WASTES AND IMPACT ON ENVIRONMENTAL PROTECTION

NOVEL MICROWAVE-BASED PROCESSING TECHNOLOGIES

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- Waste is those substances or objects that the owner gets rid of, has the intention or obligation to get rid of. In general, waste is the last stage in the life cycle of a product (the time between the date of manufacture of the product and the date when it becomes waste).
- In Romania, the notion of waste is defined in annex no. 1 A to the Government Emergency Ordinance no. 78/2000 on the waste regime, approved with amendments by Law no. 426/2001 as "any substance, material or object resulting from a biological process (defecation, excretion, respiration, leaf fall, etc.) or technological (manufacture of parts, preparation of cement, carbon black, washing of coal, etc. .), which by itself, without being subjected to a transformation, can no longer be used as such ".

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- The main objectives of waste management are the prevention and reduction of waste production and its degree of danger by:
- • development of clean technologies, with low consumption of natural resources;
- • technology development and marketing of products that by way of manufacture, use or disposal do not have an impact or have the least possible impact on increasing the volume or hazardous waste, or on the risk of pollution;
- • development of appropriate technologies for the final disposal of hazardous substances from waste destined for recovery;
- • material and energy recovery of waste, with its transformation into secondary raw materials, or the use of waste as an energy source.

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- Types of waste. Classification
- Household waste
- Street waste
- Industrial waste
- Production waste
- In addition to the wastes listed above, there are other types of waste (eg slag resulting from foundry activities or coal burning in thermal installations), for which no recovery methods have yet been found, and which are disposed of by storage. final in own warehouses, managed and managed by the generating economic agents.

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- Hazardous waste;
- Non-hazardous waste;
- Bulky waste;
- Construction waste;
- Animal or bird waste;
- Reusable waste (recoverable);
- Waste from packaging;
- Special regime waste;
- Waste generated by medical activities;
- Pesticide waste.

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- **Glass waste** is ready-made glass, having all the oxide components in the necessary proportions and incorporating a large amount of energy corresponding to the reactions and processes that took place in the formation of glass. This waste results both in the technological process of manufacturing glass products and from users, through collection. Their recycling is 100% possible. In fact, the notion of glass waste is being re-evaluated by the European Commission. Thus, since December 2012, glass waste is considered a secondary raw material, whose quality criteria are defined by Directive 2008/98 / EC.
- **Glass waste** represents 7% of the share of household waste, which means a large amount to which is added the technological waste.
- **Glass recycling** can bring significant benefits in terms of reducing greenhouse gas emissions, depending on the processing route. Closed circuit recycling (eg recycling glass bottles into glass bottles) offers significantly greater benefits than lower quality uses (eg use as aggregates) which could only produce marginal benefits.

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- The main reason why glass collection is very low in Romania is the non-adaptation of a national selective recycling system, the low importance of glass in terms of economic value, as well as a certain resistance put by the mentality of the population.
- By recycling 19,000 tons of glass, Romania can save up to 1,900 tons of coal and 440 tons of chemicals. Electricity saved by recycling glass shards at this amount represents a saving of up to 1% of Romania's current energy consumption.
- Given the low price of glass waste, the price of their collection, storage and transport substantially influences the profitability of the business of capitalizing on these raw materials.

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- Plastic waste
- According to the experience in Germany, the plastic waste contained in household waste represents on average 5-8% of the volume.
- In the case of stored household waste, the amount of plastic waste is approx. 400 kg / m3. Due to the fact that their volumetric weight is small, their sorting is very expensive. Due to the different assortments of plastics and the different qualities (foils, containers, etc.), the sorting must be done manually. And the sorting of plastic parts is difficult, their weight varying between 10-60 g / piece, up to 250 g / piece. No more than 100 kg pieces / hour can be manually sorted by a sorter. These parts have been used for recycling by making consumer products or obtaining PVC granules for processing. The granules obtained from mixed parts are used for paving slabs or presses, for columns and poles.

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- The recovery of granules from mixed plastics waste can only be cost-effective in the case of industrial wastes of mixed plastics. But in the case of household waste, the sorting percentage cannot be considered rational. In the case of plastic waste contained in household waste, only their incineration can be considered as rational, as they constitute energy components in household waste subject to incineration.
- Incineration / co-incineration of plastics has a net negative overall impact on greenhouse gas emissions as a result of the release of fossil carbon. Recycling has a significant potential for reducing greenhouse gas emissions by not using raw materials, but the magnitude of this process varies greatly depending on the processing route.

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- Non-ferrous waste
- The recovery of non-ferrous reusable materials has become a major economic problem due to the fact that non-ferrous ore and concentrate resources are declining and the cost price of non-ferrous metals is rising.
- The recovery of non-ferrous materials from residues is a source that has a share of 20-40% of the annual production of non-ferrous metals (Zn-20%, Al-30%, Cu-40%). In all countries, regardless of the degree of development, the collection of non-ferrous reusable materials is increasing.

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Sources of recovery of non-ferrous materials consist of:

- industrial residues from the production process consisting of laminated profile heads, casting networks, non-ferrous metal chips, final (irreparable) scrap, ash, oxides;
- materials resulting from scrapped or decommissioned fixed assets during repairs;
- materials collected directly from the population or from landfills such as household and long-term objects.

Non-ferrous reusable materials are classified into categories, groups and assortments.

The classification by categories is performed according to the chemical composition, the category being represented by the symbol of the metals or alloys from which the materials come.

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From the point of view of group classification, it depends on the shape and dimensions of the material and is noted as follows:

- - group B - non-ferrous materials in the form of pieces;
- - group S - chips;
- - Ox group - oxides, ashes, slag, yeast;
- - group C - cables and pipes with insulation;
- - group D - other non-ferrous materials.

The distribution on assortments is made according to the characteristics of the collected material and is symbolized by Arabic numerals.

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Waste electrical and electronic equipment (WEEE)

The use of electrical and electronic equipment (EEE - radios, televisions, computers, microwaves, copiers, refrigerators, washing machines, video cameras, fluorescent lamps, incandescents, etc.) currently occupies a significant place in both productive and household.

Due to the rapid improvement of technologies for the production of electronic equipment, mobile phones, PCs, laptops, tablets, televisions, etc., can be considered products with a short life cycle. Used morally or physically, the management of waste resulting from electrical and electronic equipment (WEEE) is a complex problem in industrialized countries.

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- In recent decades there has been an appreciable increase in this waste, about 80% representing televisions and computers that have used kinescope tubes (TC) .
- Many of these equipments have, to a greater or lesser extent, glass components.
- Their production means large quantities of raw materials, the extraction and transformation of which are an important source of environmental destruction and energy consumption.
- Hazardous materials (phosphorus films on cathode ray tubes, large amounts of lead in the conical part of the tube glass, batteries, mercury components) contained in computers can seriously pollute the environment if not properly removed from use.

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- Specific technologies allow the dismantling of kinescope tubes, thus obtaining different bottles with a high level of quality and specific chemical compositions that could be used in making useful products.
- In addition to hazardous materials, some valuable materials (motors containing copper, plastic or metal, circuit boards of gold, silver or copper contained in used computers) make their recycling worth the effort.
- In Europe, there are currently about 9 million tones of waste electrical and electronic equipment and an increase of 12.3 million tonnes is expected by 2020.

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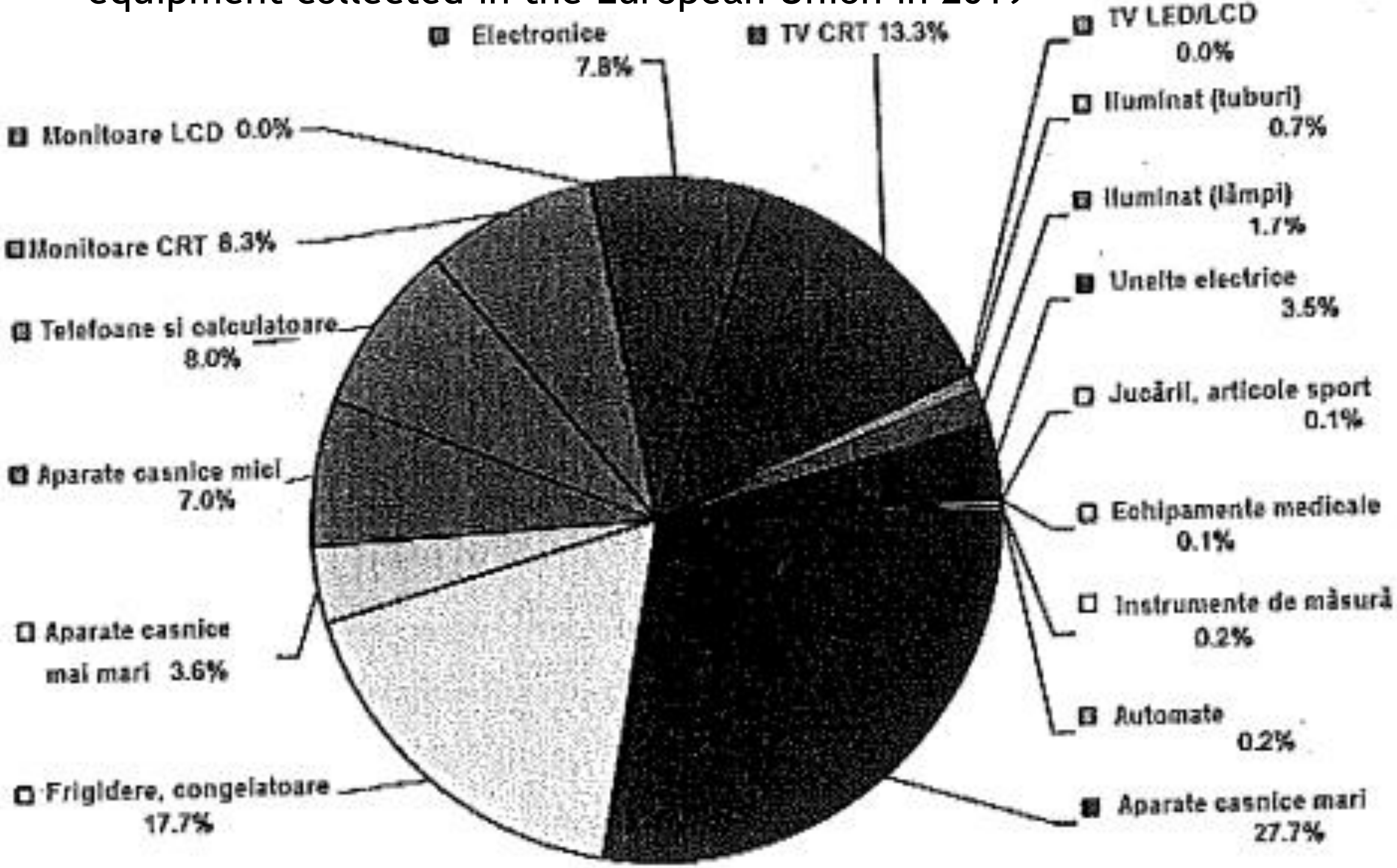
Fig. 1. Distribution by categories of the types of used electronic equipment collected in the European Union in 2019



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- In recent years, special attention has been paid to WEEE in the European Union due to the specific legislation regarding these categories of waste, determining the change of the attitude of the companies producing such equipment in the member countries, in the sense of increasing their responsibility.
- Due to the hazardous substances contained in WEEE (PCBs, halogenated substances, heavy metals, etc.), both the combustion (incineration) and the storage process represent a risk for the environment and for human health.
- For this reason, in most countries activities have been initiated for the dismantling and recovery / recovery of various components, depending on the material from which the electrical equipment is obtained (plastics, rubber, metals, glass, electronic circuits, etc.).

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Directive 2012/19 / EU [7] on restrictions on the use of dangerous substances in electrical and electronic equipment:

- implements for manufacturers the principle of taking into account the limit of use of hazardous substances at the design stage of the product;
- imposes restrictions on the use of hazardous substances in the manufacture of EEE, encouraging the alternative of using substances that are safe for human health and environmental safety;
- recommends the development of research on products to replace these hazardous materials;
- includes principles of responsibility, requiring the manufacturer to take responsibility for the environmental impact of his products throughout the life cycle;

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- encourages the planning / production of EEE that facilitates the reuse of components and materials;
- establishes different recovery and reuse percentages for each product category;
- take measures to minimize the assimilation of WEEE as municipal waste in order to collect as much as possible from household consumers and set minimum collection percentages of 65% in 2019 of the quantities of electronic and household appliances put on market in the year prior to collection.

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Regulations in the field of electrical and electronic equipment (EEE) set limit values for the use of chemicals such as lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls or polybrominated diphenyl ethers in certain types of electrical and electronic equipment. These regulations have prevented the potential disposal or release into the environment of thousands of tonnes of banned substances and have led to significant changes in product design in the European Union and around the world, while serving as a model for similar laws adopted by outside countries. European Economic Area.

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Active sludge

- The activated sludge consists of a synthetic gelatinous matrix which includes different colonies of bacteria (of different shape and consistency), colloids, organic and inorganic substances, a mass around which many protozoa and metazoans are grouped and fed. According to Thonke: "the flake is a biotope, a miniature ecosystem formed in particular environmental conditions and which has its own features."
- The structure of activated sludge consists of flakes ranging from yellow to brown, almost
- black, they are produced by growing a mixed population of bacteria and other microorganisms in the presence of biologically treatable wastewater and O2; its color may change as a result of changes in environmental conditions or excessive multiplication of bacteria or fungi; If the mushrooms multiply, its color becomes gray-whitish.

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- The consistency of the sludge depends on the type of bacteria; sometimes they form amorphous clumps, other times they form a loose - "swollen" mud.
- The smell of the activated sludge of a well-functioning installation is that of “greasy / reclaimed soil”; under malfunctioning conditions it can be fetid - under anaerobic conditions - or with a musty odor in the case of the development of fungi.
- Chemical composition of activated sludge
- The activated sludge includes living organic matter, enzymes, mineral salts, ammonia, bio- and non-biodegradable organic substances in the following chemical formula: $(C_7H_{10}NO_3)_n$ or taking into account phosphorus: $C_{118}H_{170}O_{51}N_{17}P$

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- Formation and evolution of activated sludge
- The formation of sludge flakes is based on the absorption of ions from the wastewater by bacteria (usually negatively charged). This reduces the surface load of bacteria, which leads to the possibility of cell cohesion, increased possibility and a certain degree of continuous agitation in the mass of the installation.
- The following situations are distinguished:
- 1. **Sludge from installations with an average degree of load**:
- CBO_5loads between 0.2 - 0.4 Kg / Kg / day and at O_2 concentrations of 0.5 - 2.0 mg / L, the sludge has a loose, porous flake structure and is characterized by a great diversity of species.

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- 2. **Sludges from high load or overloaded installations:**

CBO5 loads of over 0.4 Kg / Kg / day and the presence of O2 is over 0.5 mg / L, the structure of the flakes is crumbly; In the spaces between the flakes there are numerous free bacteria that cause a high turbidity in the final effluent.

- 3. **Sludge from low load installations**:

Loads of CBO_5 below 0.2 Kg / Kg / day, the sludge is very aged at a minimum O2 content or above 2 mg / L. The flakes are small, dense, sparsely populated with other living things; numerous ciliated species, but with small populations.

- 4. **Poisoned sludge:**

Under the microscope, it is observed that the bacteria lose their ability to move, the flakes are destroyed and the effluent becomes cloudy, due to the excessive multiplication of free bacteria. The hairs disappear. In many cases, although O_2 is present, methane bacteria grow.

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- **5. Swollen sludge:**
- It occurs as a result of the multiplication of filamentous bacteria or fungi. "Swelling" due to fungi (less common) occurs mainly in acidic waters, due to filamentous bacteria, under specific conditions of development, in the case of a low mineral composition of the substrate or in the case of water deficient in phosphorus or nitrogen.
- Water purification in an activated sludge basin can be attributed [8]:
- - first of all bioabsorption, a phenomenon which occurs on contact of the organic matter with the activated sludge and which acts for a very short time, and
- - secondly, intracellular assimilation, for the realization of self-maintenance processes: cell respiration and synthesis of new cells.

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The ideal curve of the development of activated sludge follows 3 phases:

- Phase I - of logarithmic development, in which a large amount of organic matter is absorbed by cells; the speed of sludge development, in the presence of a high CBO, is limited only by the minimum time for the formation of microorganisms at that temperature.
- Phase II - of slow development, in which the activity of bacteria becomes predominant and part of the stored substrate is transformed into cell mass. At this stage it is assumed that due to the decrease in the concentration of CBO begins to slow down the development of sludge.
- Phase III - of self-oxidation or endogenous, in which the mass of sludge begins to decrease as the organic matter is used entirely to ensure the energy needs of cells. At this stage, the CBO reduction is small because the organic matter is completely oxidized.

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When introducing wastewater into the installation, three phenomena occur:

- flocculation of colloidal organic substances;
- absorption on the surface of the sludge of colloidal and dissolved organic substances;
- the beginning of the degradation process of organic substances within the metabolism processes of microorganisms from and on the activated sludge flakes.

In a properly functioning installation, both the conditions in the aeration tank and the flow and pollutant concentration of the influent do not change radically from one day to the next, they become relatively constant over time. The stability of these factors allows the formation of a typical biocenotic structure in the aeration tanks, characteristic of the nature of the influent and the conditions in the respective installation. The biocenosis of the activated sludge that has formed becomes an extremely conclusive witness to the way the plant works.

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In the case of residual sludge composted with organic waste, empirical tests, based on odor reduction, black color of the mixture and constant temperature close to that of the environment, are associated with the state of sludge maturation but they are not accurate enough.The most harmful effects caused by the application of immature sludge on soils can be avoided by following the composting process until the stabilization of organic matter. Homogeneity of the mixture is essential for good composting and proper disinfection. Thus, sludge composted with organic waste will be subjected to high temperatures in order to destroy pathogens, but it can remain in anaerobiosis and produce unpleasant odors. Humidity, temperature and aeration also affect the composting process; their control is essential for disinfection and destruction of pathogens. Clean composting must eliminate these microorganisms.

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Composting of sewage sludge and the importance of volume agents

- Composting is a process that takes place spontaneously in nature, such as the degradation of leaves or the edge of the forest and / or the old cattle manure. But, the duration and methods of natural composting are long and heterogeneous and, however, undesirable for industrial use. Composting is the way to obtain a stable product starting from a similar oxidative biological transformation of what happens naturally in the soil
- In the case of sewage sludge, the composting process consists of mixing these residual materials with a bulking agent (e.g. wood chips, sawdust, chopped bark, cereal straw, etc.) before these materials are able to aerobic decomposition begins over several weeks.

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- Aerobic composting is an alternative biotechnology, suitable for handling sewage sludge. This biotechnology is simple, economical and allows the exploitation of the organic matter and nutrient content of the sewage sludge as fertilizer or soil amendment.
- Composting is the process of biological conversion of solid organic material into a product that can be used as a fertilizer, a substrate for the production of mushrooms or biogas. Compost can be considered a hygienic organic product, free of unwanted characteristics, with a wide applicability in agriculture and horticulture, as well as a relief in terms of many environmental problems.
- Composting is the sum of a series of metabolic processes and complex transformations that are caused by the activity of a mixture of populations of microorganisms. So it is quite complicated to compare the results of different composting processes. In addition, the oldest process of composting, which was based on experimentation rather than knowledge, made composting more of an art than a science

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Composting can be defined as a controlled biological process for the conversion and recovery of residual organic materials (biomass by-products, organic waste of biological origin) into a stabilized, hygienic, earth-like product, rich in humic compounds.

Composting is also an eco-technology because it allows the return of organic matter to the soil and thus reintegration into the great vital ecological cycles of our planet.

Composting means recycling organic matter and renewing natural cycles that have been disrupted by abandoning proper practices. Thus, composting:

- is a technique of stabilization and aerobic treatment of biodegradable organic waste;
- addresses all organic waste but especially solid and semi-solid waste;
- is a way to destroy, through heat and various internal factors, germs and parasites (vectors of disease), unwanted seeds;
- -it is a biological technique for recycling organic matter which, during its evolution, leads to obtaining humus, a factor of stability and fertility for soils;
- is the result of a complex microbiological activity, occurring under specific conditions.

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- Composting is a biotechnology because it meets the definition that: it represents "the industrial exploitation of the potential of microorganisms, plant and animal cells and the fractions that derive from them".
- Regarding compost, the constituent involved in the process of biological degradation and conversion during composting is the community of resistant microorganisms. Thus, the optimization of compost quality is directly related to the composition and succession of the microbial community during the composting process. Therefore, tools are needed to monitor and characterize the decomposition phase, the maturation phase (degradation of organic matter, dominant humus biosynthesis), microbial communities during the composting process and to link the microbial communities and compost quality.

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- Residual plant materials rich in cellulosic substances (straw, dried leaves, twigs, algae and other plant debris), used as bulking agents for composting sewage sludge, are very easily decomposed and mineralized by soil microorganisms, and the soil remains low in carbon. organic. Recent research suggests the use of lignin-rich bulking agents, such as wood sawdust or even wood chips and wood chips from tree felling .
- This is to allow the sequestration of carbon in the soil to turn it into a nutrient support for microorganisms and organic support for various compounds that can be combined with organic matter, thus reducing the risks of leaching.

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Waste recycling using unconventional energy - microwave techniques

Here are some examples of applications of microwave techniques in recycling and treatment of different types of waste in various TRL stages:

1. Innovative reactor based on microwave applications for waste recycling and chemical processes

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Production capacity
GREEN POLYOL
Typical plant

•Each reactor can produce 1,5 tones/day (**24 hours**)

Yearly production - 750 tones green polyol

PET recicled 300 tones/year



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Polyester polyols designed for rigid foams PUR with densities between 30 and 300 kg/m3. The foam cells can be closed as in thermal insulation applications or open as in phonic insulation applications.

- **Polyurethane rigid foam** is currently the biggest application for Green Polyols. Its consumption is expected to increase significantly in the coming years.
- **Polyurethane rigid foams have insulating properties**, thus, making them appropriate for use in applications such as refrigeration, packaging, construction etc.
- **polyurethane resins** used as raw materials for **primers and paints, resins for surface protection**, etc.

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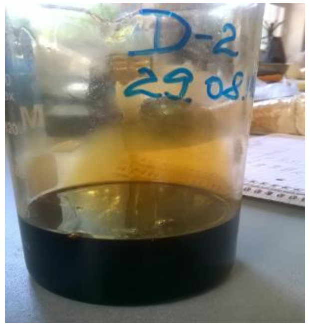
Recycling of polyurethane foam waste

Stage: Pilot scale – TRl 5 - recycling in the form of polyols using New kind of Microwave reactor



Obtaining bio-polyols from vegetable waste

- Stage - **demonstrator**– TRL 4 – using cobs and corn cob (vegetable waste)

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Recovery of non-ferrous waste and WEEE

- Stage: **industrial Pilot** – TRl 6 - used in recycling facilities with 70% metal recovery for aluminium;
- the industrial furnace for the melting of non-ferrous waste works at a maximum temperature of 1400°C and is equipped with its own pyrolysis gas purification unit;

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Thermal washes of glass waste

- Stage: **industrial pilot scale**– TRl 5 - used in recycling facilities.
- Productivity: 1200Kg /h, wash temperature 360°C, power consumption:42Kw /h, continuous flow, the resulting product has an humidity of 1%

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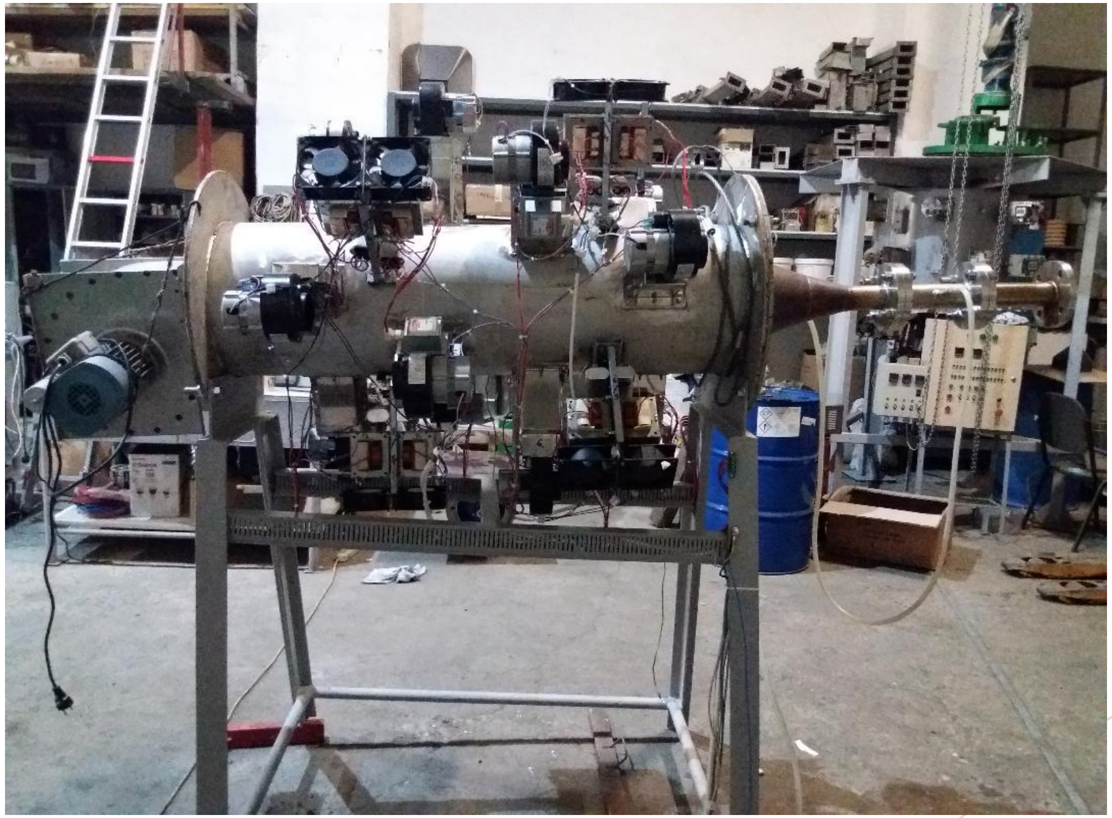
Noxes purification



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Thank you for your attention

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