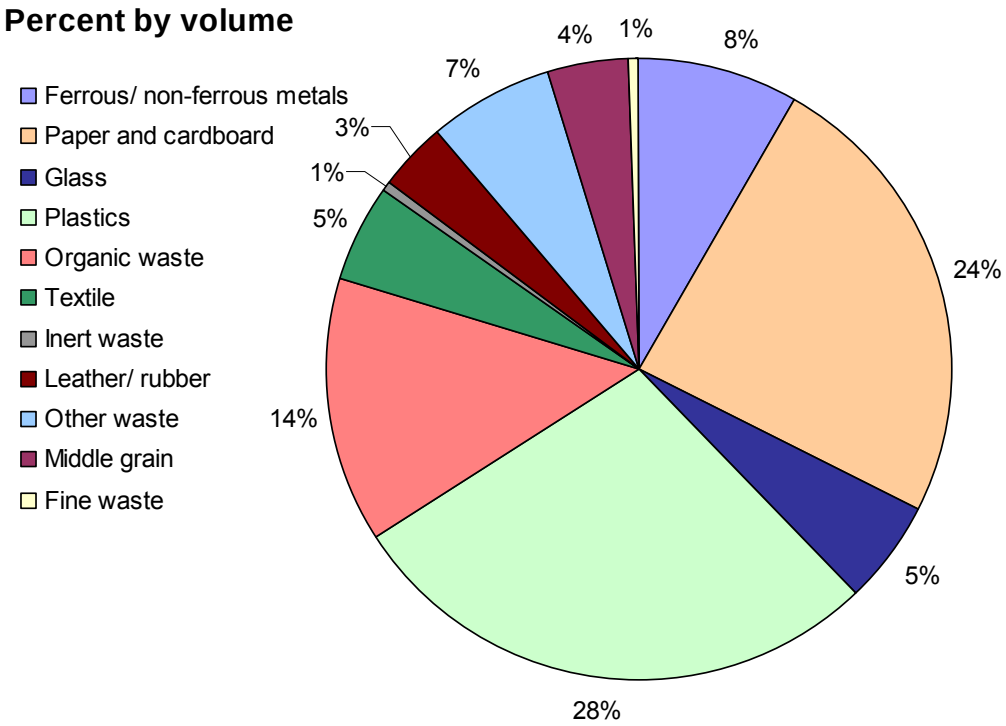


A. 4 Waste Morphology in small Town Talin (urban area)

A. 4.1 Spring

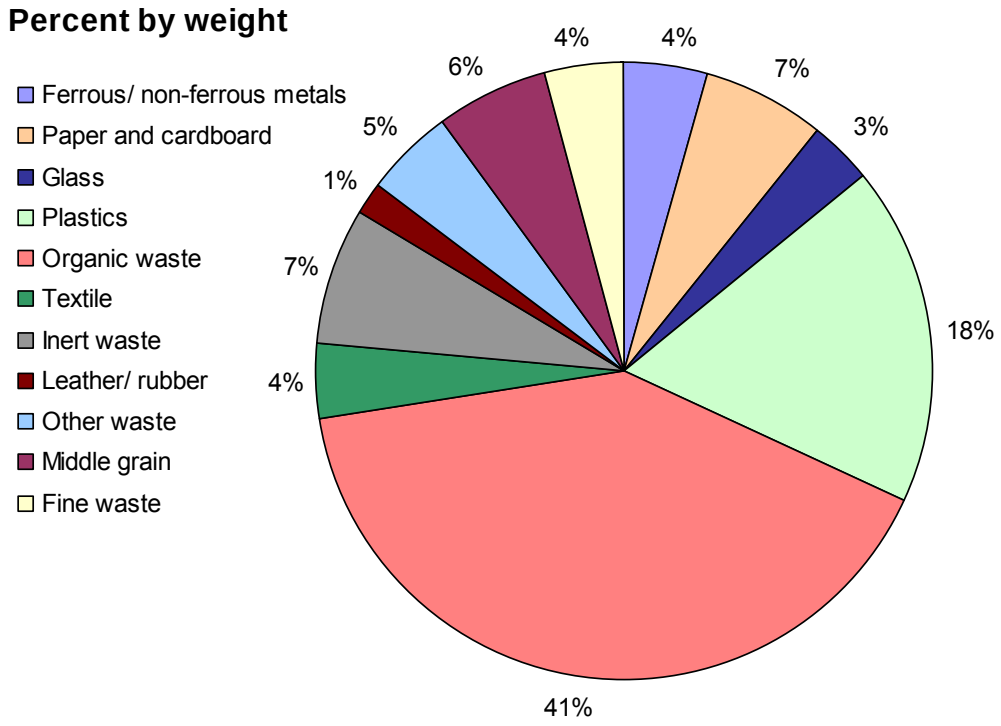
Waste amount: 11,8 m^3 and 1,86 t; Number of inhabitants: 972

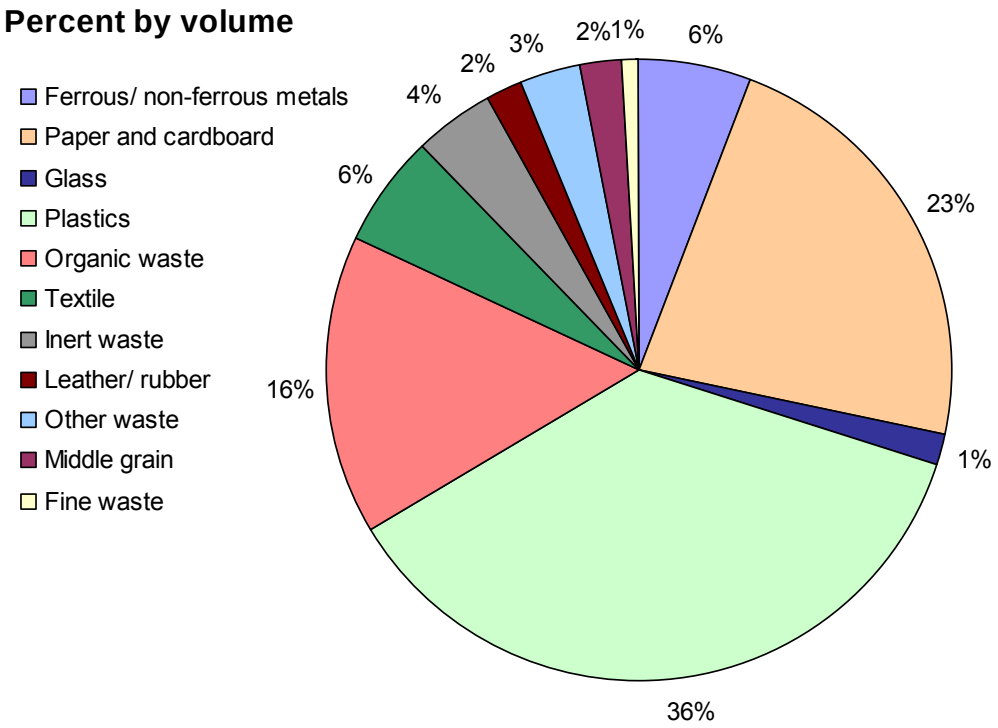




A. 4.2 Summer

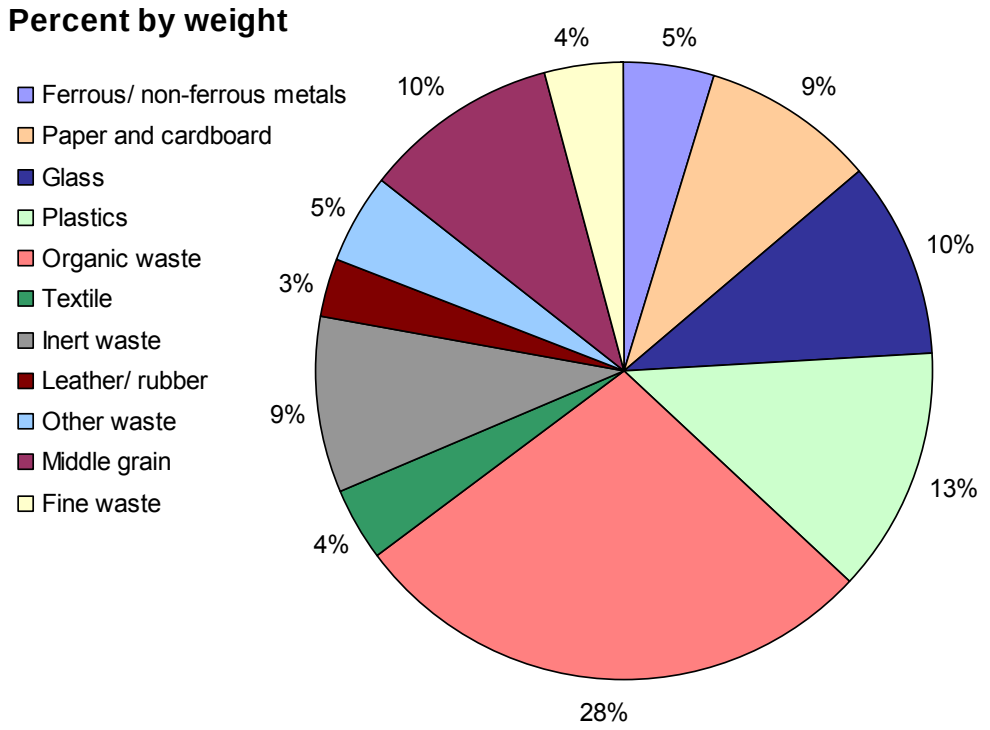
Waste amount: 11,47 m^3 and 1,72 t; Number of inhabitants: 972

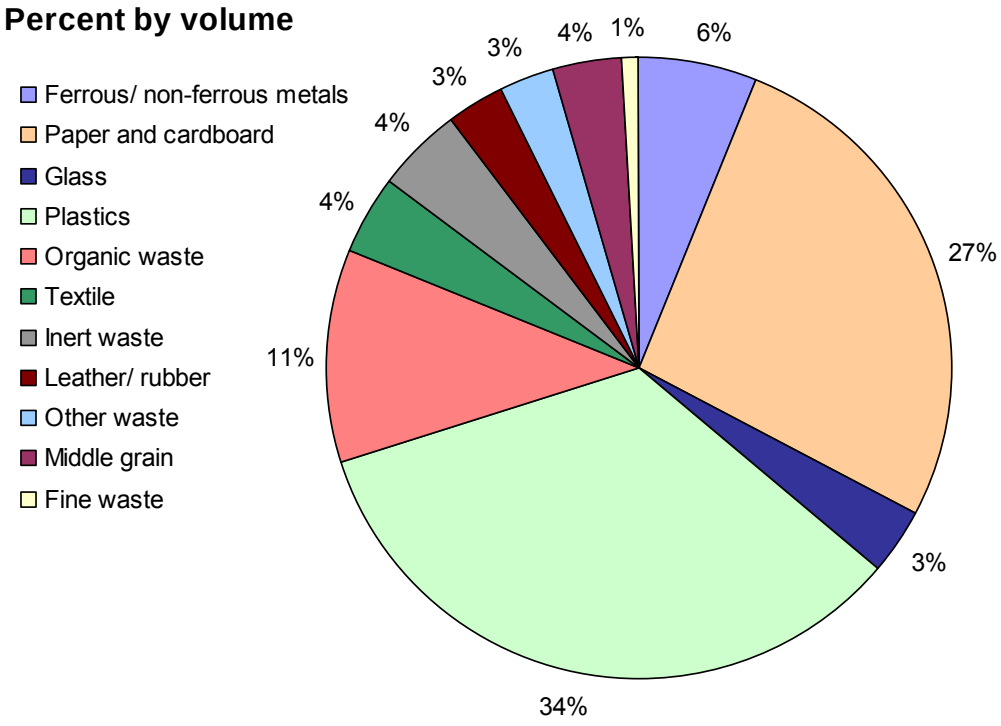




A. 4.3 Autumn

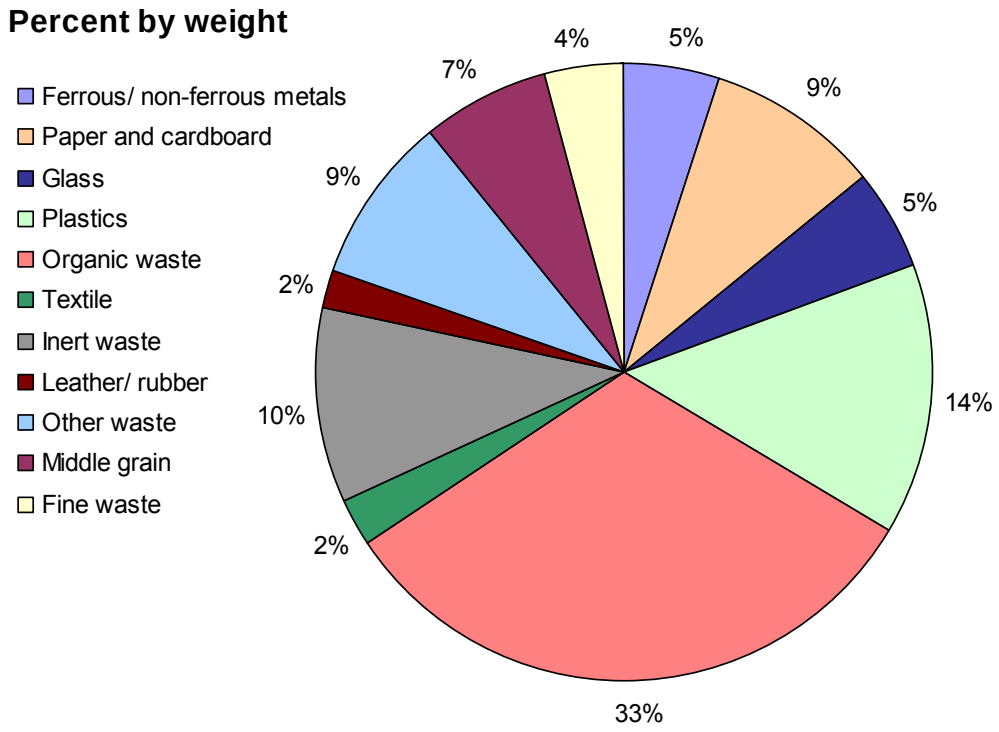
Waste amount: 10,5 m^3 and 1,63 t; Number of inhabitants: 1185

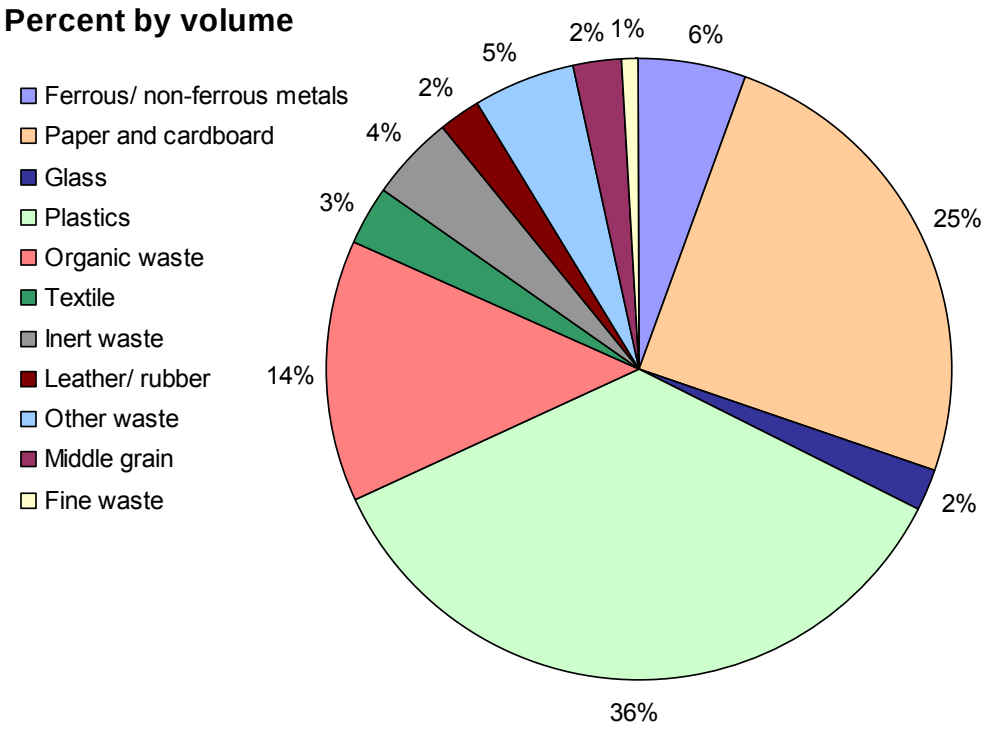




A. 4.4 Winter

Waste amount: 9,93 m^3 and 1,4 t; Number of inhabitants: 1185

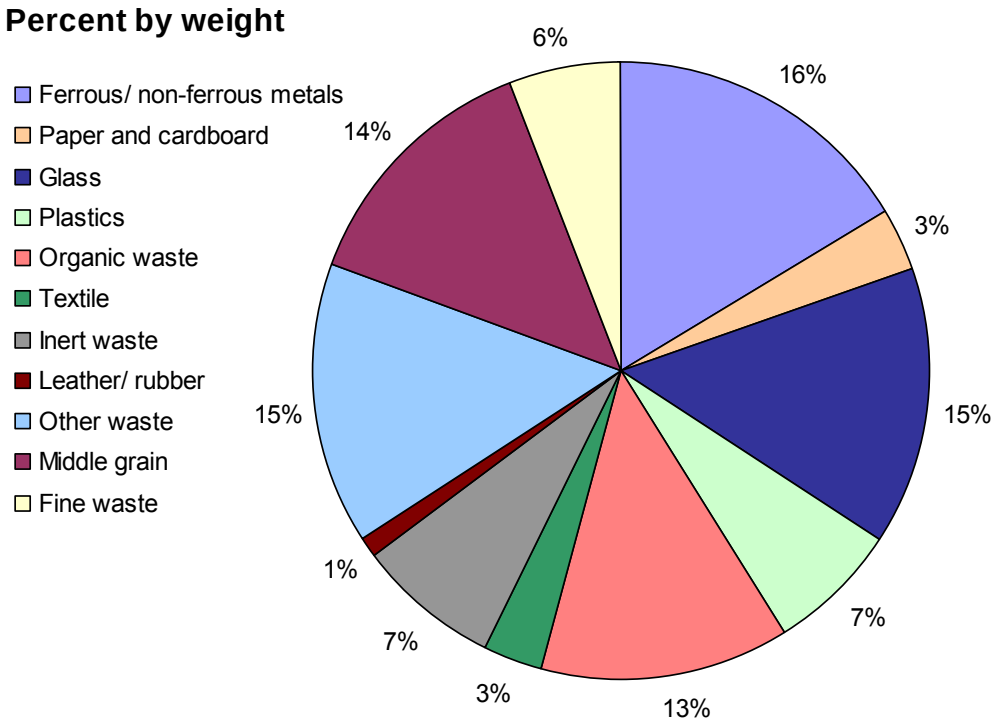


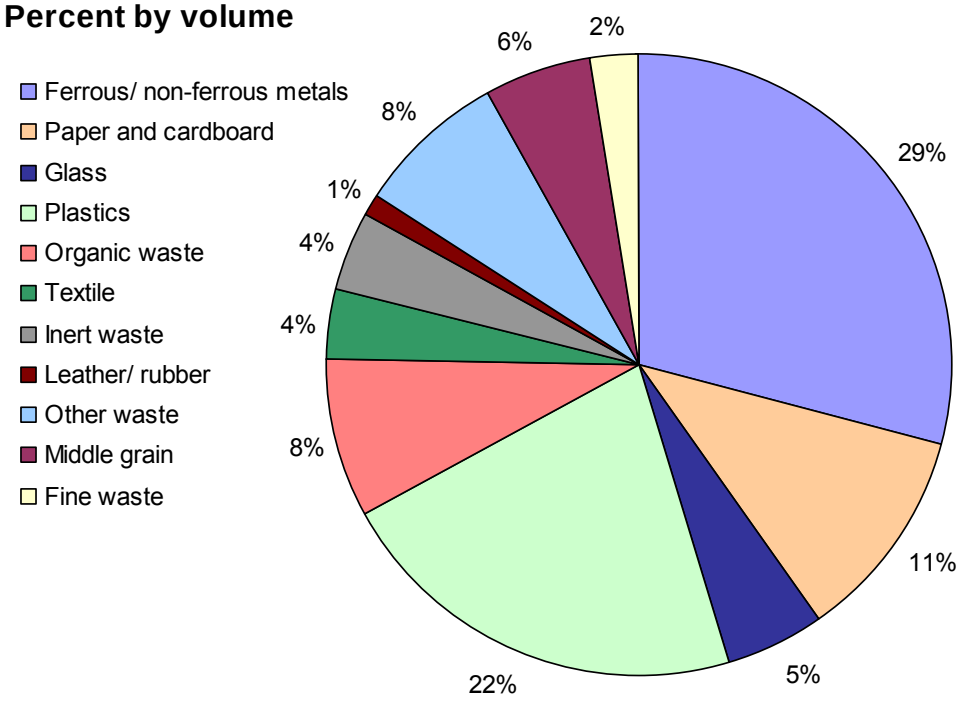


A. 5 Waste Morphology in Village Mkhchyan (rural area)

A. 5.1 Spring

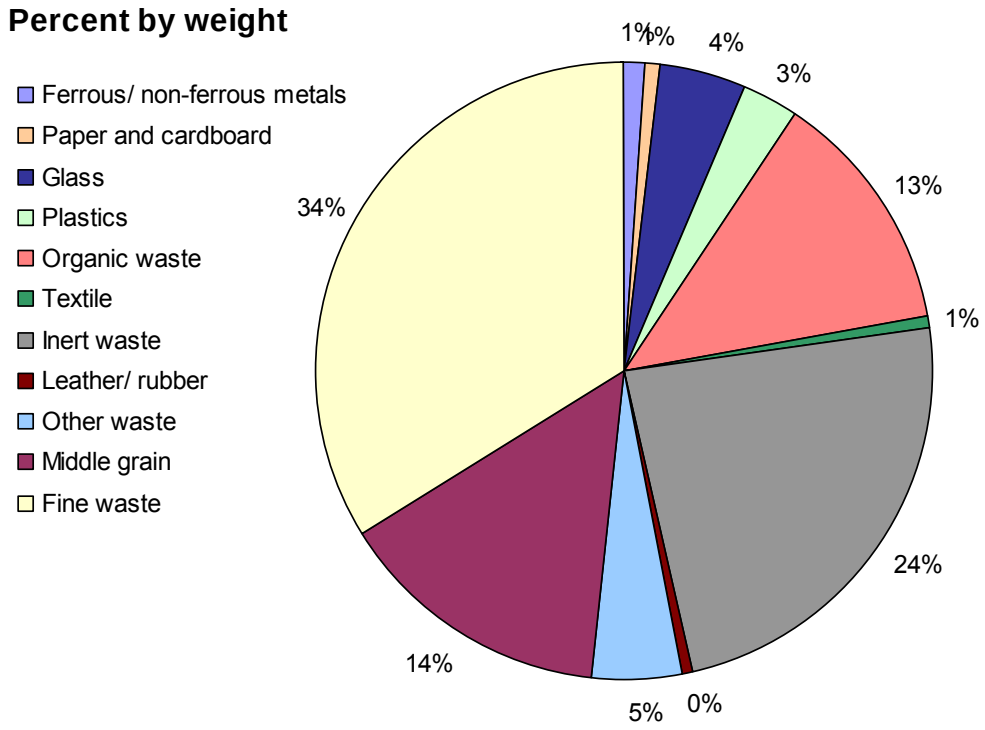
Waste amount: 8,31 m^3 and 1,65 t; Number of inhabitants: 1850

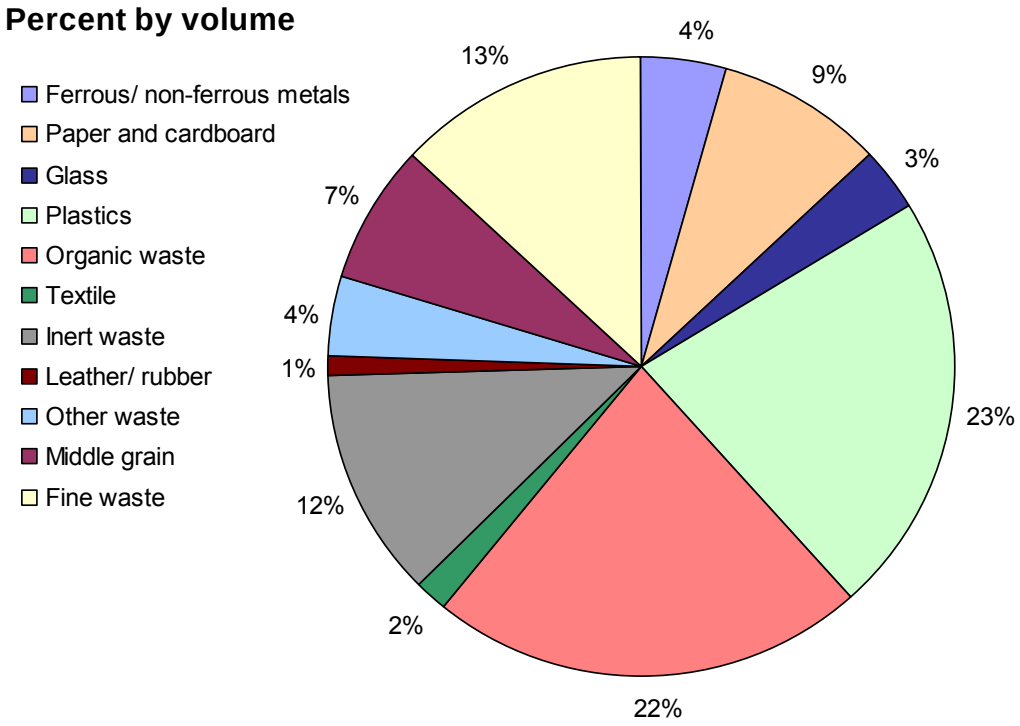




A. 5.2 Summer

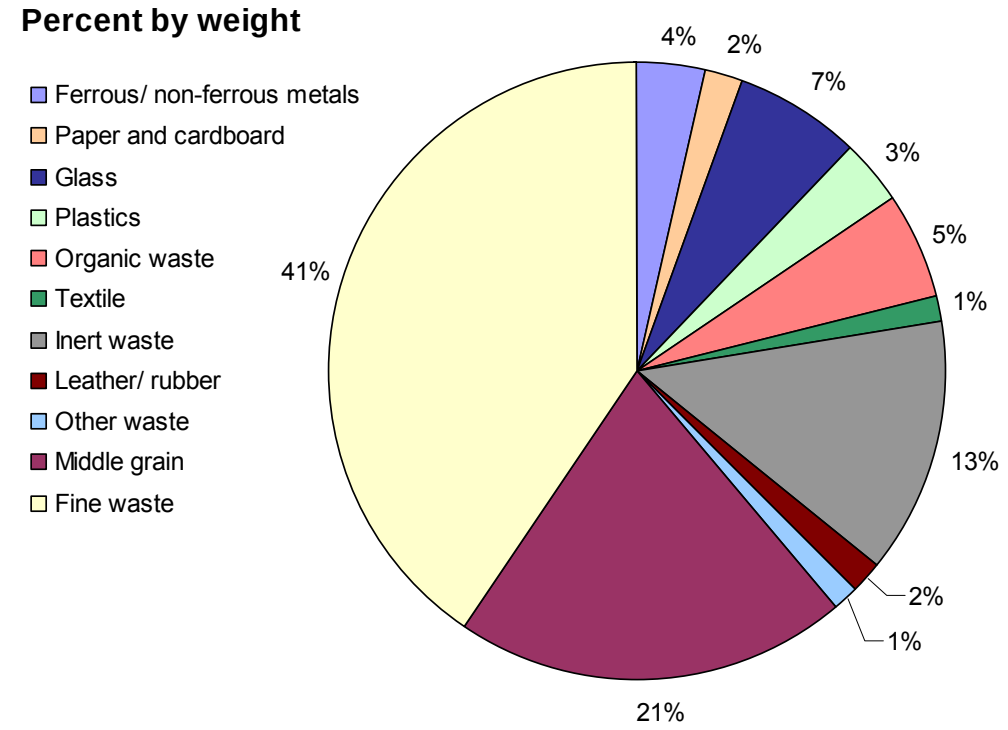
Waste amount: 5,23 m^3 and 1,51 t; Number of inhabitants: 765

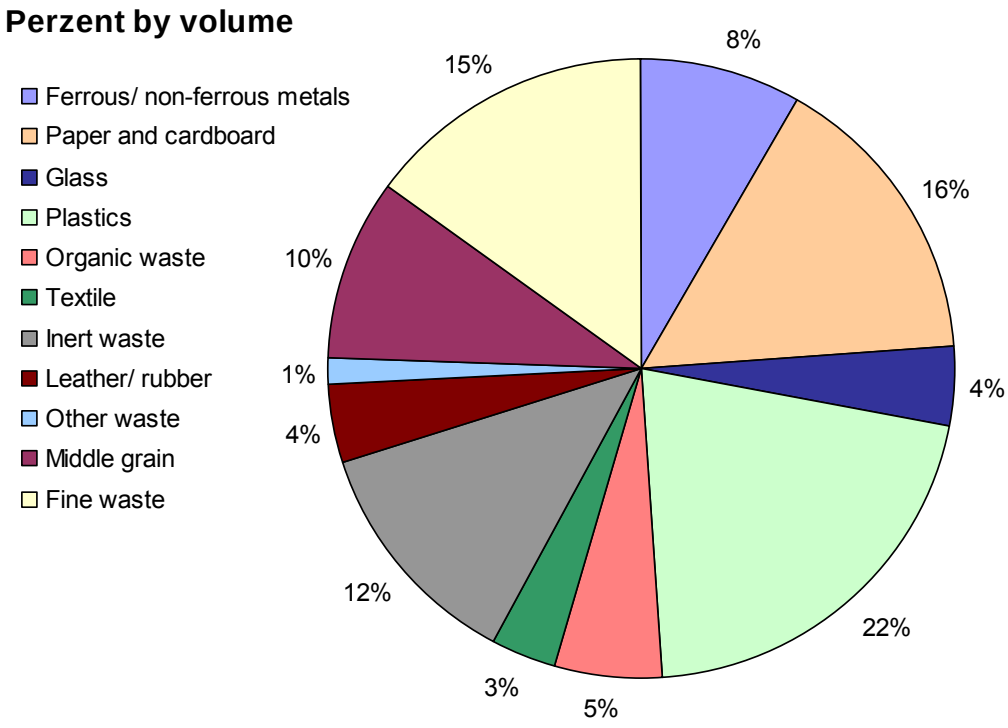




A. 5.3 Autumn

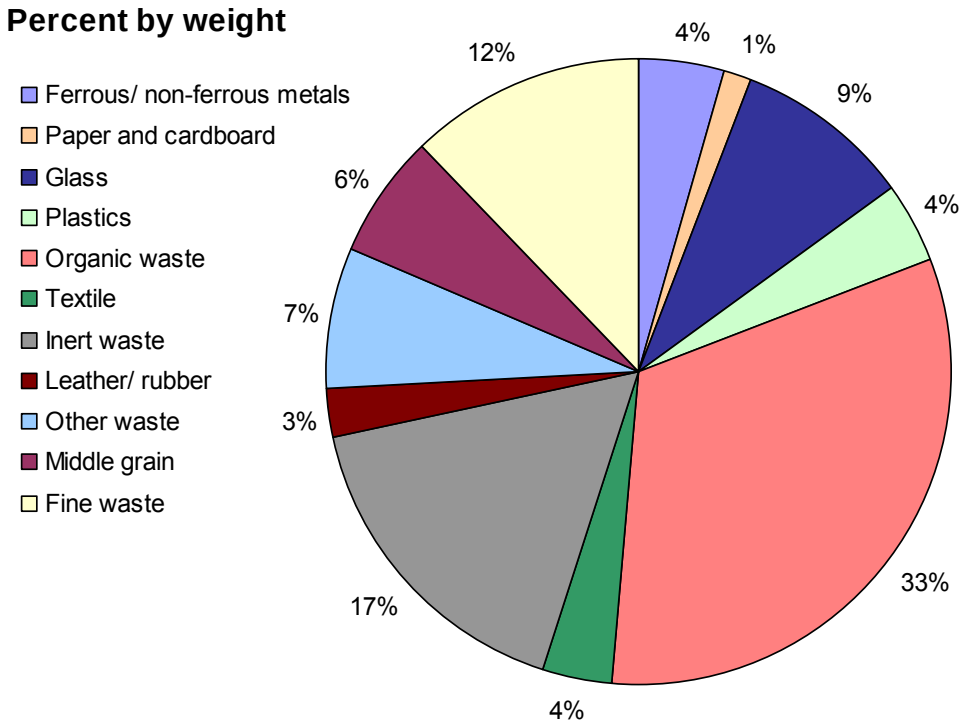
Waste amount: 8,8 m^3 and 2,9 t; Number of inhabitants: 220

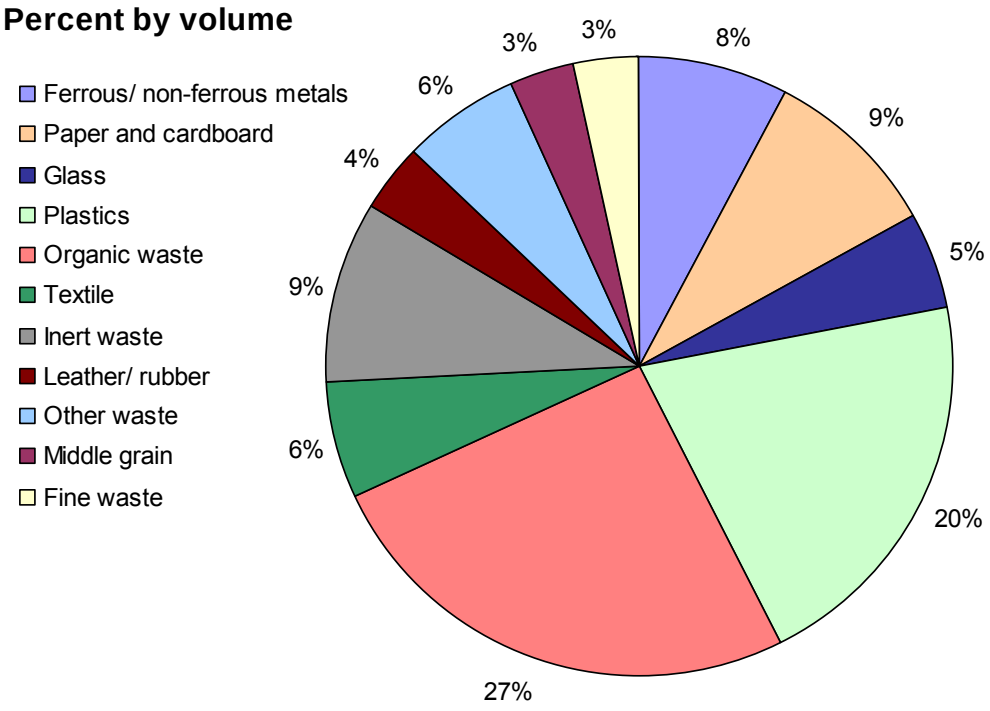




A. 5.4 Winter

Waste amount: 7,27 m^3 and 1,56 t; Number of inhabitants: 1200

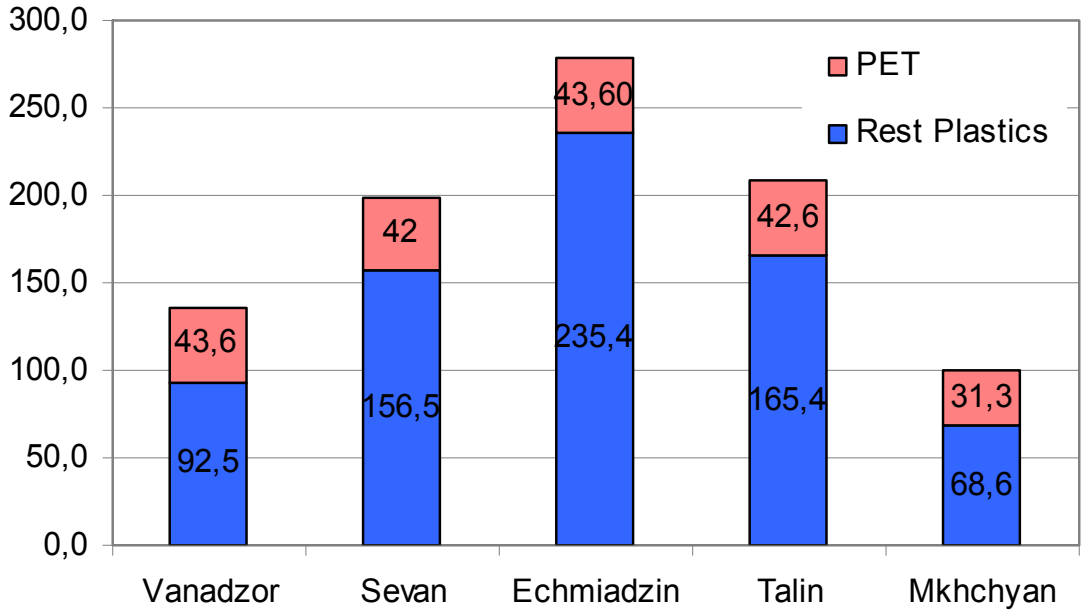




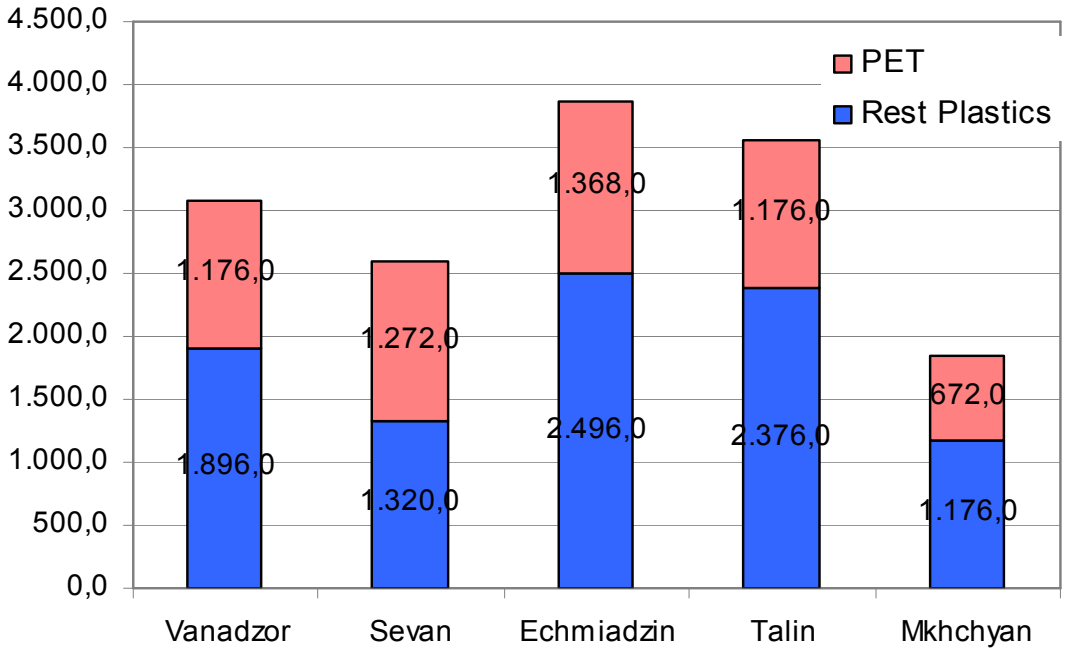
A. 6 Shares in PET and Rest Plastics in the Sorting Waste Amount

A. 6.1 Autumn

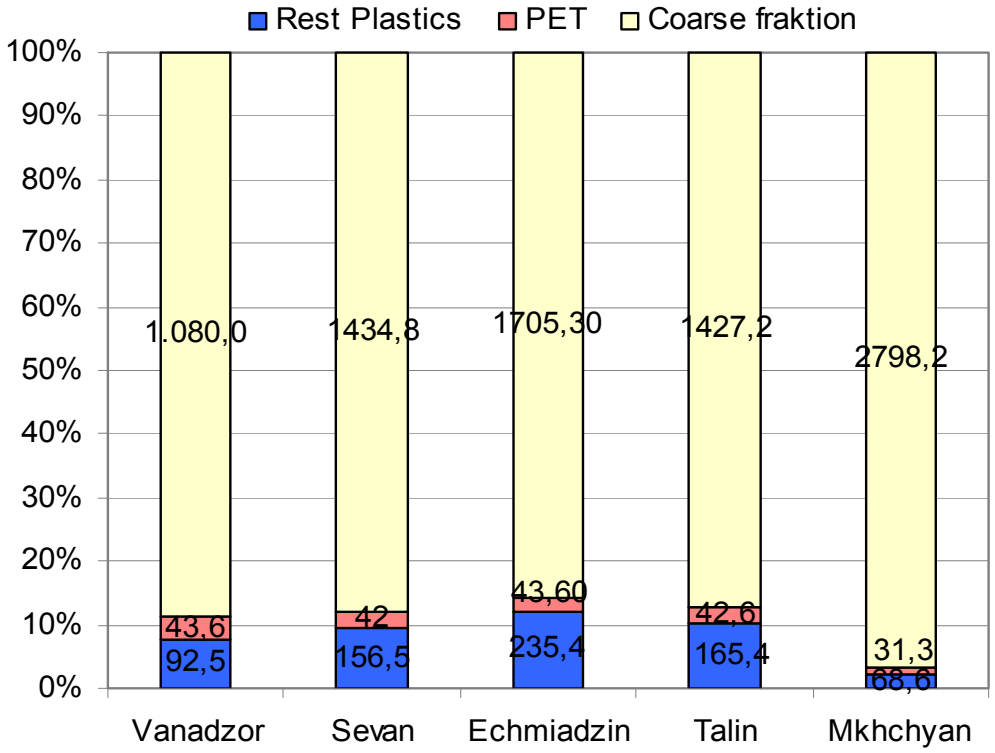
Shares in PET and Rest Plastics [kg] Autumn campaign



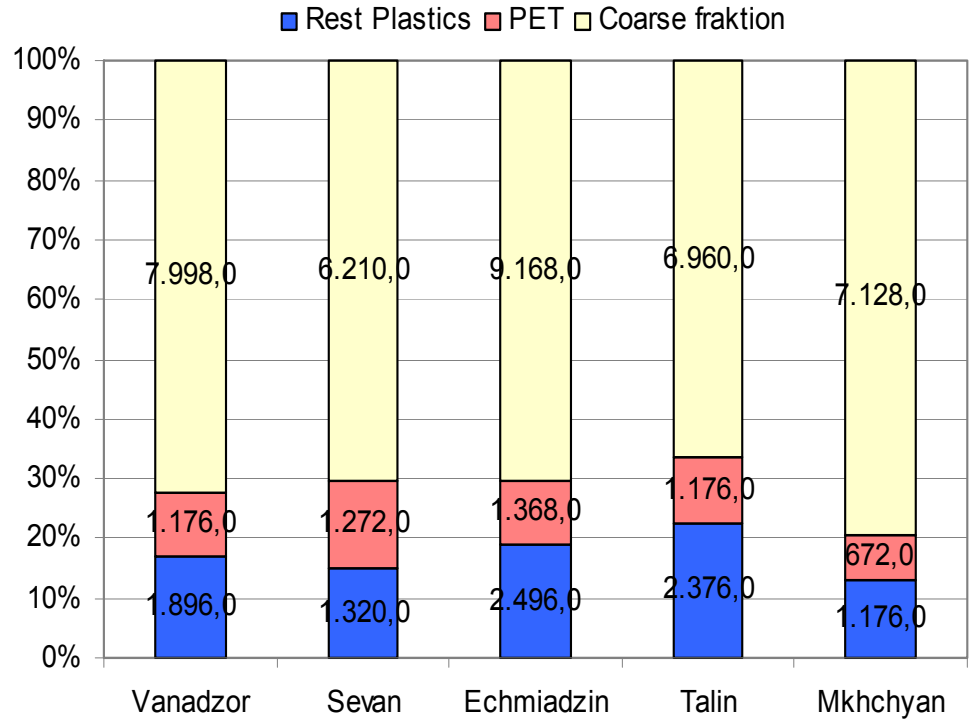
Shares in PET and Rest Plastics [l] Autumn campaign



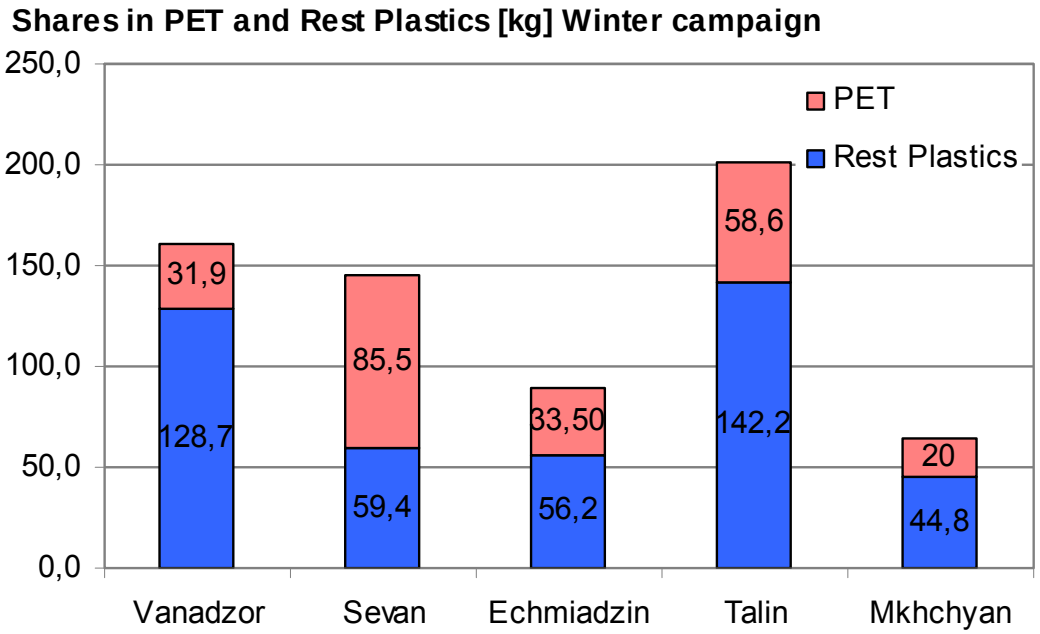
Shares in PET and Rest Plastics in the whole sorting waste amount [kg] Autmn campaign

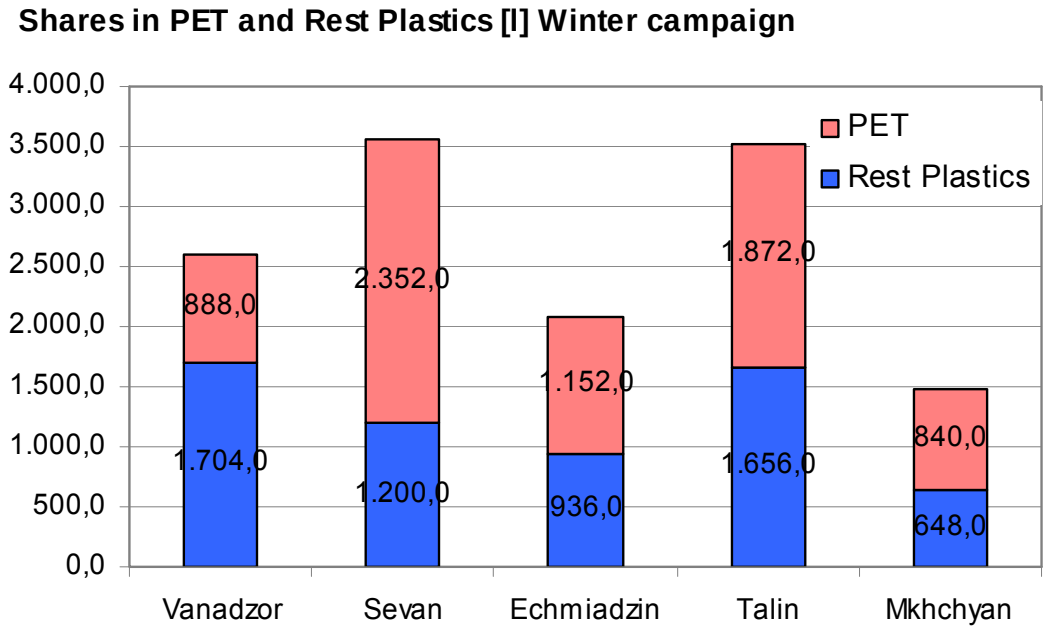


Shares in PET and Rest Plastics in the whole sorting waste amount [l] Autumn campaign

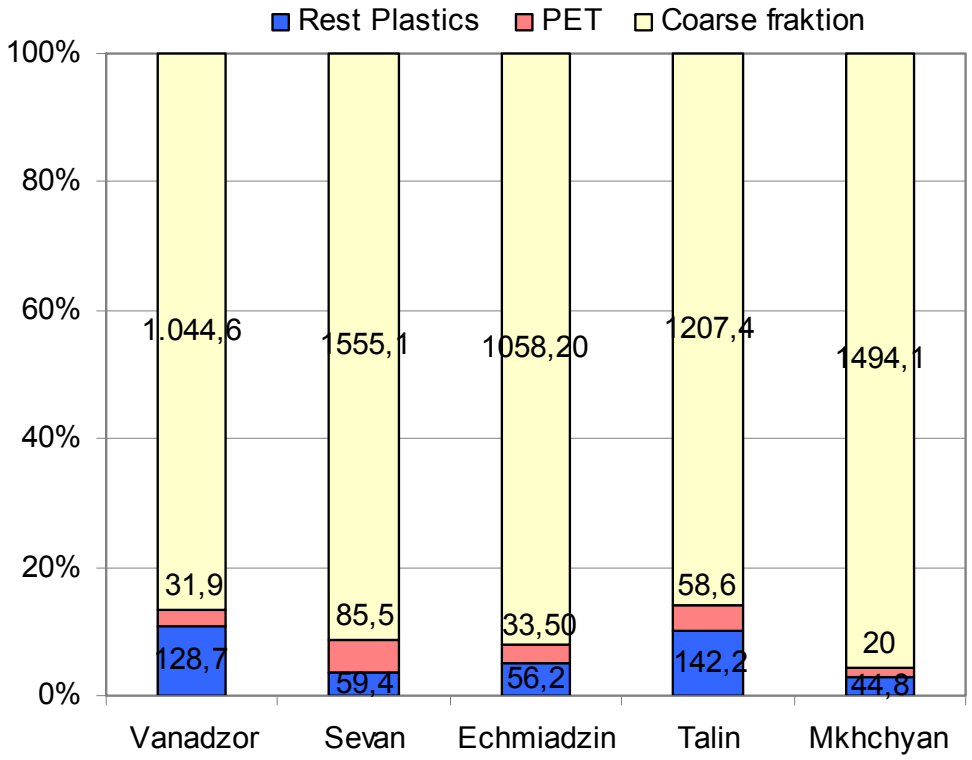


A. 6.2 Winter

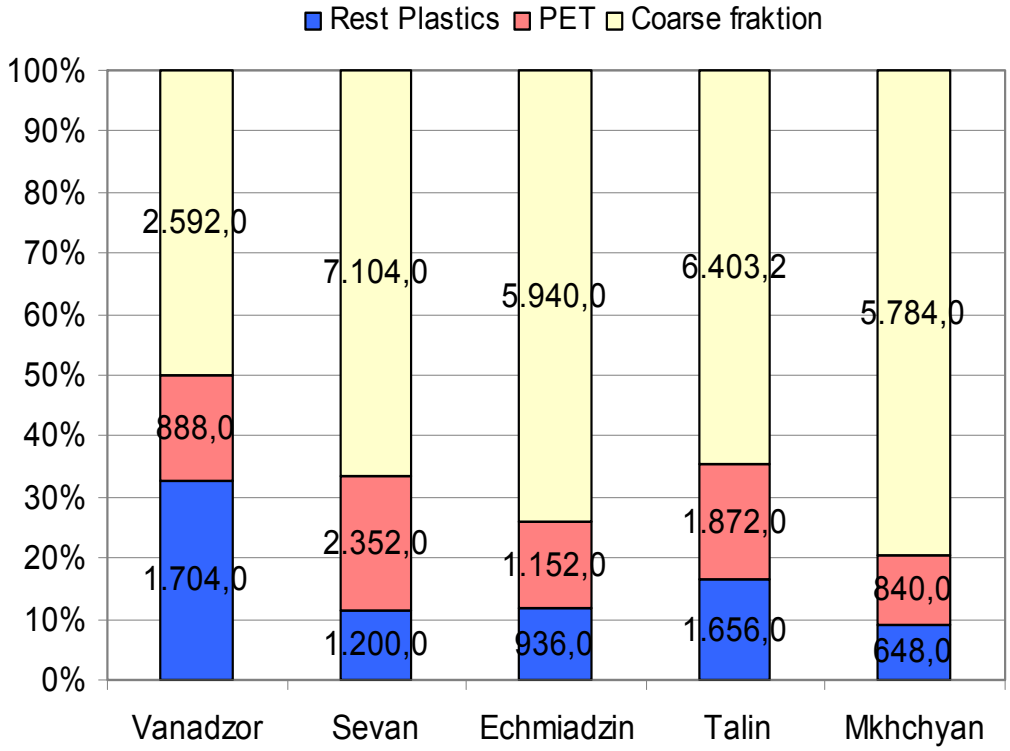

Shares in PET and Rest Plastics [kg] Winter campaign
250,0
200,0
150,0
100,0
50,0
0,0
PET
Rest Plastics
31,9
128,7
85,5
59,4
33,50
56,2
58,6
142,2
20
44,8
Vanadzor
Sevan
Echmiadzin
Talin
Mkhchyan


Shares in PET and Rest Plastics [l] Winter campaign
4.000,0
3.500,0
3.000,0
2.500,0
2.000,0
1.500,0
1.000,0
500,0
0,0
PET
Rest Plastics
888,0
1.704,0
2.352,0
1.200,0
1.152,0
936,0
1.872,0
1.656,0
840,0
648,0
Vanadzor
Sevan
Echmiadzin
Talin
Mkhchyan

Shares in PET and Rest Plastics in the whole sorting waste amount [kg] Winter campaign



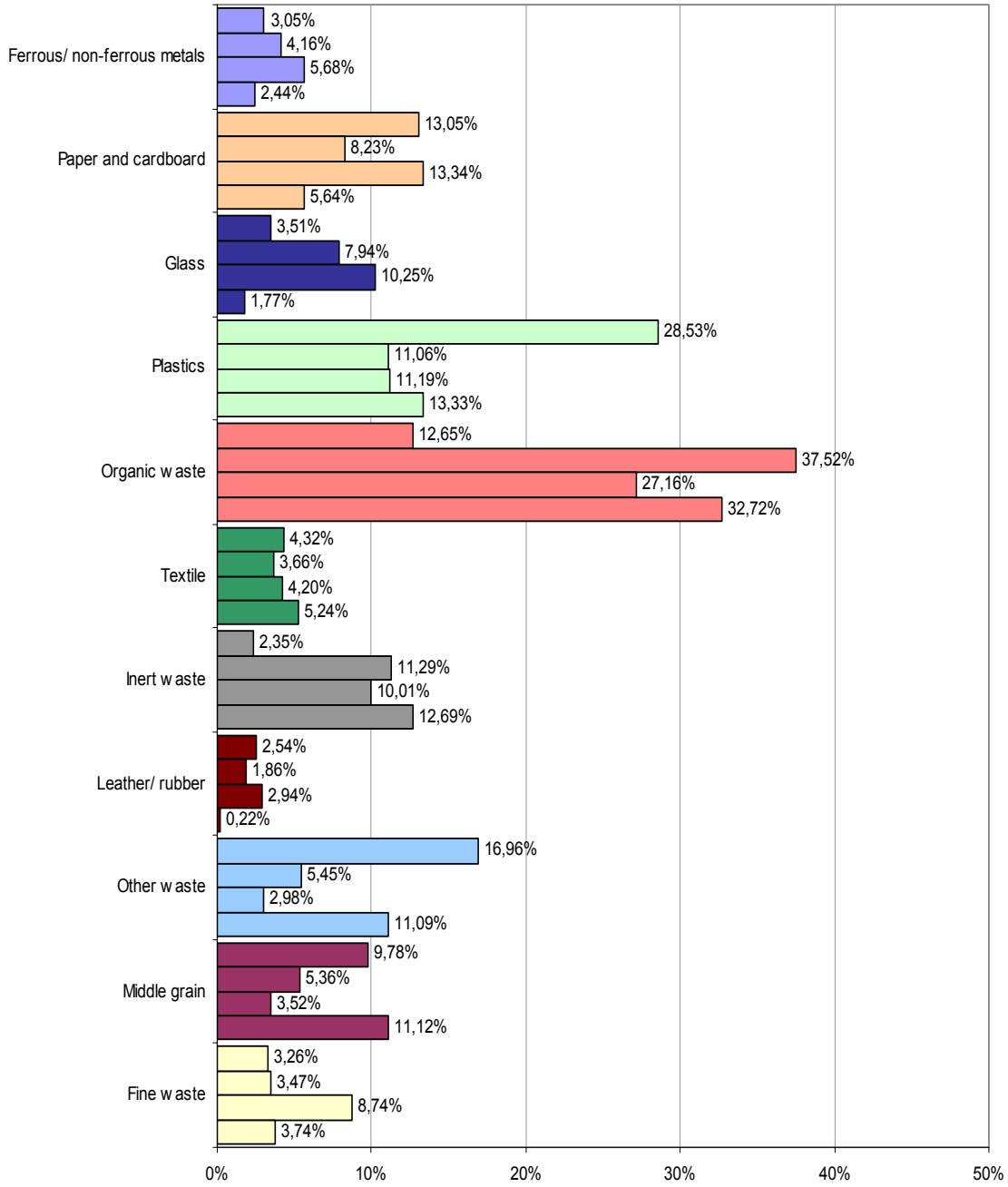
Shares in PET and Rest Plastics in the whole sorting waste amount [l] Winter campaign



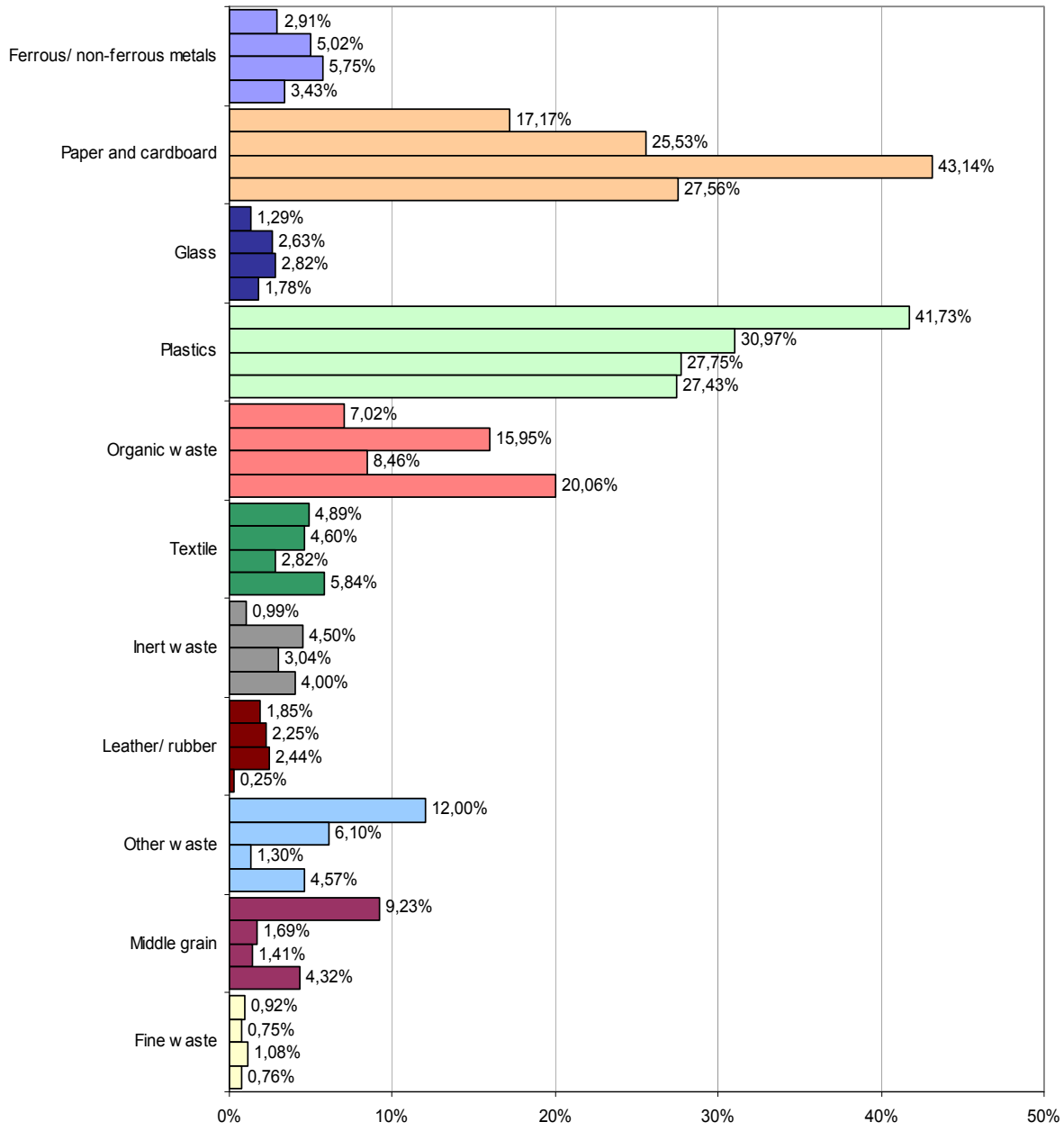
A. 7 Comparison of the Results Spring/ Summer/ Autumn/ Winter

A. 7.1 Comparison of the Results in city Vanadzor

a) Percent by weight

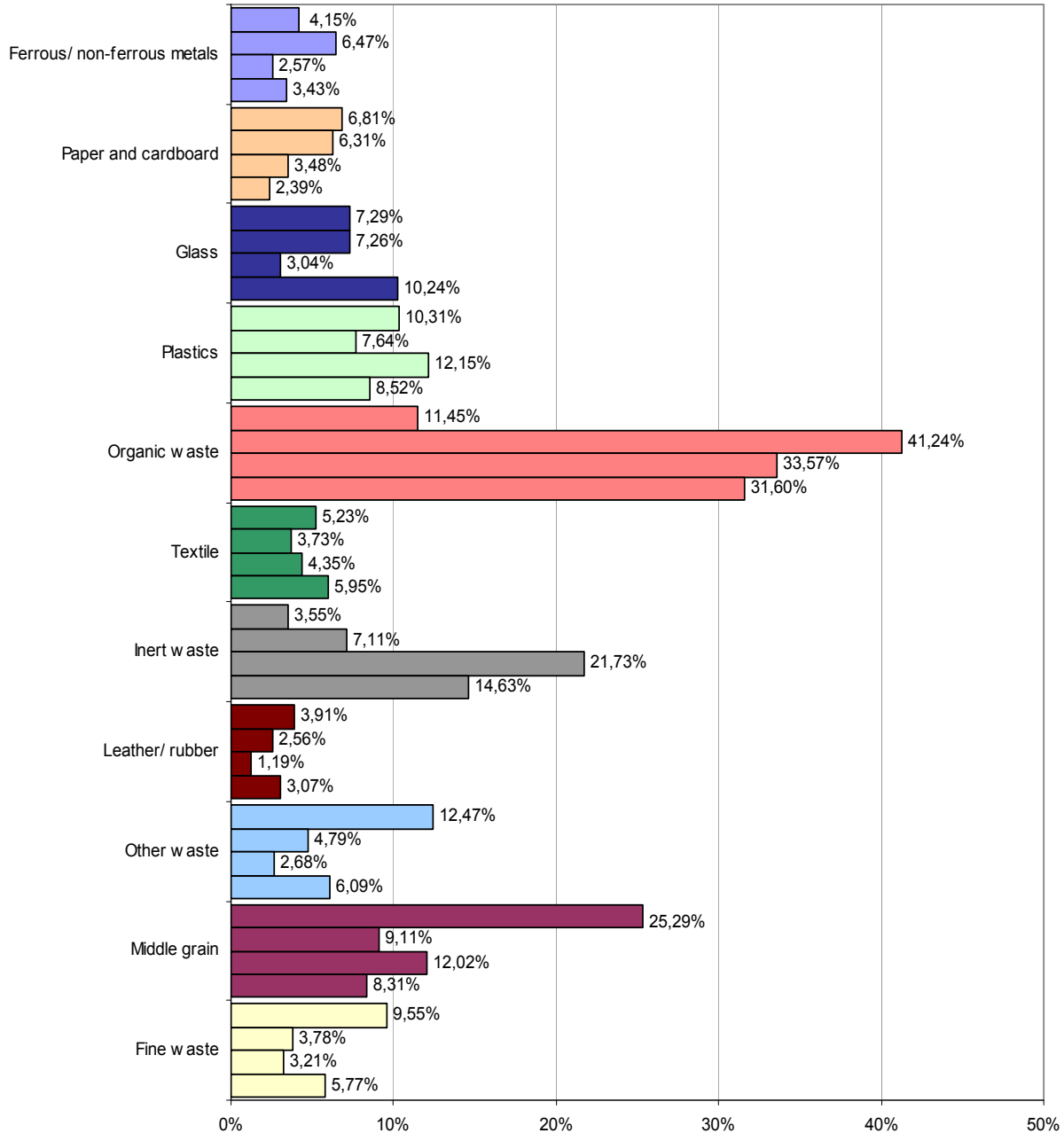


b) Percent by volume

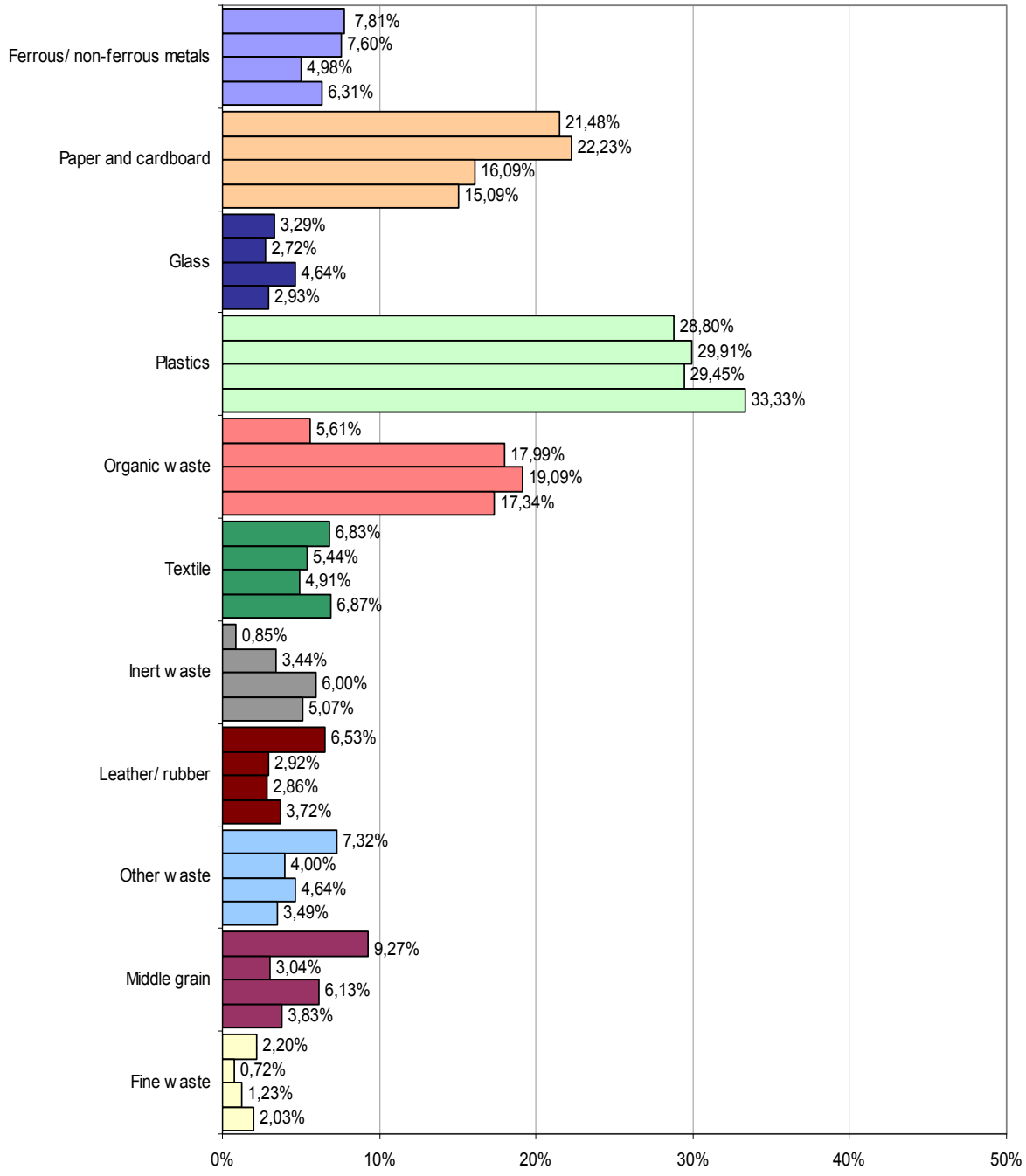


A. 7.2 Comparison of the Results in town Sevan

a) Percent by weight

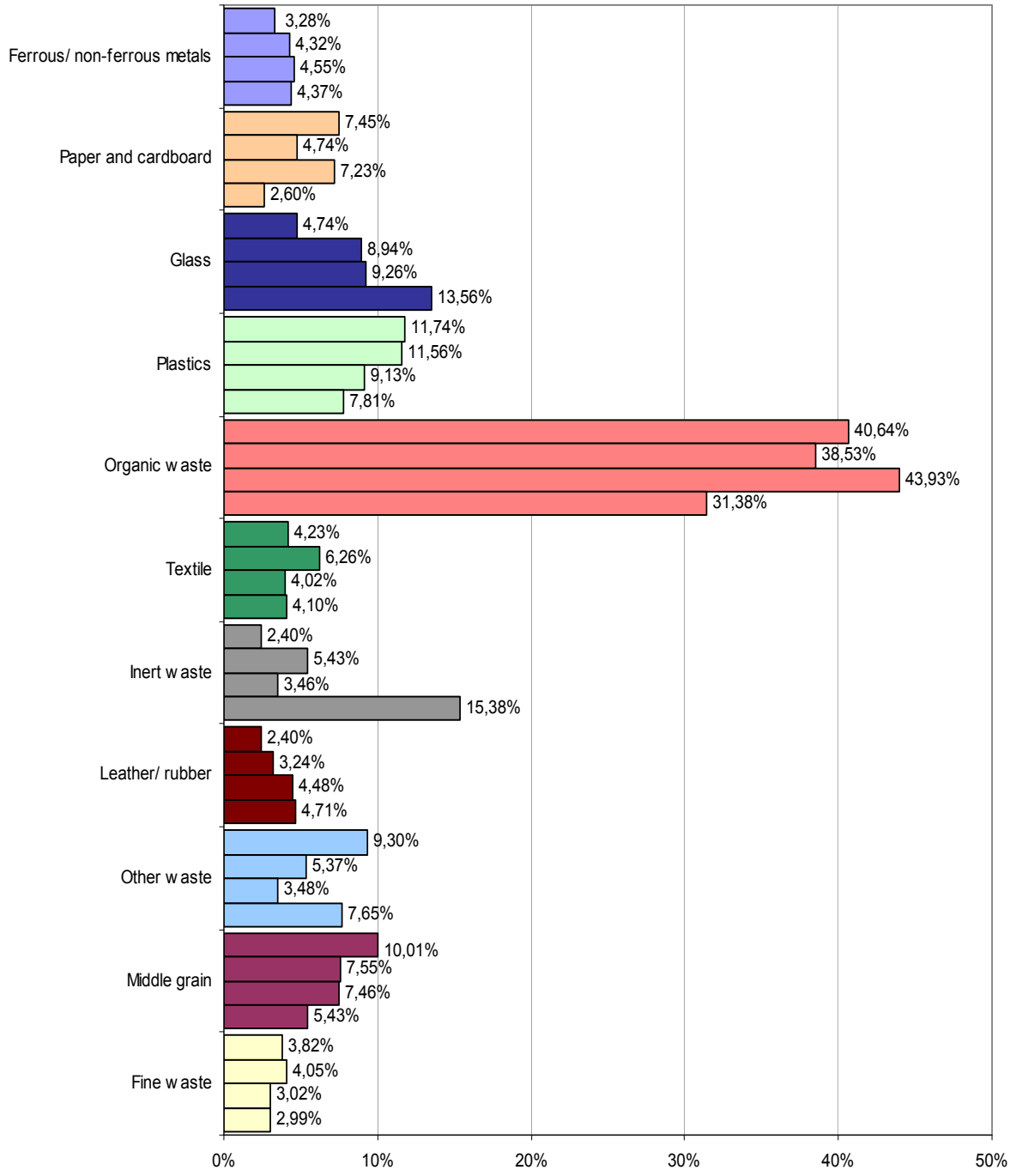


b) Percent by volume

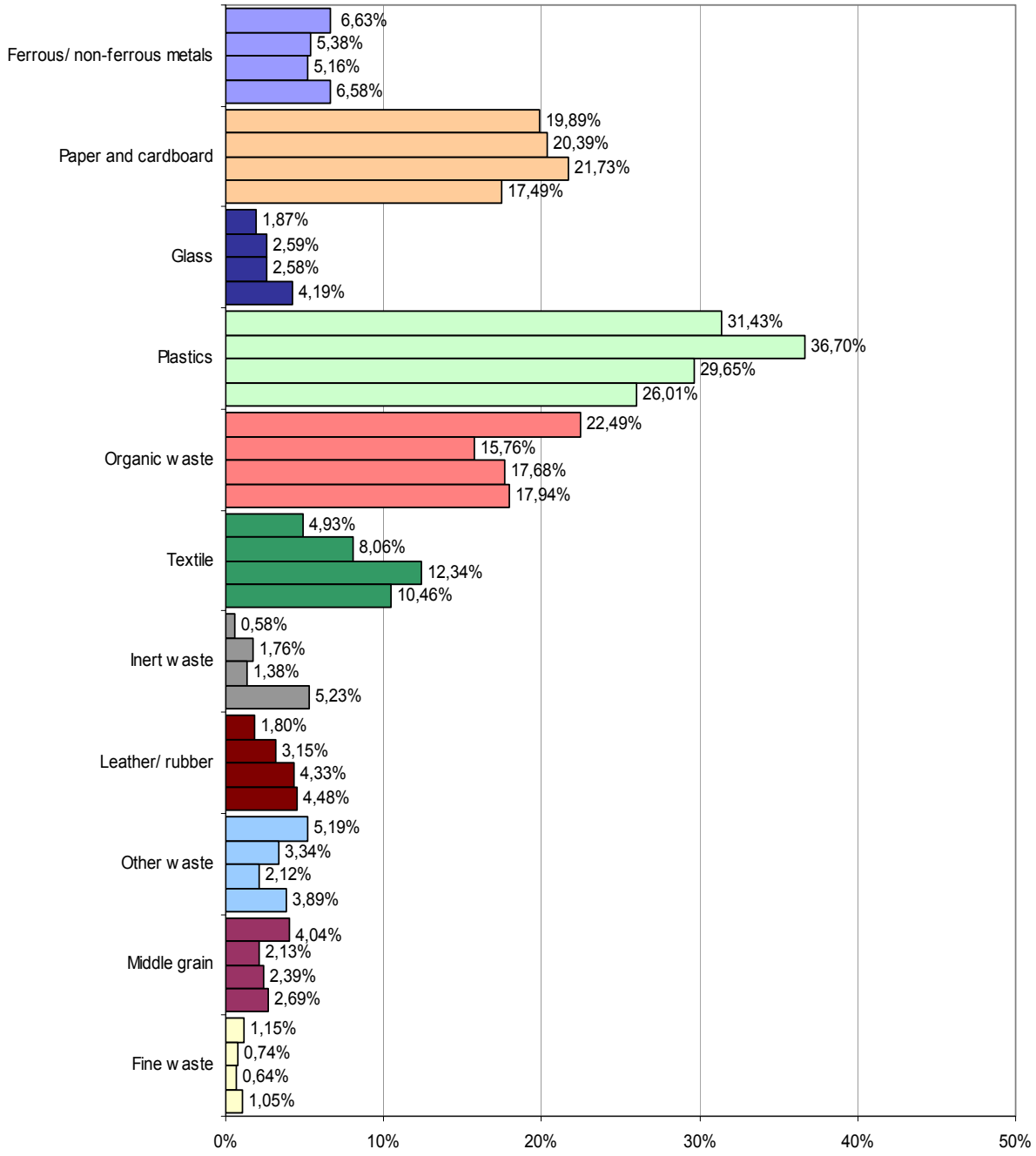


A. 7.3 Comparison of the Results in small town Echmiadzin

a) Percent by weight

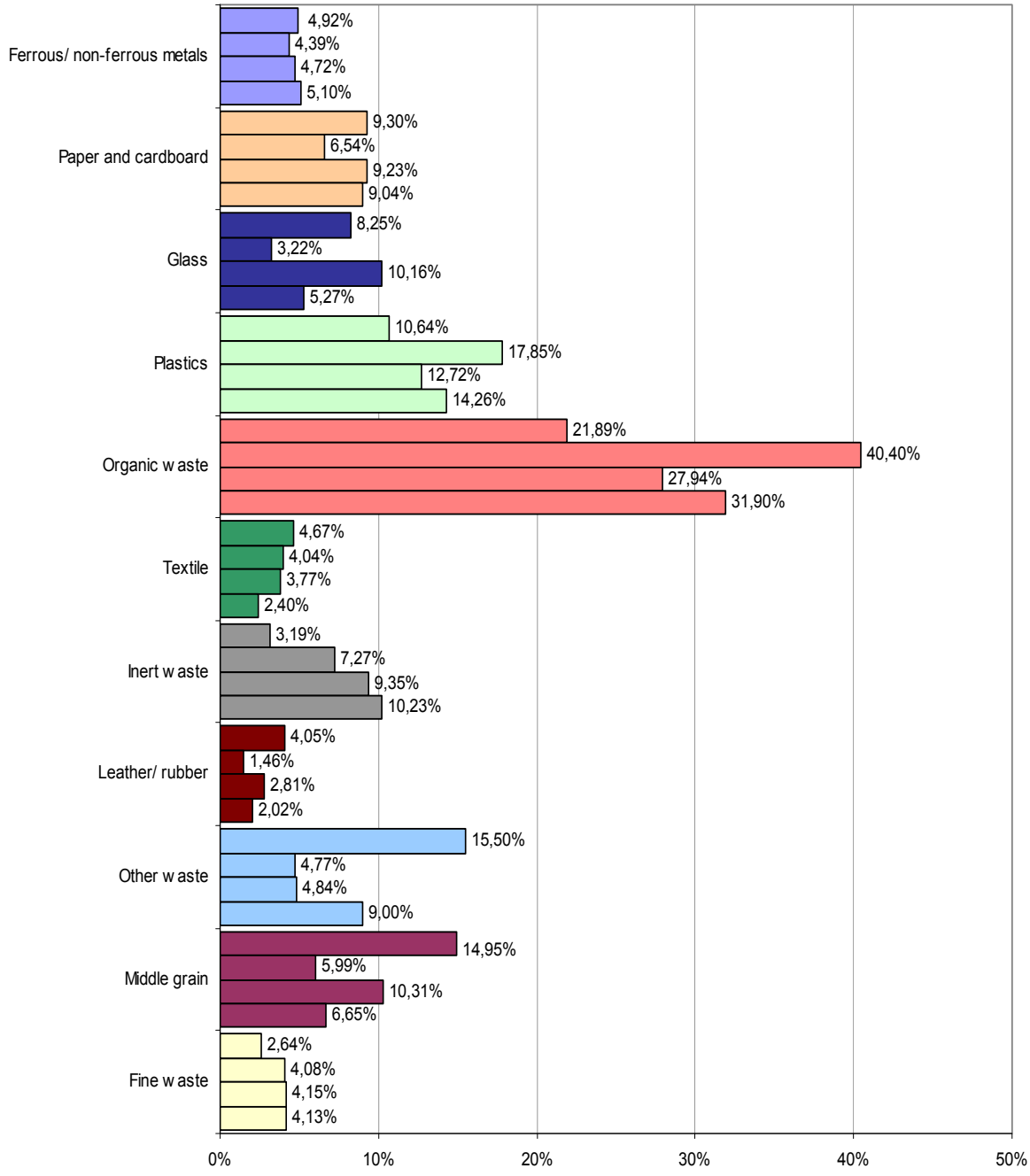


b) Percent by volume

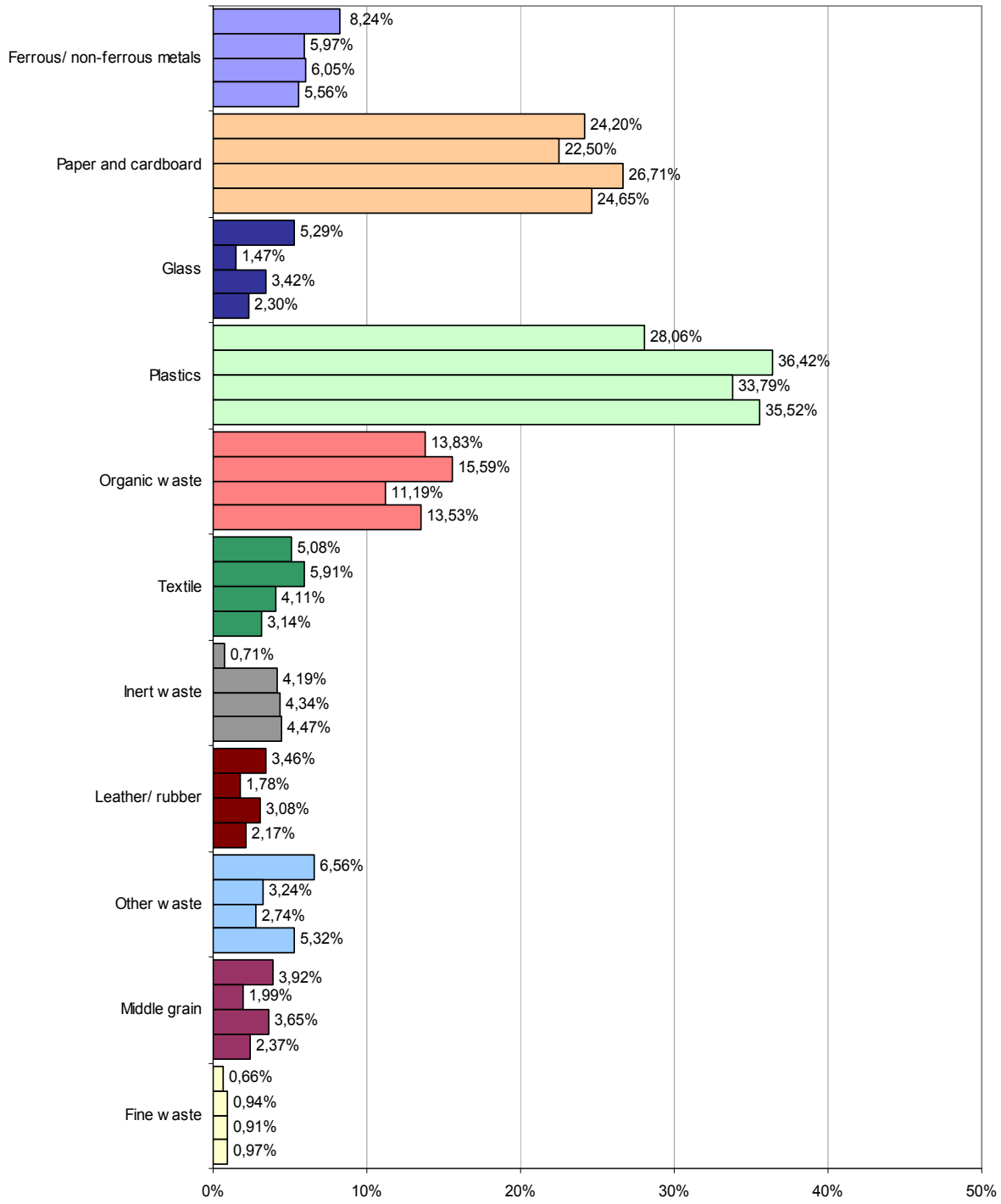


A. 7.4 Comparison of the Results in small town Talin

a) Percent by weight

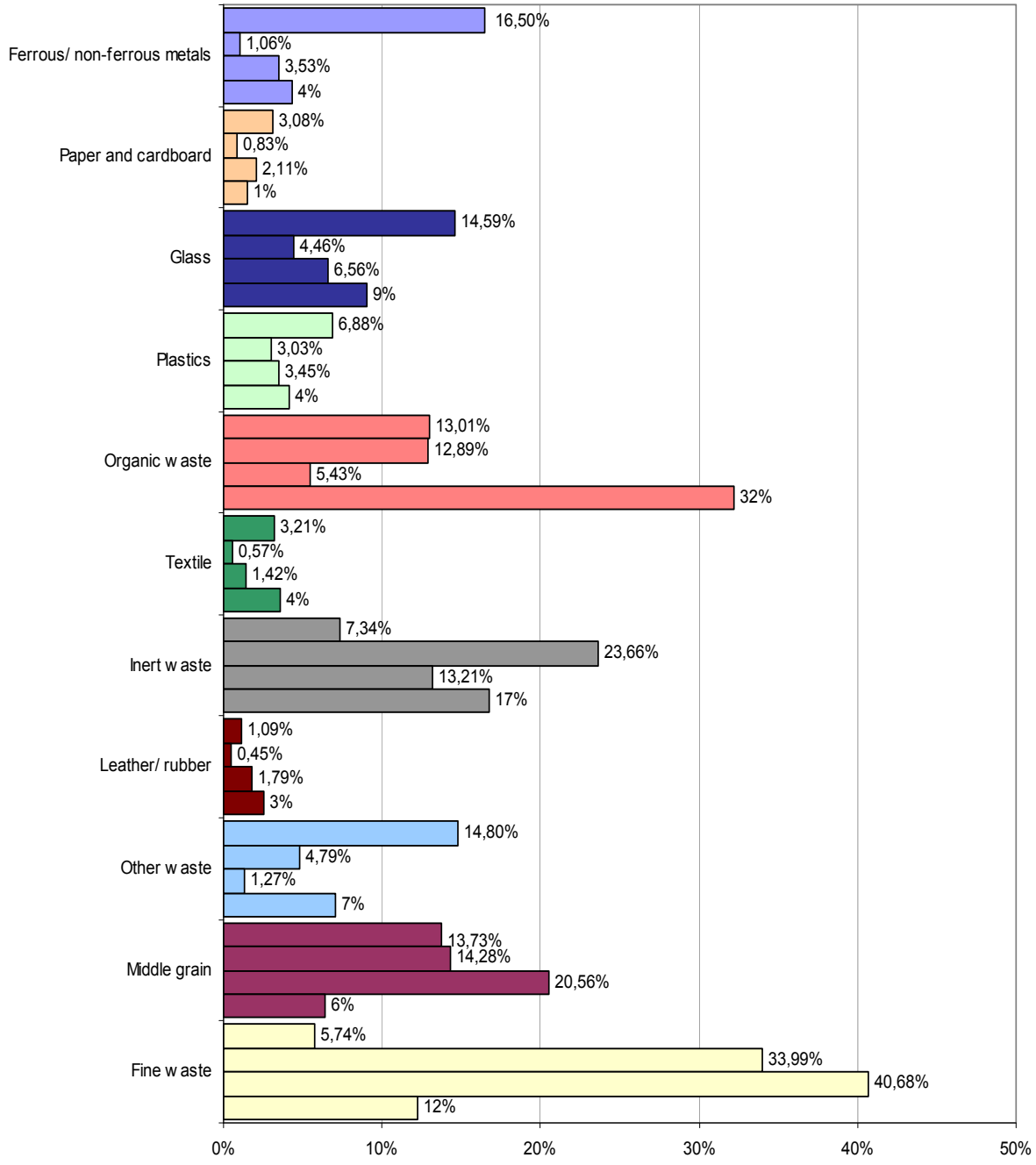


b) Percent by volume



A. 7.5 Comparison of the Results in Village Mkhchyan

a) Percent by weight



b) Percent by volume