

Intellectual Output 4

Curricula on Recycling

Part A

WASTE MANAGEMENT AND RECYCLING Handbook

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1. General

Waste management is one of the major global environmental issues and one of the challenges individuals, society, and the government have to face nowadays. Most of the products we use in our daily life are packaged and this is one of the main situations we have to deal with. Plastics, glasses, paper and aluminum are the main packaging materials that end up as waste. Packaging materials can be recycled and this is the positive aspect, but the negative is that we don't do it as much as we have to on a global scale. Awareness has to be raised on the effects of waste disposal in the environment.

The term "waste" refers to any substance or object which the holder discards or intends or is required to discard, while the term "waste management" refers to the collection, transport, recovery and disposal of waste, including the supervision of such operations and the after-care of disposal sites, and including actions taken as a dealer or broker (EU, 2008).

Sources of waste can be broadly classified into four types: Industrial, Commercial, Domestic, and Agricultural. Every human activity produces waste and their specific characteristics make their management complicated. Waste generation and composition is something more complex than we think and is driven by culture, economic development, climate, and energy sources. Waste composition determines the frequency of waste collection and the disposal method.

In the context of the project, schools are informed on waste management issues with emphasis on the management of household waste and waste found in the school. Types of waste produced in everyday life include:

1. Biowaste 
2. Plastics / packaging materials 
3. Paper 
4. Glass 
5. Metal

"Waste hierarchy", defines the priority of decisions and actions to be taken to manage our waste sustainably. Over time, waste management has changed. Actions that in the past were considered as improvements do not seem to have the same effect nowadays. There has been a significant change in the hierarchy of waste management compared to the previous century.

The European Union's (EU, 2008) approach to waste management is based on the "[waste hierarchy](#)" which sets the following priority order (Images 3 and 4) when shaping waste policy and managing waste at the operational level: prevention, (preparing for) reuse, recycling, recovery and, as the least preferred option, disposal (which includes landfilling and incineration without energy recovery).

The basic principles of waste management are described in the following chapters. It is important for anyone attending this course or using this curricula for teaching, to understand suggested waste management practices at the European level and to which extent are followed by the countries which are participating in the project. Exchange of knowledge and best practices can contribute to raise awareness of young people and improve their overall environmental behavior.

1.1 Waste categories

1.1.1 Food waste

According to Fussions (2016), food waste is “Fractions of “food and inedible parts of food removed from the food supply chain” to be recovered or disposed of (including - composted, crops plowed in/not harvested, anaerobic digestion, bioenergy production, co-generation, incineration, disposal to sewer, landfill or discarded to sea)”

One of the main targets in the EU is to halve per capita food waste at the retail and consumer level by 2030 and reduce food losses along the food production and supply chains.

1.1.2 Packaging materials

Nearly all products of daily use are packaged, so packaging materials have to be disposed. The types of packaging materials include:

- Plastic

Plastic production is widespread and is found in almost all sectors of modern society. They are mainly used as packaging materials but are found in the construction industry, electronics and vehicles, too. Image 1 shows plastics demand in Europe in 2015. It seems that the products and their demand vary.

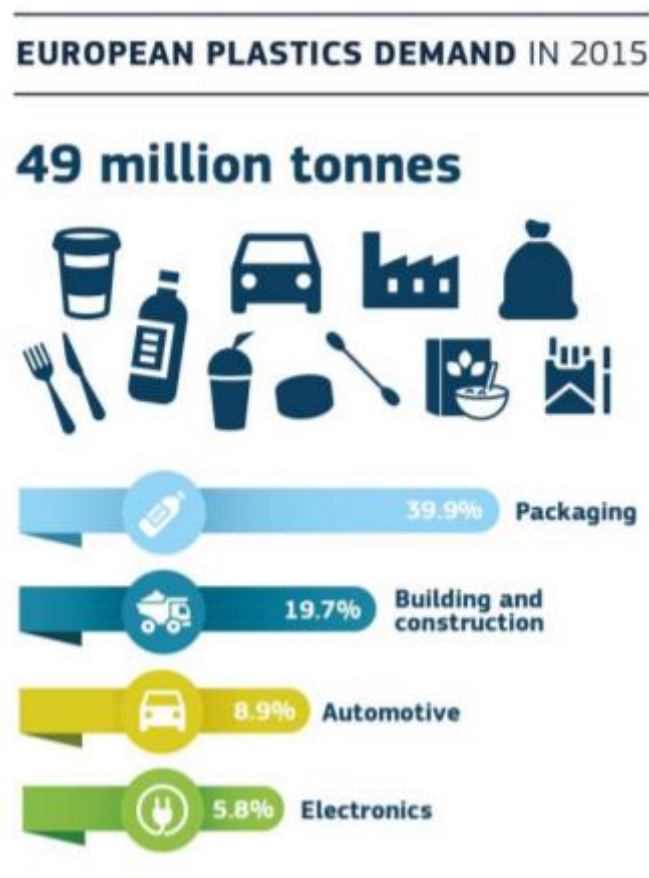


IMAGE 1. EUROPEAN PLASTICS DEMAND IN 2015, EUROPEAN COMISSION (2018)

- Paper and cardboard

Paper is also in high demand as a packaging material for modern societies. Figure 1 shows the production volume of paper and cardboard worldwide between 2007 to 2017, which

appears to grow globally reaching 419.69 million tons in 2017. The quantities required for packaging are huge.

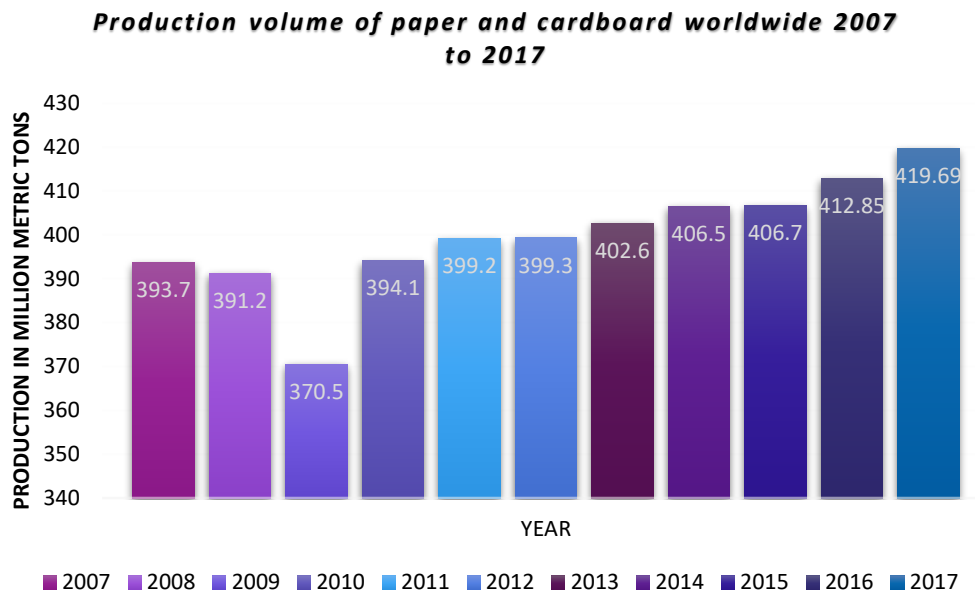


FIGURE 1. PRODUCTION VOLUME OF PAPER AND CARDBOARD WORLDWIDE FROM 2007 TO 2017, SOURCE: STATISTA 2020

Specifically for the European Union, the different quantities of paper produced by each country are represented in Image 2. The image is a map that shows total paper and cardboard production according to Eurostat.

- Glass

Glass packaging” had the highest value in terms of preservation of the quality of food and was the only packaging material that could guarantee that there would be no toxic substance transfer from the package to the food” according to Yaris et al. (2017).

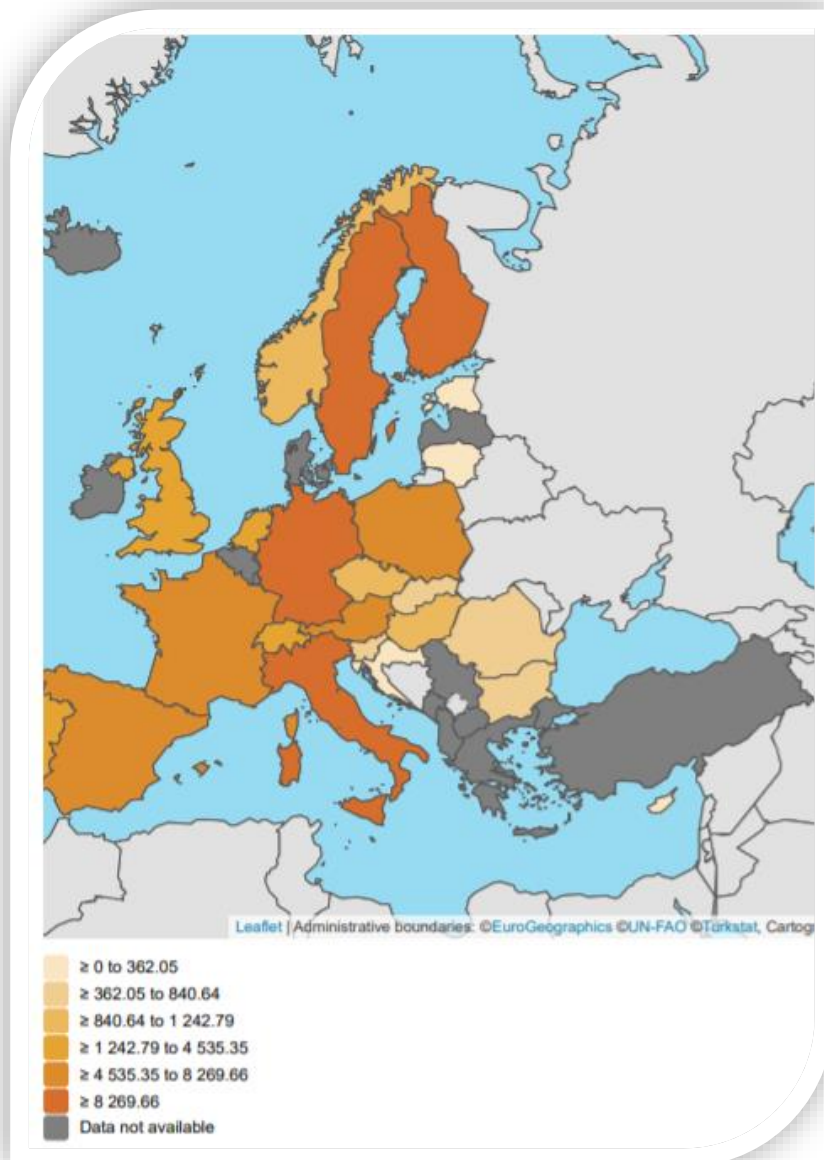


IMAGE 2. TOTAL PAPER AND PAPERBOARD PRODUCTION, EUROSTAT (2018)

1.2 European legislation on waste management

First on the list is one of the directives EU has since the '90s. European Union in 1994 had given a directive on packaging materials and packaging waste. Specifically, **Directive 94/62** defines packaging, the composition of packaging materials, and packaging waste. The definition for packaging waste according to Directive 94/62 *“‘packaging’ shall mean all products made of any materials of any nature to be used for the containment, protection, handling, delivery, and presentation of goods, from raw materials to processed goods, from the producer to the user or the consumer. ‘Non-returnable’ items used for the same purposes shall also be considered to constitute packaging”*. There is the text in which prevention, reuse, recovery, recycling, energy recovery, and organic recycling completes the holistic view on waste management in the EU.

It is quite important to mention that Directive 94/62/EC “covers all packaging materials placed in the market in the Community and all packaging waste, whether it is used or released at the industrial,

commercial, office, shop, service, household or any other level, regardless of the material used. They even have requirements in heavy metals.”

Targets set by the Directive for recycling and recovery are as follows:

1. Maximum in five years from the date by which this Directive must be embedded in national legislation, between 50 % as a minimum and 65 % as a maximum by weight of the packaging waste will be recovered
2. Within the same timeframe, between 25 % as a minimum and 45 % as a maximum by weight of the totality of packaging materials contained in packaging waste will be recycled with a minimum of 15 % by weight for each packaging material
3. In less than 10 years time, the percentage of packaging waste that will be recovered and recycled will have to be determined by Council

More information is available at:

<https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31994L0062&from=en>

14 years after setting those targets, EU moved on the next step with a new Directive which sets goals for the reduction of materials we use in our daily life. Specifically, according to the Waste Framework **Directive (2008/98)**:

1. By 2020 preparing for re-use and recycling of waste materials such as at least paper, metal, plastic, and glass from households and possibly from other origins shall be increased to a minimum of overall 50 % by weight.
2. Also by 2020, the preparing for re-use, recycling, and another material recovery, including backfilling operations using waste to substitute other materials, of non-hazardous construction and demolition waste excluding naturally occurring material defined in category 17 05 04 in the list of waste shall be increased to a minimum of 70 % by weight.

Directive 2008/98/EC sets again the basic concepts and definitions related to waste management, such as definitions of waste, recycling, recovery. It explains when waste ceases to be waste and becomes a secondary raw material (so-called end-of-waste criteria), and how to distinguish between waste and by-products. The Directive lays down some basic waste management principles: it requires that waste should be managed without endangering human health and harming the environment, and in particular without posing any risk to water, air, soil, plants or animals, without causing a nuisance through noise or odors, and without adversely affecting the countryside or places of special interest.

The Directive 2008/98/EC introduces the "**polluter pays principle**" and the "extended producer responsibility". It incorporates provisions on hazardous waste and waste oils (old Directives on hazardous waste and waste oils being repealed with the effect from 12 December 2010), and includes two new recycling and recovery targets to be achieved by 2020:

- 50% preparing for re-use and recycling of certain waste materials from households and other origins similar to households
- 70% preparing for re-use, recycling, and another recovery of construction and demolition waste.

The Directive requires that the Member States adopt waste management plans and waste prevention programs.

More information is available at:

<https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008L0098&from=EN>

1.3 Waste Management pyramid hierarchy

The way we manage our waste was not always the same. Priorities are defined by the “waste management hierarchy”, which is reversed nowadays compared to the past century. So, this is a sign that we can change complete the priorities we first set in a different period.

Waste used to end up in landfills in the past, while today this is the least preferable option. Image 3 and Image 4 show how waste management was structured in the past and how it is or how it has to be right now on a global scale. This is called the waste management hierarchy.

The key to proper waste management is to follows of this hierarchy. The sequence of procedures is prevention, reuse, recycling, recovery, and as a last choice the rejection in a suitable place. However, attention seems to be focused on recycling and not so much on prevention if one considers the increase in the production of plastics over time.

The inverted triangle of the waste management hierarchy explains the way we should handle the situation. The sequence of acts that a society has to follow to manage in an ideal way the produced waste is prevention, reduction, reuse, recycle, transformation, waste to energy, and last disposal. This concept aligns very well with the basic principles of Circular Economy, which seems to be the most preferable economic model that the European Union suggests for sustainable development of the member countries (EU, 2020).

It is crucial to see how numbers reflect the actions taken in European level.

Figure 2 shows the evolution of municipal recycle waste per capita from 1995 to 2018. The increase of quantities of recyclable materials during time is significant.

Figure 3 presents a comparison of the percentage of waste treated with different practices in the years 1995 and 2018. Data were retrieved after calculating the percentage of average values of the municipal waste production (kg per capita) which are treated with each method.



IMAGE 3. WASTE MANAGEMENT PYRAMID 20TH CENTURY, SOURCE: FAGARIBA AND SONG, 2017

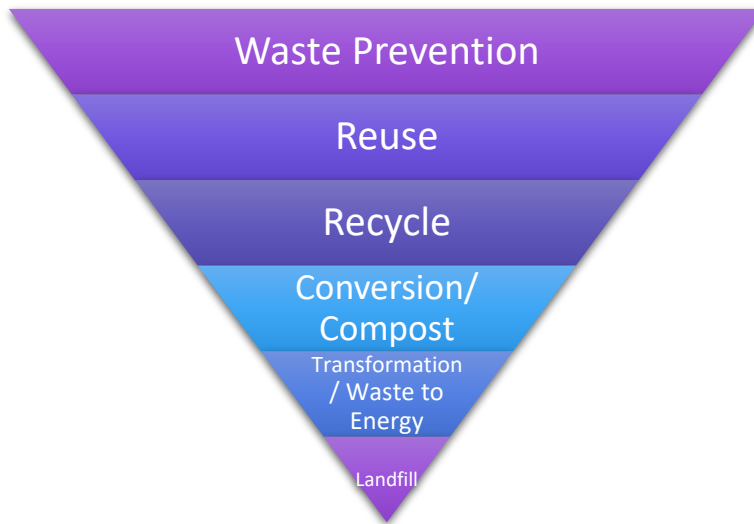


IMAGE 4. WASTE MANAGEMENT PYRAMID 21ST CENTURY, SOURCE: FAGARIBA AND SONG, 2017

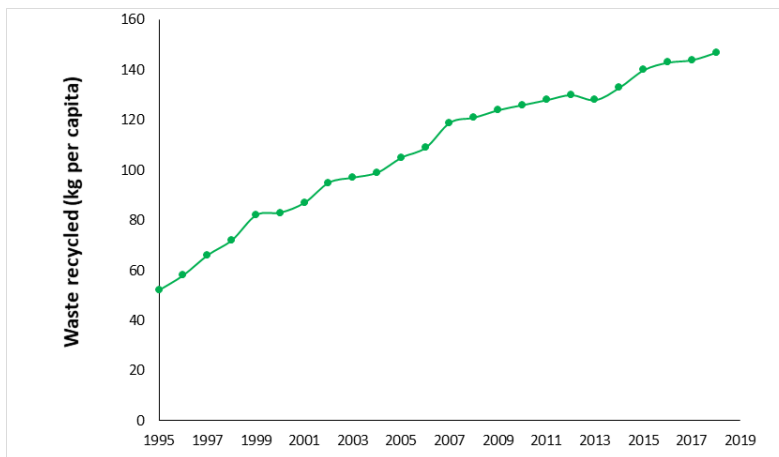


FIGURE 2. MUNICIPAL RECYCLE WASTE PER CAPITA EU-28 1995 TO 2018, (RAW DATA OBTAINED FROM EUROSTAT)

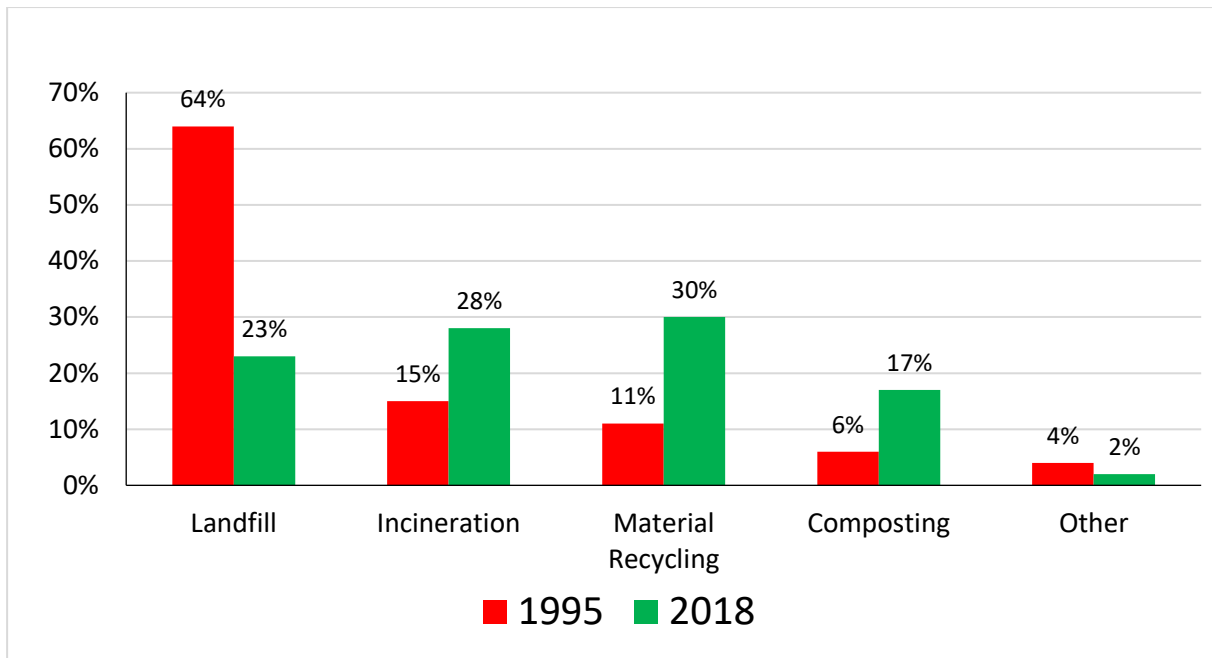


FIGURE 3. COMPARISON OF WASTE MANAGEMENT BETWEEN 1995 TO 2018, (RAW DATA OBTAINED FROM EUROSTAT)

1.4 Circular Economy and Waste Management

The circular economy seems to be a major goal for the European Union. *The circular economy is a new model of production and consumption.* This model includes principles such as sharing, reusing, and recycling existing materials and products as much as possible to extend the life cycle of products. The general model for circular economy is presented schematically in Image 5.

It is understandable that when a system works as a cycle the leaks that will exist will be minimal. The waste that will be produced under such a model will have been significantly reduced as in the various proposed ways they will regain some useful value.

The European Union has created “A new Circular Economy Action Plan For a cleaner and more competitive Europe” in 2020. The report suggests actions for all categories of waste such as electronic wastes, batteries, vehicles, plastics, packaging, and food waste. This Circular Economy Action Plan provides a future-oriented agenda for achieving a cleaner and more competitive Europe in co-creation with economic actors, consumers, citizens and civil society organisations. It aims at accelerating the transformational change required by the European Green Deal, while building on circular economy actions implemented since 2015⁶. This plan will ensure that the regulatory framework is streamlined and made fit for a sustainable future, that the new opportunities from the transition are maximised, while minimising burdens on people and businesses. The plan presents a set of interrelated initiatives to establish a strong and coherent product policy framework that will make sustainable products, services and business models the norm and transform consumption patterns so that no waste is produced in the first place. This product policy framework will be progressively rolled out, while key product value chains will be addressed as a matter of priority. Further measures will be put in place to reduce waste and ensure that the EU has a wellfunctioning internal market for high quality secondary raw materials. The capacity of the EU to take responsibility for its waste will be also strengthened.

More information is available in <https://ec.europa.eu/environment/circular-economy/>



IMAGE 5. OPERATION OF CIRCULAR ECONOMY, SOURCE: EUROPEAN COMMISSION, 2020

2. About prevention

Prevention is the first and most important action that needs to be taken according to the waste hierarchy. Prevention is about producing less waste, thus reducing the amount of waste generated, the amount of hazardous waste and the impact in the environment. Lower waste production means that we consume fewer resources. Waste prevention involves strict avoidance of waste generation. It also involves qualitative and quantitative reduction at the source of waste production. Reuse of products is also a key aspect of waste prevention. Waste prevention does not include recycling of materials and separate waste collection. Waste prevention is also known as source reduction. Waste prevention programs involve 3 key steps - reduce, reuse, and donate or exchange.

According to **DIRECTIVE 2008/98/EC** "prevention means measures taken before a substance, material or product has become waste, that reduce:

1. the quantity of waste, including through the re-use of products or the extension of the life span of products
2. the adverse impacts of the generated waste on the environment and human health or
3. the content of harmful substances in materials and products".

3. About reduction

Waste **reduction**, also known as source reduction, is the practice of using less material and energy to minimize waste generation and preserve natural resources. Waste reduction is broader in scope than recycling and incorporates ways to prevent materials from ending up as waste before they reach the recycling stage. The waste reduction includes reusing products such as plastic and glass containers, purchasing more durable products, and using reusable products, such as dishrags instead of paper towels. Donating products, from office equipment to eyeglasses and clothing, reduces the amount of

material manufactured overall. Purchasing products that replace hazardous materials with biodegradable ingredients reduce pollution as well as waste. In general, waste reduction offers several environmental benefits. Greater efficiency in the production and use of products means less energy consumption, resulting in less pollution. More natural resources are preserved. Products using less hazardous materials are used. Finally, less solid waste ends up in landfills.

Some benefits of the reductions are:

- Reduces the amount of waste that will need to be recycled or sent to landfills and incinerators,
- Reduces the pollution and greenhouse gas emissions associated with landfill,
- Helps sustain the environment for future generations.

It is important to understand who can help with waste reduction. Waste can be reduced by individuals, businesses, institutions such as hospitals or educational facilities, organizations, municipalities, or government agencies. In other words, we can help with this issue from different parts of society.

4. About reuse

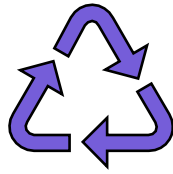


Reuse is an act in which we have to reuse goods before ending up in the recycle bin or landfill. We can reuse a majority of products in creative ways making them useful in different ways. According to **DIRECTIVE 2008/98/EC** “reuse means any operation by which products or components that are not waste are used again for the same purpose for which they were conceived”.

Benefits of reusing products are:

- prevention of pollution caused by reducing the need to harvest new raw materials,
- saving energy,
- reduction of greenhouse gas emissions that contribute to global climate change,
- saves money,
- allows products to be used to their fullest extent,
- buy iron straw that can be reused instead of plastic,
- borrow, rent or share items that are used infrequently, like party decorations, tools or furniture,
- transform empty packages to decorations.

5. Recycling



Recycling of waste is defined as any recovery operation by which waste materials are reprocessed into products, materials, or substances whether for the original or other purposes. It includes the reprocessing of organic material but does not include energy recovery and reprocessing into materials that are to be used as fuels or for backfilling operations.

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5.1 Recyclable materials

Knowledge of recyclable material is basic to recycle the right way. Categories of recyclable materials are plastics, glass, metal and paper. Those categories include the majority of packaging materials which is a part of our society. Just realizing how many of those items every person uses daily can give an image of the situation society has to deal with.

5.2 Benefits of recycling

Recycling of materials means less trash and saves space in dumps and landfills.



Resources - When we use materials again, this means we can take fewer resources from the Earth.

Pollution - In general, recycling materials can produce less pollution helping to keep our environment clean.

- reduces the amount of waste sent to landfills
- conserves natural resources such as timber, water, and minerals
- increases economic security by tapping a domestic source of materials
- prevents pollution by reducing the need to collect new raw materials
- saves energy
- supports manufacturing and conserves valuable resources
- helps create jobs in the recycling and manufacturing industries

We have to understand that both producers and consumers are responsible for recycling. Specifically, two different aspects of responsibility are producer’s responsibility and consumer’s responsibility. Producers are financially responsible once their products become waste and that is the reason they have to develop products that avoid unnecessary waste and can be used in recycling and recovery operations. On the other side, consumers have the responsibility for their own choices. They must choose products smartly and use the 3R strategy for the products they use. 3R strategy means is to reduce, reuse, and recycle.

5.3 Single-use plastics

Many plastic products are purposely designed to be used only once. No matter the product, proper disposal is key to making sure no plastics end up where they shouldn't. Plastics are an important category because plastics have a long lifetime and a lot of consequences on the environment, especially in the marine environment.

Single-use plastic is one special category of plastic waste that leads the EU to create a strategy to reduce them. The Single-Use Plastic Directive was initially proposed to tackle the single-use plastic items that are most frequently found on beaches, as well as lost and abandoned fishing gear. Single-use plastic items are products made wholly or partially from plastic, and which are primarily conceived to be used only once (or a few times) before they are thrown away. Therefore, the definition also includes single-use paper items with plastic lining, such as cups and plates made of paper but with a plastic layer (also called plastic-coated paper).



IMAGE 6. EU PLASTIC STRATEGY LOGO, SOURCE: EUROPEAN COMMISSION, 2018

More information is available at:

https://ec.europa.eu/environment/waste/plastic_waste.htm

The production of plastics is so large that in 2050 is estimated that the ratio of plastic bottles to fish in the sea will be approximately equal to 1: 1 as shown in Image 7. In other words, the number of fish will be about equal to the number of bottles that have ended up in the sea. If we just imagine this situation we can easily understand that the state of the marine ecosystem is certainly under

Even a fisheries employee may understand the impacts on the ecosystem. A simple example is that it is likely to find a larger number of plastic items than fish. It will be therefore one of the most directly affected areas of employment.

If today's need for action against plastics in aquatic ecosystems is huge in the future will be necessary for survival. The best action that can be done is to take seriously into consideration the estimates of the scientific community on the actions to take place immediately and not when the problem is overcrowded.

The hierarchy proposed by the pyramid of waste management, which has prevention as its first and foremost step in the direction of reducing what will end up being rejected, must always be the starting point.

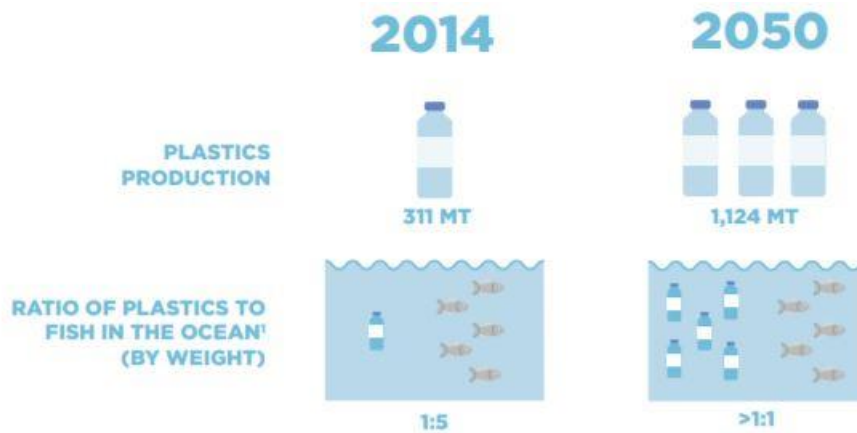


IMAGE 7. ESTIMATED RATIO OF PLASTICS TO FISH IN THE OCEAN, SOURCE: WORLD ECONOMIC FORUM (2016)

More information is available at:

http://www3.weforum.org/docs/WEF_The_New_Plastics_Economy.pdf

5.4 Recycling actions in participating schools

Environmental education seems to determine waste management behavior. “Environmental attitude is defined as a psychological tendency expressed by evaluating the natural environment with some degree of favor or disfavor” according to Liao et al. (2019). Students' awareness via education is essential to shape proper environmental behavior gradually. Curriculums like 3D REMATH's program can achieve aware students of the topics via a wide range of activities. The activities aim to persuade, educate, and encourage students to participate in waste management. Minimization, reuse, and recycling can start at school and be part of their daily life. In this way, students can affect their families to change their habits about what waste is.

Schools can have a major role in recycling due to the activities of children which includes a lot of paper. This includes copy paper, computer paper, notebook paper, colored papers, and file folders. Separate collection of their paper can reduce the amount of trash generated at schools.

Plastics such as cups, plastic forks, and spoons to food packaging, plastic waste that can be recycled. Much recycling and waste reduction can be done with plastics and other materials in the cafeteria. Schools can set up new policies to reduce trash created in the cafeteria.



IMAGE 8. KIDS SEPARATE RECYCLABLE MATERIALS, SOURCE: [HTTPS://WWW.HEPBURNADVOCATE.COM.AU/](https://www.hepburnadvocate.com.au/)

One project about waste management at school is the “Zero Waste School project” of Lisbon in Portugal. Basic actions of the project is identifying the main problem , making a plan to inform school community and starting the project. The motos used are :Sentir (Feel), Imaginar (Imagine), Criar (Create), Partihlar (Share).

More information is available at:

https://www.researchgate.net/publication/342174054_Zero_Waste_School

Practices that provide good waste management ideas are spread worldwide more and more. Italy gives a good example of the following action.

Eco-point initiative in Italy was a good practice relative to the packaging of food. There dry food sold in bulk through dispensers at Italian supermarkets reduces packaging and allows customers to buy the amount they want. Saving them money and prevent the use of single-use packages per year.



IMAGE 9. ECOPOINT IN ITALY PROMOTING NON PACKAGED FOOD, SOURCE: EUROPEAN COMMISSION, 2009

It is efficient to understand that if we act on a local scale we can make important changes to every issue we can think and that can happen with waste management, too.

6. European week for waste reduction

In order to spread the message that the avoidance of waste generation can become a reality, the European week for waste reduction was founded. Within the framework of the LIFE+ project “European Week for Waste Reduction” (EWWR), a guide of good practices on awareness-raising actions for waste reduction has been elaborated.



IMAGE 10. LOGO OF EUROPEAN WEEK FOR WASTE REDUCTION

More information is available at

https://www.ewwr.eu/docs/case_studies/EWWR_Guide_GP_EN_LD.pdf

7. Waste Management and recycling systems in 3D ReMath municipalities

In the framework of the project, it is important to record the similarities and differences in the practices followed by the participating countries for waste management. It is the key to understand waste management on a local and wider scale. Students' involvement in recording the current situation and their knowledge on the subject is crucial. Understanding the different systems and the pros and cons of each one is also important, so students can evaluate their efficiency.. It is important to describe the recycling practice followed by each country and the specific characteristics of the practices that may be used in the participating municipalities. In case the methods in local level are different from the national ones, discussion with the students should follow in order to understand the reasons. Understanding the system of each region will prove the complexity of waste management issues.

7.1. Chios

7.1.1. Waste management and recycling in the Municipality of Chios

Organised recycling in Chios island is taking place only the recent years. The usual practice is to collect the recyclable materials at homes , schools and elsewhere ,then gather them in specific parts of town where there are the appropriate bins and finally the Municipality gathers them and sorts them out at the Recycling center of the island.

There are a lot of basic recycling bins in many parts of Chios town for paper, plastic and aluminum. There are fewer bins for glass ,oil, electrical appliances and lamps. Batteries are disposed in special bins, usually found in schools and in many shops. There are green bins for the residual wastes. The Municipality has distributed some composting bins at schools and houses .

Chios Municipality is trying using different ways to inform and convince more and more citizens to participate in recycling programmes. Often, brochures are distributed either by placing them inside the bills received by post (e.g. bills for water consumption that are distributed by our Municipality) or at schools ,civil services e.t.c.This happens 1-2 times per year. More often they are informed through the local TV and radio. There are advertisements on the internet , in local newspapers and also in posters. In every given chance, schools are participating in programmes and they organize bazaars with manufactures of recyclable materials in order to get the attention and the participation of more citizens in recycling.

7.1.2. Practices at home and at schools

School recycling program is based on the existing recycling system of the municipality of Chios. There are special recycling bins for paper and plastic provided by the municipality in the school's playground. On weekly basis, some students are responsible for collecting recyclable materials from every classroom.

To raise children's awareness on of the protection of the environment and the reduction of our environmental imprint, the school organizes activities with both ecological and social character.

An example of such an activity is the collection of thousands of plastic bottle caps by the students and the teachers. The revenue from the recycling of the plastic caps is used for the purchase of wheelchairs. The school participates in environmental actions such as coast cleaning in the area. Every year, a Christmas bazaar is organized with construction of ornaments and decorations from useless materials (e.g. old textiles) and reuse of old toys etc.

In addition, the teachers of the school and the guest colleagues from abroad use multipurpose cloth bags with our school logo instead of plastic

Chios school does not collect food waste.

7.2 Sarzana

7.2.1 Waste management in Sarzana

In Sarzana, there are 5 waste streams: organic waste, plastic and tin (collected together), paper, glass, dry waste. There are bins for paper (white), glass (green), organic waste (brown); plastic/tin and dry waste are collected in specific bags: Yellow bags (plastic/ tin) and grey bags (dry waste).

7.2.2. Recycling in Sarzana

Plastic, paper and glass are collected separately.

7.2.3. Practices at home and at schools

Big bins are placed outside of every school's building and many schools have also little bins, provided by Acam/Iren, for the classrooms. They have banned the use of plastic bottles and during this school year every student has received a tin water bottle as a gift.

The school canteen uses environmentally friendly tableware, which is produced with renewable resources and biodegradable materials.

The buildings of the Primary and Secondary schools of Marinella are located in front of the beach, so they are often engaged in clean-up actions on the beach. There is also a compost station in the garden and pupils from the fifth grade are responsible for the single foodwaste bins of each class. They daily come to pick up and empty the bins.

The school cooperates with Acam/ Iren. There are projects on recycling Tetra Pak and separate waste in general.

7.3 Leiria

7.3.1. Waste management and recycling in Leiria

For families, there is no specific type of box, each family separates the waste from their home using the containers they consider most practical and / or appropriate. The municipality, in partnership with Valorlis (a private company), organized actions to raise awareness, in which families and institutions receive containers for the separation of solid waste (photo 1) and for the packaging of used cooking oils (photo 2). After the domestic containers are full, the families put their contents in ecological containers existing in the different neighborhoods and streets of the municipality (photos 3 and 4).

In the municipality of Leiria there are about 630 ecological containers, while in the village of Marrazes, where the building of the participating school is located, there are 116 and 1 in the main entrance. There are also ecological containers for the collection of used cooking oil, although in a less significant number (photo 5), Residents also have large capacity containers, existing in various locations in the municipality of Leiria, for placing bulky unused household objects (photo 6).

In recycling, the municipality of Leiria works with Valorlis, a company participated by six municipalities and whose objective is the recovery and treatment of urban solid waste in the region.

Valorlis, first, collects the materials deposited in the bins scattered throughout the municipality (paper, cardboard, plastic, metal and glass). Then, at its Sorting Station, it separates the waste from the selective collection of bins, with the exception of the glass, which is deposited in a specific silo, being periodically sent to licensed receivers. Finally, Valorlis sells the materials it separates to recycling companies.

There is no recycling center in the municipality of Leiria, as Valorlis is dedicated only to the collection and sorting of waste, such as plastic, ECAL, steel, aluminum, glass, paper, cardboard, edible oils, which it then sends to recycling centers .

Valorlis also collects the waste deposited in the normal garbage container, from the municipalities it serves and those served by another company. The Valorlis Organic Recovery Center transforms, through a mechanical and biological process, the organic matter resulting from urban solid waste into a final product called Valorterra - organic corrective for soils with energy utilization of the biogas resulting from the process.

The used cooking oil is collected by Valorlis and then sent to a recycling center in the region for a company in another city, called Torres-Oil. Once a week, large household waste (appliances, mattresses, furniture, sofas...) is collected by the services of the Municipality of Leiria, and Valorlis also collects this type of waste and sends it to recycling centers. Small electrical and electronic waste, as well as lamps, batteries and cork stoppers can also be deposited in specific ecological containers that exist in hypermarkets and / or shopping centers (called "ponto electrão" - photo 7).

The municipality transmits information related to waste management using several methods:

- Promotion of campaigns, environmental programs and study visits to schools;
- Organization of workshops for children and families;
- Delivery of flyers to the community;
- Delivery of informative and educational materials
 - <http://www.valorlis.pt/sensibilizacao-ambiental/materiais-informativos-e-pedagogicos/>
- Delivery of information on the websites of the Municipality of Leiria- and Valorlis:

- <https://www.cm-leiria.pt/pages/896>
- https://www.cm-leiria.pt/pages/617?news_id=3878
- https://www.cm-leiria.pt/pages/617?news_id=3095
- <http://www.valorlis.pt>
- Press announcements / public debates
 - <http://destaques.municipiosefreguesias.pt/gestao-de-residuos-em-leiria-em-debate/>

Furthermore, the municipality has a Plan which includes various actions, campaigns and environmental programs, such as the eco-schools program, actions to manage beautiful gardens, planting trees in the Leiria pine forest and the Marrazes forest, cleaning beaches, visits to recycling companies, workshops, exhibitions, contests ...

7.3.2. Practices at schools

The school separates the waste in the same streams as organized by the Municipality of Leiria. At school they recycle paper and cardboard, plastic, cork, small pieces and capsules of the bottles, piles and coffee capsules. They organize workshops and develop partnerships in order to incentivate recycling at home and in the community.

They try to save energy and water since the school is old and the infrastructures aren't very energy efficient. This is why they try to adopt the best behavior. Thus, they work in this issues in classes and do class projects where various curriculum subjects intervene in order to improve sustainable habits and behaviors in our students and school community.

The school cafeteria delivers daily food that hasn't been consumed to an organization (ReFood) which collects food and helps needy families.

8. The role of environmental education

Environmental education seems to determine waste management behaviour. "Environmental attitude is defined as a psychological tendency expressed by evaluating the natural environment with some degree of favor or disfavor" according to Liao et al. (2019). Students awareness via education is essential to shape proper environmental behaviour gradually. Minimization, reuse, and recycling can start at school and be part of their daily life. In this way, students can affect their families to change their habits about what waste is.

"Experiential learning means learning from experience or learning by doing. Experiential education first immerses learners in an experience and then encourages reflection about the experience to develop new skills, new attitudes, or new ways of thinking." according to Lewis & Williams (1994,5 as referring by Busch , 2019).

3D Remath is an combination of environmental education and experiential learning. Activities of each curricula aims to awareness of students based on participation. Especially in recycling participation could be much more. It can be a habit and after a lifetime change.



IMAGE 11. RECYCLING BINS IN PARTICIPATING MUNICIPALITIES



IMAGE 12. PARTICIPATION OF KIDS IN WASTE MANAGEMENT, SOURCE: [HTTPS://DE.FREEPIK.COM](https://de.freepik.com)

9.Reused materials as art pieces on streets in Portugal

We need to highlight positive actions in each country, so an example from Portugal and the artistic way of reusing different materials is presented below.

A practice that gives another chance to materials chosen not to be disposed to landfills is transforming them into art pieces on streets. A characteristic example of this idea is the way artist Bordalo II uses old tires, bumpers and other junk he collects from trash bins to produce his 3D creations which adorn the streets of Lisbon (Images 13, 14 and 15).



IMAGE 13. ART PIECES ON LISBON STREETS PROJECTING REUSE, SOURCE: [HTTP://WWW.BORDALOOII.COM](http://www.bordaloii.com)



IMAGE 14. ART PIECES ON LISBON STREETS PROJECTING REUSE, SOURCE: [HTTP://WWW.BORDALOI.COM](http://www.bordaloi.com)



IMAGE 15. THE ART PIECE ON LISBON STREETS PROJECTING REUSE, SOURCE: [HTTP://WWW.BORDALOI.COM](http://www.bordaloi.com)

10. 3D ReMath countries waste management programs

10.1 Greece's Waste Management Program

Starting with Greece's program we have to refer the name. [National Waste Prevention Strategic Plan \(2014-2020\)](#) is the program Greece uses to this day, but something crucial about this program is that it does not set quantitative targets. Quantitative targets must be a point of programs to control the situation and to control in which level the country is in every single different aspect of waste management. The program also proposes concrete measurements that focus on four priority waste streams: food waste, paper waste, WEEE and packaging waste. Only implicitly includes measures on qualitative waste prevention Changes in legislation about the requirements of tourism accommodation.

Current targets are:

1. **Recovery** at least **60%** by weight

2. Recycling between 55% and 80%
3. Minimum targets by weight: Glass 60%, Paper 60%, Metals 50%, Plastic 22,5%

10.2 Italy's Waste Management Program

Italy's program title is *Programma Nazionale di prevenzione dei rifiuti* (The national program for waste prevention, 2013-2020). Quantitative goals are set and specifically, it sets objectives aimed at decoupling economic growth from the environmental impacts generated by waste.

1. 5% reduction in the ratio of generated MSW to gross domestic product unit
2. 10% reduction in the ratio of generated special hazardous waste to GDP
3. 5% reduction in the ratio of generated special non-hazardous waste to GDP

10.3 Portugal's Waste Management Program

Portugal's program title is *Strategic plan for urban waste (2016-2020)*. There are also some targets to be achieved by the end of 2020.

The two major objectives to be quantified according to Portugal's program are:

- up to 31 December 2016, achieving a minimum reduction of waste production per capita of 7.6% by weight relative to the verified value in 2012
- up to 31 December 2020, achieving a minimum reduction of waste production per capita of 10% by weight relative to the verified value in 2012

According to the EU, there is a big difference in plastic production today than decades before. This is not something strange as these days we use plastic almost everywhere. In 1950 plastic production was 1.5 million tones and in 2015 this number was up to 322 million tonnes.

10.4 Landfills in the participating countries

Landfill is the least preferable option for waste management. Nowadays people must drastically reduce the amount of waste they send to landfills and support steps before landfills to give to their waste more lifetime and even make them useful again and again.

The following image presents some examples from Greek, Italian and Portuguese landfills



IMAGE 16. LANDFILLS IN GREECE, ITALY, AND PORTUGAL

11. Other waste streams

11.1 Batteries



Batteries and accumulators are a part of many daily-used products, appliances and services, constituting an indispensable energy source in our society. Every year, approximately 800.000 tons of automotive batteries, 190.000 tons of industrial batteries, and 160.000 tons of consumer batteries enter the European Union.

Most of them are not properly collected and recycled at the end of their life. Batteries are an important waste because of their composition. In batteries, there are heavy metals that are hazardous substances and we have to deal with them in a different way than disposing them on the natural environment. Batteries and accumulators could be recycled, avoiding the release of hazardous substances to the environment.

The EU legislation on waste batteries is embodied in the Batteries Directive 2006/66. It intends to contribute to the protection, preservation, and improvement of the quality of the environment by minimizing the negative impact of batteries and accumulators and waste batteries and accumulators. It also ensures the smooth functioning of the internal market by harmonizing requirements as regards the placing on the market of batteries and accumulators. With some exceptions, it applies to all batteries and accumulators, no matter their chemical nature, size, or design.

Schools can have separate collectors for batteries too.

To achieve these targets, the Directive prohibits the marketing of batteries containing some hazardous substances, defines measures to establish schemes aiming at a high level of collection and recycling, and fixes targets for collection and recycling activities. The Directive also sets out provisions on the labeling of batteries and their removability from equipment.

It also aims to improve the environmental performance of all operators involved in the life cycle of batteries and accumulators, e.g. producers, distributors and end-users and, in particular, those operators directly involved in the treatment and recycling of waste batteries and accumulators. Producers of batteries and accumulators and producers of other products incorporating a battery or accumulator are given responsibility for the waste management of batteries and accumulators that they place on the market.

11.2 Waste of Electrical and Electronic Equipment (WEEE)



Waste of electrical and electronic equipment. The directive for WEEE is Directive 2012/19/ EU which set collection, recycling and recovery targets for all types of electric devices. The WEEE directive defines ten different categories of waste:

1. Large household appliances

2. Small household appliances
3. IT and telecommunications equipment
4. Consumer equipment
5. Lighting equipment
6. Electrical and electronic tools
7. Toys, leisure and tools
8. Medical devices
9. Monitoring and control instruments
10. Automatic dispensers

11.3 End of life vehicles



Every year, end-of-life vehicles (ELV) generate between 7 and 8 million tonnes of waste in the European Union which should be managed correctly. Directive 2000/53/EC (Directive 2000/53/EC - the "ELV Directive") on end-of-life vehicles aims at making the dismantling and recycling of ELVs more environmentally friendly. It sets clear quantified targets for reuse, recycling and recovery of the ELVs and their components. It also pushes producers to manufacture new vehicles without hazardous substances (in particular lead, mercury, cadmium and hexavalent chromium), thus promoting the reuse, recyclability and recovery of waste vehicles (see also Directive 2005/64/EC on the type-approval of motor-vehicles with regards to their reusability, recyclability and recoverability). The remaining specific exemptions to the prohibition of the use of hazardous substances in vehicles are listed in Annex II to the ELV Directive and are subject to regular reviews according to technical and scientific progress.

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