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Zero-waste energy-efficient agricultural communities in the GR- Republic of North Macedonia cross-border area - ZEFFIROS

DELIVERABLE 3.2

Public campaign on bio-waste management and the circular economy

06/2020

Sub-Deliverable 3.2.4 – Background analysis aiming to the investigation of the available capability for the certification of compost products which originate from anaerobic degradation of biowastes.

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Introduction

Nowadays, following the global trend for cyclic economy the composting and digesting activities of collected bio-waste are increasing in order to reduce the landfilled waste and to implement the European Union legislation. One of the main issues for this implementation is the established quality assurance system that an organization should have for the control of the quality of compost and digestate. The compost products are used as organic fertilizers, soil improvers, and mixing component in growing mixtures for plants. Annually in Greece, 5.8 mtn municipal waste are produced. A fraction of 2.6 Mtn of these wastes are bio-waste. Until now, the major quantity of the produced wastes is deposited in sanitary burial sites while a small quantity is recovered through bio-treatment installations.

European politic guidelines as well as European strategy for 'Europe 2020' imposes the transition to practices which are in accordance with the hierarchical management principles. The national strategy of Greece for waste treatment practices was reviewed, and now includes the above-mentioned spirit and moreover targets and activities for the promotion of the separated collection of biowastes locally and nationally. One of the final aims of these activities is the development of a national unit network for pre-sorted organic wastes collection. Greek programming framework for 2014-2020 period provides the enhancement of such activities considering the Prefectural Plan for Waste Treatment.

Following the above, the development, construction, and operation of small composting units will be the stake for municipals and prefectures. This is not only Greek but European policy. EU Member States decided to increase the composting and digesting activities of separately collected bio-waste.

The key for a successful venture on composting and digesting activities is the establishment of a quality assurance system (QAS), which comprises an organisation with the competence to control the quality of compost and digestate (Quality Assurance Organisation, QAO). Many countries across the EU have already successfully implemented QAS and QAO infrastructures.

This deliverable intends to investigate the capability for compost products certification which are originated from anaerobic digestion of bio-wastes. It also intends to report European and Greek legislation framework for the certificated compost products and to declare the physical and chemical parameters they play a key-role on the conversion process of bio-waste to certified valuable product. Finally, global practices for certified qualitative compost products achievement will be presented herein.

2. Composting Process

2.1 Legislation Framework

With the Greek law 4042/2012 and with the changes to the National Plan for Waste Management (NPWM), was established in Greece the practice for separately collected bio-wastes and a network for its recovery was promoted. In this spirit the compost units will play an important role to bio-wastes management.

More specifically, according to a study carried out by the NPWM (2014), the following activities should be do for the bio-wastes management.

2.1.1 Creation of an agency for biowaste management coordination. This agency should organize, supervise, and support the municipal and prefectural departments for waste management. Moreover, this agency should cooperate with companies and services which exploit such wastes.

2.1.2 Development of projects for household/domestic composting process carrying all over Greece, especially to rural or semi-urban areas.

2.1.3 Development of recovery networks of pre-separated organic wastes. This will be carried out by, the construction of units for treatment of pre-separated organic wastes, the re-configuration of existed Units for Wasted Treatment (UWT), and the construction of municipal units for composting. The re-configuration of UWT should be carried out to accept pre-separated organic wastes.

2.1.4 Development of a network for independent bio-waste collection. This network should be feed the bio-waste recovery units or/and the municipal composting units. Apart of household, this network should include 'big producers' of bio-wastes such as green space areas, restaurants, hotels, sanitary units, army units, food supply units, e.t.c.

2.1.5 Expansion of the network for separated collection of wastes from olives and fats for biofuel production.

2.1.6 Promotion of old agreements with other productive bodies and agencies for the co-treatment of organic wastes.

Figure 1 presents the existing Greek law framework for separated collection and composting of bio-wastes. This framework works in combination with the European legislation frame and needs to expand in order to achieve high quality composting products. A more detailed description of figure 1 is as follows:

2.2 Separated Collection

2.2.1 National Target: With the law N. 4042/2012 (article 41) the following national target was established: until the end of the 2015 the separated collection fraction of the bio-wastes ought to be at 5% of the total weight minimum, and until the end of the 2020 this ought to be rise at 10% minimum.

According to a study of the European Agreement for Human Rights agency, the separated collection of bio-wastes promoted through the household and domestic composting process. Moreover, the development of the 'Sorting at Source' network aims to the maximization of recovery fractions from the pre-sorted biowastes.

A special emphasis was devoted to the 'Sorting at Source' of urban areas, island areas, and of the 'big bio-waste producers' such as green space areas, restaurants, hotels, sanitary units, army units, food supply units, e.t.c. According to this law frame, the 'Sorting at Source' is mandatory for the public feed companies and for the public profit organizations.

2.2.2 Directions: A guide for the application of the 'Sorting at Source' and for the use of bio-waste management systems was developed (Greek EPPERAA, July 2012).

2.3 Composting in Greece

2.3.1 National Target: The turn from the waste burial procedure to the bio-wastes treatment is promoted via the minister decision K.Y.A. 29407/3508/2002 (article 4), where the targets for this turn considering the Biodegradable Urban Wastes is described. Also, this turn is promoted indirectly by the law N. 4042/2012 (article 43) which imposes a special fee for waste burial procedure. According to a study of the European Agreement for Human Rights agency, the full exploitation of the pre-selected organic wastes treatment unit is an urgent situation and the municipally composting in combination with the prefectural treatment unit activities are increasing the benefits. Moreover, the re-configuration capability of already existed units for mixed residues treatment is investigated.

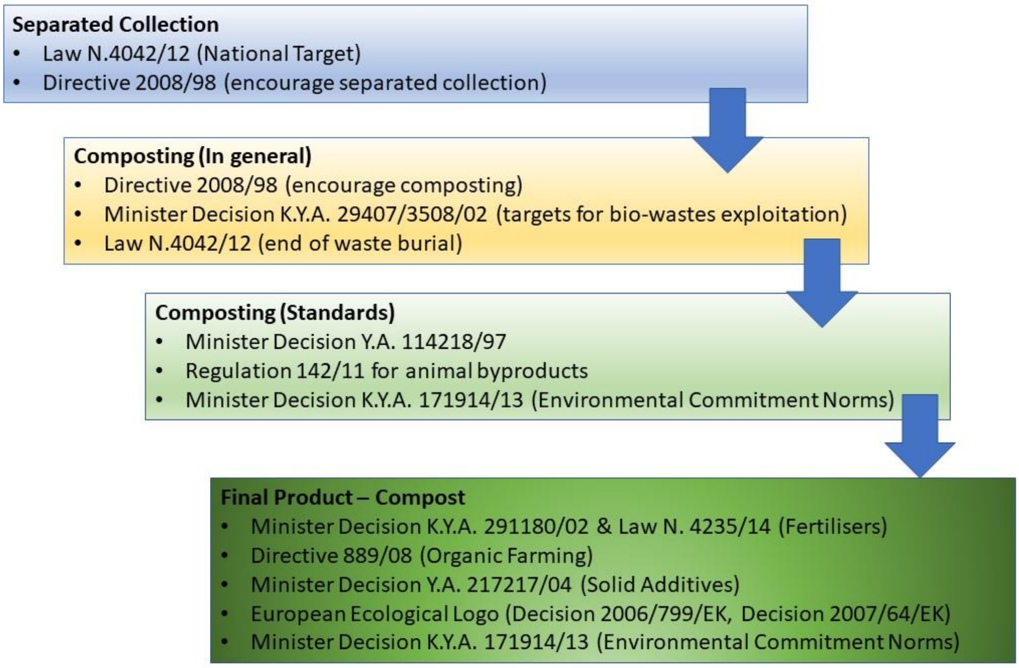

Figure 1: Greek legislation framework for composting.

2.3.2 Standards: The standards which are described in chapter 7 of the minister decision Y.A. 114218/1997 entitled 'Development of standard framework and solid waste treatment projects' are considering the standards for Mechanical Selection and Composting Machinery.

When a composting unit treated animal subproducts, such as food residues, additional regulations are imposed which are described by the European Commission regulation No. 142/2011.

Finally, terms, regulations, and standards for composting unit construction and operation are described in the ministry decision K.Y.A. 171914/2013. These units and the final product should be developed according to the 'Standard Environmental Commitments'.

2.3.3 Environmental licensing of composting units: According to the ministry decision Y.A. 1958/2012, the composting units come under the Group 4-'Systems of Environmental Infrastructure' and especially under the code A/A 15-'Individual installations in industrial buildings or other appropriate constructions for terrestrial improvement-compost production using pre-selected or separated organic fraction of municipal solid wastes e.g. greenhouses, e.t.c.

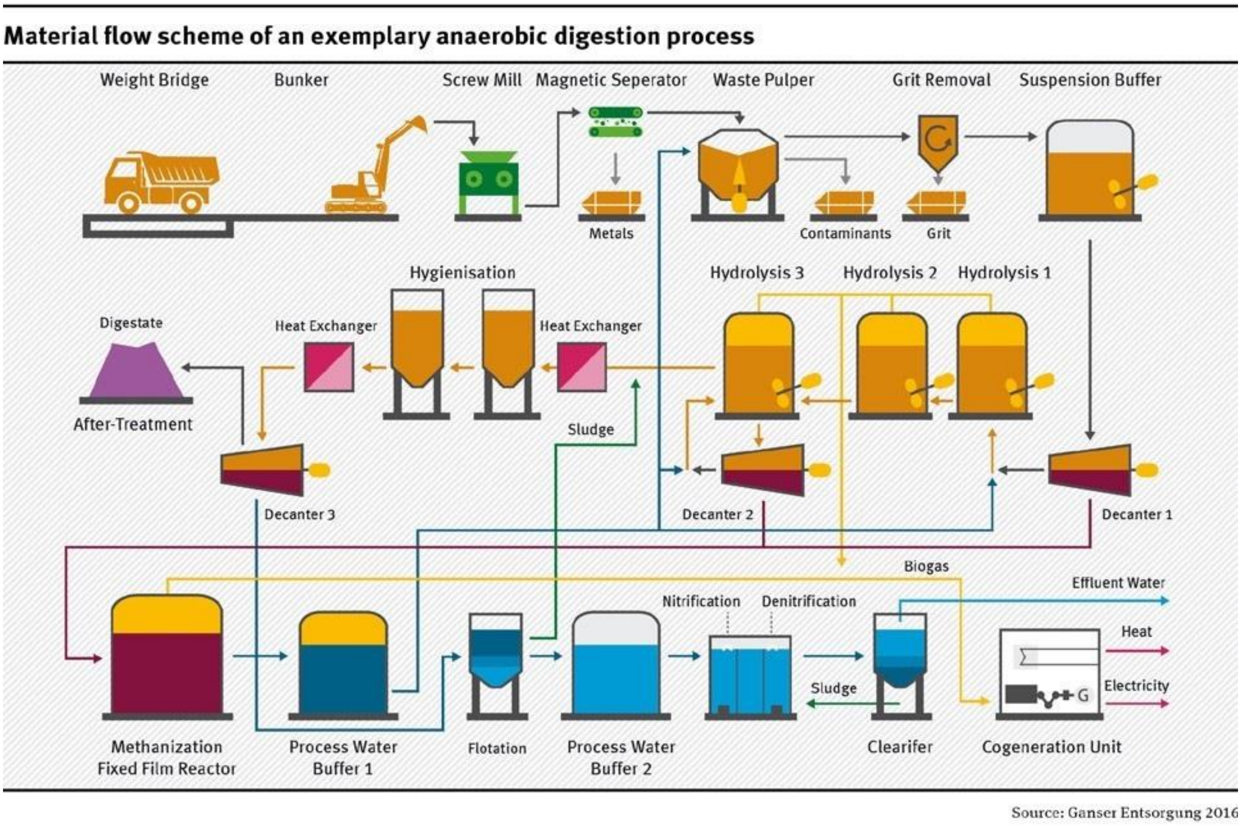

Figure 2: Scematic diagramm for anaerobic digestion process

2.3.4 Classification of compost units: If the daily input to a unit is in the range 1-20 tn/day the unit is classified as B type and should obey to Environmental Commitment Norms. Otherwise, if the daily input is over 20 tn/day the unit is classified as type A2 and for its construction a Study of Environmental Effects and a Decision of Approval of Environmental Conditions is required. For example if this unit works annually 5 days per week, without public holidays, and with only one shift, then the upper input limit for the B category is 5200 tn/year or 6240 tn/year if the unit works 6 days per week.

Procedure for a unit to fall under Environmental Commitment Norms: The procedure for a unit to fall under Environmental Commitment Norms and the required documentation for this is described to the Annex 11 of the ministry decision Y.A. 1958/2012. The basic criteria for the location of a composting unit are described in the same Annex.

2.3.5 Bio-waste treatment: Bio-waste represents a subset of biodegradable waste. The EU Commission defines bio-waste as follows:

Bio-waste from municipal sources can be distinguished into two types:

- food and kitchen waste (food and kitchen waste from households and household-like commercial waste, e.g. from restaurants, retail premises, etc.) and
- green waste (biodegradable garden and park waste) [EC 2008].

Type and composition of bio-waste influence, which treatment will be the most efficient. Efficiency means thereby a low environmental impact while creating a product of high quality [UBA 2016c]. Pre-condition for an efficient treatment towards high-quality products suitable for agricultural or horticultural use is, inter alia, the separate collection of bio-waste.

The different bio-waste types can be treated in various ways:

- anaerobic digestion,
- composting, or
- energy recovery.

Anaerobic digestion

Anaerobic digestion is a process, where bio-waste is converted into biogas as well as a liquid and/or solid digestion residue by means of microorga- nisms under anaerobic conditions (exclusion of oxygen). At the beginning, the input material is shredded, processed (removal of impurities, homogenisation, etc.) and filled into a closed vessel (see e.g. first steps in Figure 1). Due to the work of microorganisms, the material undergoes various stages of digestion, until methane (biogas) is produced. The energetic utilisation of this biogas usually takes place in a combined heat and power plant, where the gas is combusted and converted into electricity and heat. The remaining digestate (liquid or solid) can be used as a fertiliser. Solid digestate can also be used for a subsequent composting process. To achieve an effective anaer- obic digestion, wet bio-waste, e.g. food and kitchen waste, is the most suitable input material.

2.4 Final Product

2.4.1 General Standards: According to the minister decision K.Y.A. 171914/2013, the fertilizing products should fullfil the following requirements of the decision 2006/799/EU (European Ecological Logo):

- Hazardous substances content (Annex 2)
- Nitrogen content (Annex 4)
- Admixtures (Annex 3)
- Capacity (Annex 5)

This minister decision concerns the units that should follow the Environmental Commitment Norms. In this deliverable, the standards for compost quality depending to the origin of the organic wastes are described (e.g. pre-sorted organic wastes from industrial activities, animal residues, plant residues from industrial activities, agricultural and livestock wastes, muds e.t.c.) as well as the appropriate uses.

2.4.2 Compost for Agricultural use: The legislation framework for the compost use in agricultural activities is determined from the Ministry of Rural Development and Food.

1. **Minister decision K.Y.A. 291180/11034/02, Licences for new type of fertilizer release** which is a modification of the K.Y.A. 257921/2004 where the quality standards for heavy metals and nutrient substances are incomplete.
2. **Regulation 889/2008 for Organic Agriculture,** where the appropriate fertilizers and soil improvements that allowed for use in organic agriculture are determined (awarded logo, figure 3).

Figure 3. Organic agriculture logo

3. **Law 4235/2014,** where in article 49, paragraph 3, products from urban or industrial wastes as well as raw materials from animal wastes are mentioned.
4. **Minister decision Y.A. 217217/2004,** for soil improvement materials and cultivating substrates (soil mixtures). Exception from this group are materials for private use from producers.

2.4.3 Compost Certification:
1. **Decision 2006/799/EU,** for the determination of the revised ecological criteria and for the determination of the requirements for the evaluation and the verification of soil improvements to be awarded with the European Ecological Label (Figure 4).

Figure 4. European ecological label

2. Decision 2007/64/EU, for the determination of the revised ecological criteria and for the determination of relevant requirements for evaluation and verification of cultivation means to awarded with the European Ecological Label (Figure 4).
3. Only the product of the compost unit (and not the unit) could be certified and awarded with a kind of logo such as the European Ecological Label.

2.5 Composting in Europe

2.5.1 General: Composting is the biological decomposition of bio-waste by means of micro- organisms under aerobic conditions. The remnant is a nutrient-rich compost, which can be used as soil improver and fertiliser. The main composting process can be divided into three steps:

- degradation phase,
- conversation phase, and
- maturation phase (see Figure 2).

First, the input material is shredded, homogenised and impurities are removed in several steps. During the degradation phase, the bio-waste is decomposed under controlled oxygen and moisture supply. The temperature during this process reaches 60 – 70 °C, whereby pathogenic agents and bacteria are elim- inated. The conversation phase completes the decomposition process at lower temperatures. During the maturation phase, the process slows down and the fresh compost is thereby stabilised and converted into humus (mature compost). For the composting process lignin and cellulosic plant material is the best suitable input material [UBA 2016c; LUBW b].

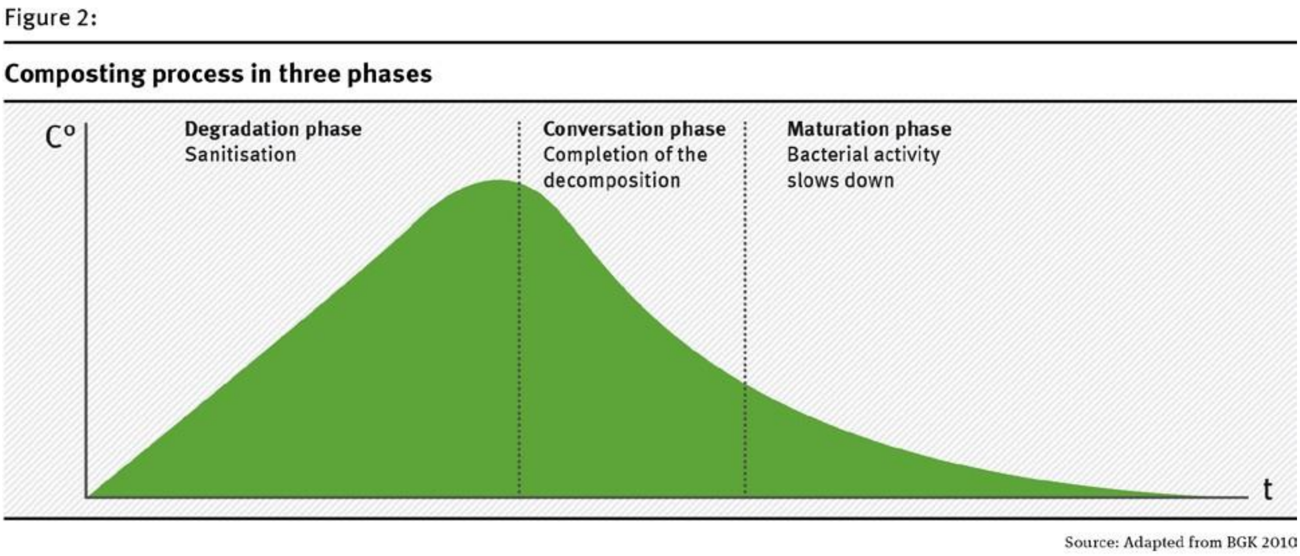

Figure 5: Phases of composting process

2.5.2 EU policy framework on waste: With the first Waste Framework Directive (EU WFD) dating back to 1975, waste policy has been one of the first environmental policy fields covered by EU legislation. Today, the EU waste policy aims not only at minimising health and environmental threats from waste and waste management, but also at resource efficiency. The EU's efforts for resource efficiency are reflected in the new ambitious Circular Economy Package, which underlines the value of waste as a secondary raw material [EC 2016c; UBA no year]. EU waste legislation today covers a number of regulations and directives setting out substantial and detailed requirements for the MS. These requirements relate to general principles of waste management systems, to standards for the entire management of waste, including treatment, and to specific waste streams.

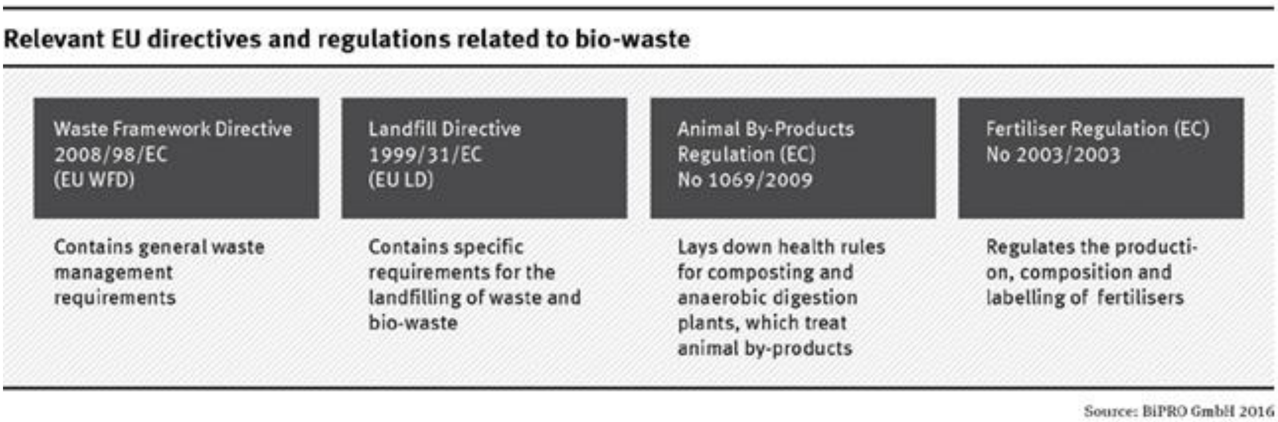

Figure 6: *http://www.europarl.europa.eu/EPRS/EPRS-Briefing-573936-Circular-economy-package-FINAL.pdf*

2.5.3 Energy Recovery: The third option is the energy recovery in an incineration process as sole purpose. For this treatment process, only wood-containing components of green waste with high calorific value are suitable and can be used, for exam- ple, as fuel in biomass-fired combined heat and power plants [UBA 2016c].

3. Procedure of Composting Units

3.1 Stages

To understanding better the operational requirements of a composting unit there is 6 stages and 13 procedures which should be applied from the operational agencies. Figure 7 presents analytically the 13 procedures and how they are connected with the 6 stages of unit production.

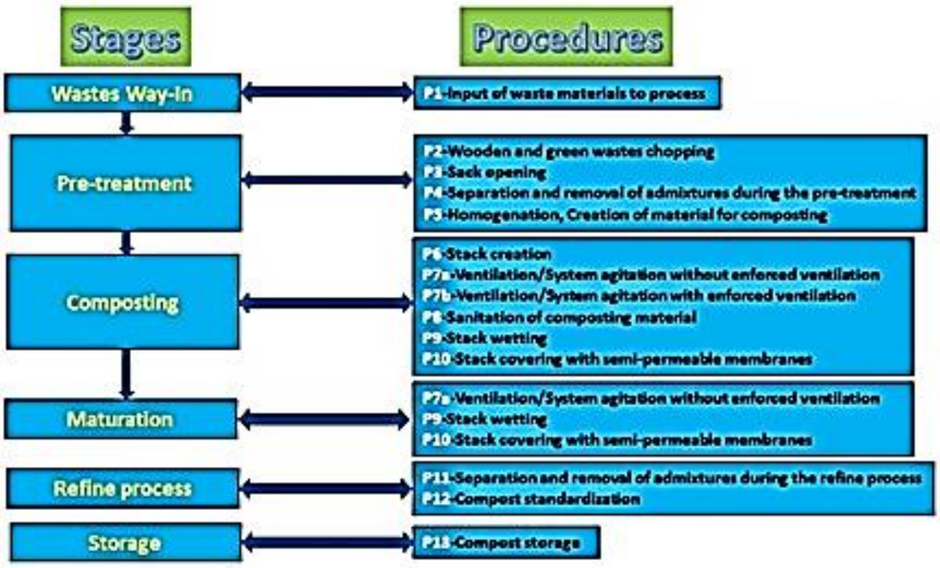

Figure 7: Procedures of composting unit per stage

3.1.1 P1-Entrance-Receiving of incoming material

This proceduce includes the incoming and possibly the weighting phase of wastes, the unloading, the optical control and the final receiving phase. The receiving procedure is carried out at specific time range and days in cooperation with municipal agencies for better scheduling and improved services. One person on duty, which could be from another department of the unit, is enough to control the receiving phase. During the weighting procedure, the relevant quantities should be recorded as well as the kind and the origin of the waste material. Optical control and biowaste identification are carried out during the unloading phase. An empirical estimation of admixture quantities is sending to municipal offices as an information for the “Separation to the Source” project. In case that a loading includes high quantities of admixtures or hazardous materials, this loading gets away from unit. Also, in case that a loading exhibits high moisture content, this loading should be pre-treated within 24 hours from the receiving phase. Otherwise, the loading should be stored for maximum 3 days covered with matured compost. The entrance space should be cleaned and sanitized everyday when the unit stopped because the loading contains meat, milk products, and other animal by-products which could attract rodents, insect, and other parasites which are dangerous for the public health.

3.1.2 P2-Chopping of green material (wooden wastes)

This procedure includes the chopping of wooden material (trees, wooden branches, e.t.c.) because the large wooden wastes such as branches with diameter greater than 4 cm are not degradable with the use of microbes. The chopping procedure increases the active surface for microbes and the material becomes degradable. For the initiation of the composting process and the creation of a start-up material with the appropriate porosity an initial quantity (40%-60% v/v) of chopped wooden material is necessary. The green wastes with low nitrogen and moisture content could be stored for long time and chopped just before their use. The necessary machinery for wooden wastes chopping is a shredder machine which works at low rpm frequency, and a chipper or grinder machinery which works at high rpm frequency, but they have requirements for feeding free of metals or other admixtures.

Figure 8: Shredder machine, Chipper machine, wooden waste.

3.1.3 P3-Sack opening

This procedure refers to alternative methods for sack opening, considering that the pre-selected municipal biowastes are received packed in close sacks (biodegradable or not). This should be done in a time range 24-72 hours from the receiving phase. The first phase of this procedure is the hand-selection (for small units with capacity below than 1000tn/yr). The chopping machinery for green wastes could be used for the sack opening but with extra attention because of metals present in the biowaste material. Other machines for the sacks opening is the mixing machine, the sack cutter (it is not appropriate for small composting units because of tis high cost), and the mixer (if a unit have a mixer machine for the materials homogenization this could open sacks in parallel).

Figure 9: Sacks opening machines.

3.1.4 P4-Admixture separation and removal during the pre-treatment phase

During this procedure only big size admixtures, which are visible with our own eyes, could be removed. More effective separation and removal could be carried out during the refinery procedure. The techniques for carrying out this procedure is the hand-selection (mainly for removal of big things), meshing (but it is not common), magnetic separator (this method is applied only to pre-selected bio-wastes with big quantity of metals), and the fan separator (it is rare used method directly to the incoming wastes because of high moisture content).

Figure 10: Machinery for admixtures separation and removal.

3.1.5 P5-Homogenization-Creation of material for feeding into the composting process

At this procedure, a homogenization process of different materials with the use of a mixer is carried out for the creation of the appropriate mixture for composting. The incoming waste materials are mixed to the appropriate composition to achieve the best C/N ratio, the best moisture content, and the best porosity. All kind of wastes could be added to the mixed machinery such as preselected bio-wastes (even if they are packaged in sacks), chopped green wastes, muds, e.t.c. If greater moisture content is necessary then extra water could be added, or other additives such as stone powder, soil, matured compost, e.t.c. With the use of the mixer a homogenized material is achieved which is appropriate for composting process start. The mixing machinery is necessary in case that big quantities with different kind wastes feed to the unit and a stable and standard mixing procedure is required.

Figure 11: Mixing machinery

3.1.6 P6-Stack creation

During this procedure, a stratification of materials is carried out and a triangle or trapezoid stack is created. The first shape exhibits best behaviour This stratification should exhibit the best values for the C/N ratio, the moisture content, and the porosity. Equipment for this stack creation is a loader with which we stratified the appropriate material for the best composting feed and an inverting machine which is mixing the material (this is not necessary in the case of mixed material, P5).

Figure 12: Stack creation phases

There are two main shapes of stacks, the triangle shape, and the trapezoidal shape. The triangle shape is better choice for wet periods while the trapezoidal shape is better choice for periods with strong winds and high temperatures. Low mass content stacks are worse for low temperature periods because of high heat loss and low microbial activity during these periods. High mass content stacks are difficult to handle and homogenize. The maximum height of a stack is around 2.5 m and the maximum wide is around 5m.

Figure 13: Stack shapes

3.1.7 P7a-Ventillation / System agitation without enforced ventilation

Stack ventilation of systems which do not have enforced ventilation facilities is carried out via mixing procedure with mixing machines or with loaders. This procedure plays an important role on the composting procedure because of its strong effect on several composting parameters. There are two phases during ventilation procedure. The first one is the active composting phase. During this phase, oxygen is supplied, and aerobic microorganisms start to act for the organic substances' oxidation. Temperature and moisture are controlled during this stage, and the active surface area of particles is increased to make the microorganism access easier. All the above mentioned are facilitated with the homogenization procedure and should be carried out twice a week at least.

The second phase is the maturing phase during of which, oxygen is supplied for aerobic microorganisms acting and for resistant substances degradation. During this phase, the moisture content of the stack is also controlled.

Mixing machines are the main mechanical equipment for this process. These machines could be auto-motivated or could be mounted on other equipment. They have the capability to shape stacks as triangle or trapezoidal and to contribute to the optimization of mixing, homogenization, and ventilation process. An alternative solution to these machines is the loaders. But in this case the operational cost and efficiency factor of the mixing process will be lower.

The stack temperature also plays a key role during the thermophilic stage of the composting process. The desired temperatures lie in the range of 55-60 °C. In the case that this temperature increases further or in the case that the sanitization of the stack is completed then the mixing procedure should start, and if this is not effective, the reduce of the stack is necessary. In an opposite situation where the temperature decreases below the desired range, the mixing process contributes to the temperature increase due to the biodegradation process of substances which were on the outer surface of the stack. Moreover, this procedure enhances the air-diffusion into the raw materials.

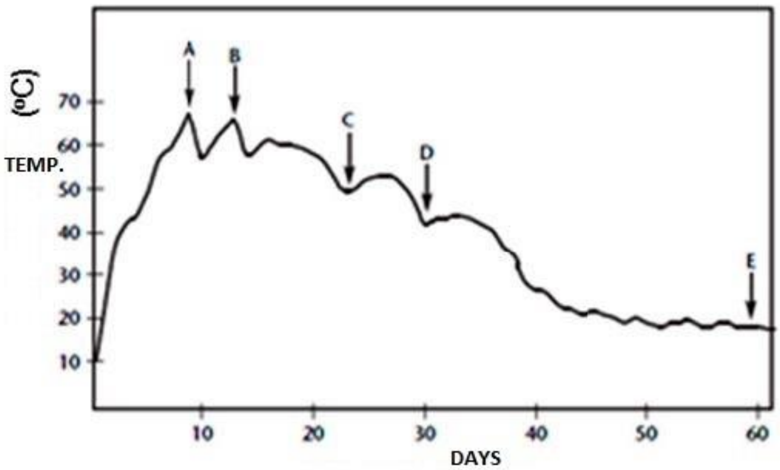

Figure 14: Mixing procedure effect on temperature evolution

Another important parameter of ventilation process is the oxygen concentration which should be over than 7% v/v. The problem which is taking place for concentrations below 7% v/v, is that anaerobic conditions are starting to exhibit. This start is confirmed by the increase of the CO_2 concentration over 12% v/v. It is also confirmed by strong odours.

Finally, moisture content over 60% w/w is a high content which should be decreased. This could be also achieved by the mixing process.

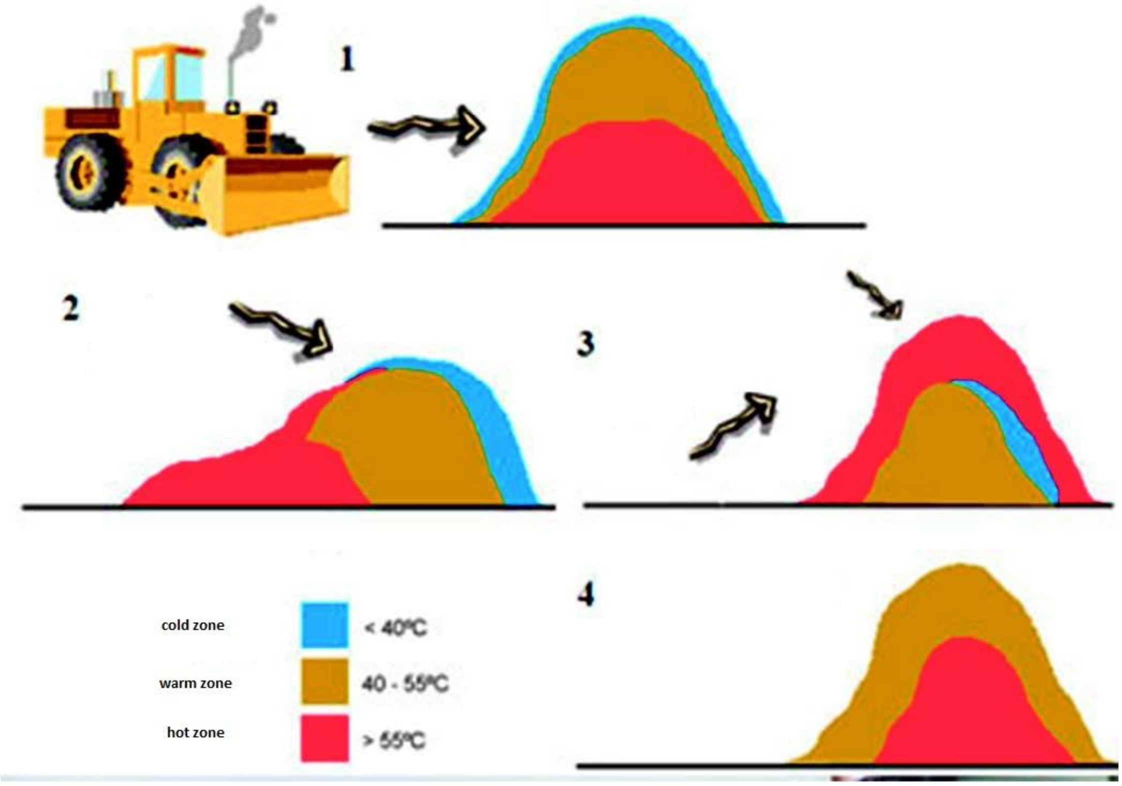

Figure 15: Mixing process stages using a loader machine

Figure 16: Stack mixing

3.1.8 P7b-Ventilation / System agitation with enforced ventilation

Stack ventilation with enforced ventilation systems is carried out with fresh air feeding through air ducts. This procedure is guaranteed a homogeneous distribution of air and moisture inside the stack. These systems could be combined with mechanical mixing systems. With these systems, the ventilation of stacks is carried out automatically and controlled by measured parameters such as temperature, moisture, CO_2, e.t.c. The systems for enforced ventilation are of two kinds. The first group is blowing air into the stack and the second group is sucking air from the stack. In the most cases there is a combined system which is sucks air at the beginning and blowing air at the end. At the beginning the air is passed through bio-filters because of the strong odours. At the end, the air is passing through pierced tubes which are installed to the base of stacks.

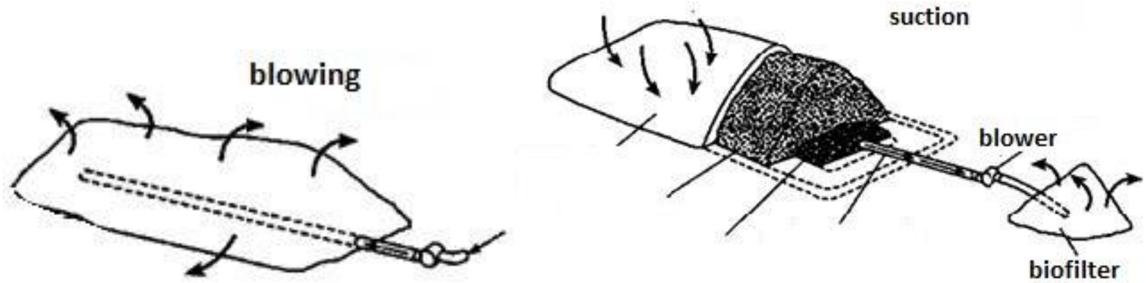

Figure 17: Enforced ventilation systems

3.1.9 P8-Sanitization of composting material

Sanitization of compost is an important stage because of the animal bio-wastes. But there are no official directives for pre-selected municipal biowastes composting. For this reason, three temperature vs time profiles are proposed, (i) 65°C or more, for five days at least, (ii) 60°C or more, for seven days at least, (iii) 55°C or more, for fourteen days at least. Any other profile is acceptable only if it is proven that similar or better results are achieved and if the composting organization received the permission from the relevant ministry office. In the case of animal biowastes which are not described in the directive 142/2011 annex 5, these should be sanitized under 70°C or more for 60 minutes. At the above mentioned high temperatures the pathogenic microorganisms such as e.coli, bacillus, salmonella, e.t.c. and the weed seeds are destroyed. Nevertheless, relevant analyses for these organisms and seeds should be carried out with the final product.

3.1.10 P9-Stack wetting

The stack wetting process helps to keep moisture content in a desired optimal range (45-60% w/w). This helps to avoid the deceleration or the pausing of the composting procedure. It is appropriate to do the wetting process simultaneously with the mixing process. The liquid wastes are collected to a tank and could be reused during the composting process. The excess of these liquid wastes should be treated to liquid wastes installations. The reusing procedure helps to save pure water. The commonly used equipment for the wetting procedure is the wetting reel and the water clouding nozzles.

3.1.11 P10-Stack covering with semi-permeable membranes

At this stage, stacks are covered with a semi-permeable membrane of fleece type aims to their protection from bad weather conditions (e.g. rain, sun, wind). This covering is most important especially at winter season or if no mixing carried out. The fleece type membranes keep moisture levels stable and prohibit the inlet of rainwater. Moreover, they protect the stack from birds and rodents. The protect stacks from wind and at the same time they ensure the homogeneous ventilation of stacks. Finally, they drastically reduce odours. There are machines for semi-permeable membrane stratification.

Figure 18: Stack wetting equipment

Figure 19: Stack covering with semi-permeable membranes

3.1.12 P11-Separation and removal of admixtures during refine process

This process includes the removal admixtures, which income with non-pure feeding material, from compost, as well as the separation of non-biodegradable materials (e.g. wood materials). There are three stages for this separation procedure, the sieving, the air-separation, and the magnetic separation. This procedure is taking place after the maturation stage. Commonly used equipment for the sieving procedures is a big sieve machine with rotary mesh (10mm-25mm bore). Particles larger than this size could be reused to the composting process. Otherwise, it should be further treated. The optimal moisture content for the sieving procedure is 40% w/w.

The air separation machines are treated the large size fraction from the sieving machines. At this stage, the plastic material (e.g. plastic bags, plastic bottles e.t.c.) is removed from this fraction and the residual material is reused for composting.

The magnetic separator machine is used for the removal of metallic materials. There is a variety of types of magnetic separators for several types of composting units.

Figure 20: Admixtures removal machines

3.1.13 Compost Standardization

At this stage, further treatment of compost leads to a product with specific qualitative characteristics and increased additional value. This is the final stage of the composting process. This stage includes three phases.

The first phase is the sieving phase and the final particle size depends on the use of the compost. For example, 10mm particle size is required for cultivation procedures, 10mm-20mm particle size is required for agricultural procedures, and 40mm particle size is required for soil covering. If compost should be storage for a long time, it is suggested to sieve the raw material just before the storage phase. It depends from the kind of final use of compost the addition of admixtures such as fossil additives or peat. These additives could be also added to the compost at the maturing phase, just in the case that the unfavourable admixture will be removed. The bagging procedure could be carried out according to the demand i.e. totally or partially. Usually, the commonly used bags are of 40-80 lt volume.

Figure 21: Compost bagging equipment

3.1.14 Compost storage

At this stage, the already matured compost is storage under appropriate conditions for a certain time in order to avoid its quality deterioration. The stored compost should be protected from extreme weather phenomena such as heavy rain, drought, strong winds, e.t.c. This because the storage duration could exceed the one year. Stack height should not exceed the 1.5m and the stored material should be mixed every 3-4 weeks. If the compost temperature increases over 30°C this is an indication that the maturing phase did not completed. In case of high temperatures, the compost material should be wetted to keep the desired moisture content. The machinery which will be used after the storage phase should be disinfected to avoid a new contamination of the compost. The protection of the stacks from the sun or heavy rain could be done with shelter of semi-permeable membranes.

Figure 22: Compost storage under shelter

3.2 EU policy framework on waste

With the first Waste Framework Directive (EU WFD) dating back to 1975, waste policy has been one of the first environmental policy fields covered by EU legislation. Today, the EU waste policy aims not only at minimising health and environmental threats from waste and waste management, but also at resource efficiency. The EU's efforts for resource efficiency are reflected in the new ambitious Circular Economy Package, which underlines the value of waste as a secondary raw material [EC 2016c; UBA no year]. EU waste legislation today covers a number of regulations and directives setting out substantial and detailed requirements for the MS. These requirements relate to general principles of waste management systems, to standards for the entire management of waste, including treatment, and to specific waste streams.

Relevant EU directives and regulations related to bio-waste

Waste Framework Directive 2008/98/EC (EU WFD)	Landfill Directive 1999/31/EC (EU LD)	Animal By-Products Regulation (EC) No 1069/2009	Fertiliser Regulation (EC) No 2003/2003
Contains general waste management requirements	Contains specific requirements for the landfilling of waste and bio-waste	Lays down health rules for composting and anaerobic digestion plants, which treat animal by-products	Regulates the production, composition and labelling of fertilisers

Source: BiPRO GmbH 2016

Figure 23: EU legislation

3.3 EU legislation on bio-waste

Bio-waste represents one of these specific waste streams. The EU directives and regulations presented in Figure 3 are of particular importance for bio- waste management, including its treatment.

3.3.1 Waste Framework Directive

Article 4 of the revised EU WFD of 2008 describes the different steps of the hierarchy of waste treatment. Article 6 defines end-of-waste crite- ria. Article 11 determines re-use and recycling targets regarding all types of waste and Article 22 sets out specific measures for bio-waste. The MS are required to promote the separate collection of bio-waste in order to be treated according to the waste hierarchy (see Figure 4), as well as to use environmentally safe materials produced from bio-waste [EU WFD].

3.3.2 Landfill Directive

To ensure that the bio-waste management of MS is in accordance with the waste hierarchy, the Landfill Directive 1999/31/EC (EU LD) stipulates specific requirements for the landfilling of biodegradable waste. Not later than five years after entering into force of the national laws implementing the EU LD, bi- odegradable municipal waste going to landfills must be reduced to 75 %, after eight years to 50 %, and after 15 years to 35 % of the total amount (by weight) of biodegradable municipal waste produced in 1995 [EU LD].

3.3.3 Animal By-Products Regulation and Fertiliser Regulation

Specific requirements for input material and for the use of compost or diges- tate are laid down in the Animal By-Products Regulation (EC) No 1069/2009 and in the Fertiliser Regulation (EC) No 2003/2003/EC. The Animal By-Prod- ucts Regulation specifies, inter alia, which animal by-products are allowed to be composted or digested and, after this, used in agriculture [EU Ani-
mal By-Products Regulation].

The Fertiliser Regulation on the other hand, regulates the production, the composition and the labelling of fertilisers. For this purpose, the regula- tion contains requirements on the permitted input material, the content and the efficacy of nutrients. In addition, it limits the quantity of undesirable substances [EU Fertiliser Regulation].

With the objective of achieving an EU-wide circular economy with closed loops of resources, new regulations are under discussion, e.g. a revised EU Fertiliser Regulation, which promotes the use of organic and waste-based fertilisers. The draft of the revised EU Fertiliser Regulation “contains several elements that will help create a level playing field for all fertilising products, while at the same time ensure high safety and environmental protection standards” [EC 2016b].

3.4 Status of implementation of EU bio-waste legislation in the EU Member States

Despite the fact that EU waste policies today include a number of legal doc- uments, which define substantial and detailed requirements for MS, and despite several guidance documents on how to meet these requirements, various sources show that the state of implementation in the MS differs largely, in particular regarding municipal waste management. For instance, the “Assessment of separate collection schemes in the 28 capitals of the EU” shows that some MS have established well-functioning municipal waste man- agement systems with high recycling rates. However, as many as 12 MS do not collect bio-waste separately, meaning that the five-step waste hierarchy can- not be implemented for bio-waste in those MS [EC 2015]. As Figure 5 shows, in many MS landfilling is still the preferred treatment option for mixed municipal waste, containing bio-waste. This fact is of particular significance, because 20 – 60 % of the munici- pal solid waste consists of bio-waste. The actual potential for recycling of bio-waste from municipal solid waste in Europe (EU 28, Switzerland, and Norway) is about 90 million tonnes per year. Only 30 million tonnes of bio- waste in Europe are currently recycled per year. Therefore, the resources of 60 million tonnes of bio-waste, e.g. nutrients, are lost [ECN 2017].

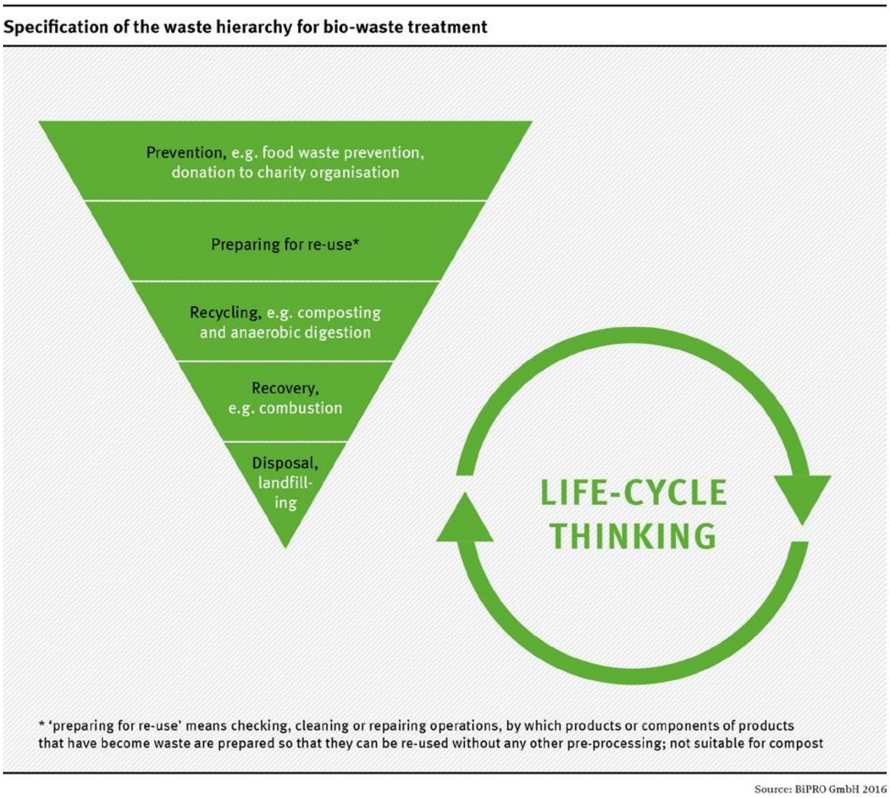

Figure 24: Waste hierarchy for bio-waste treatment

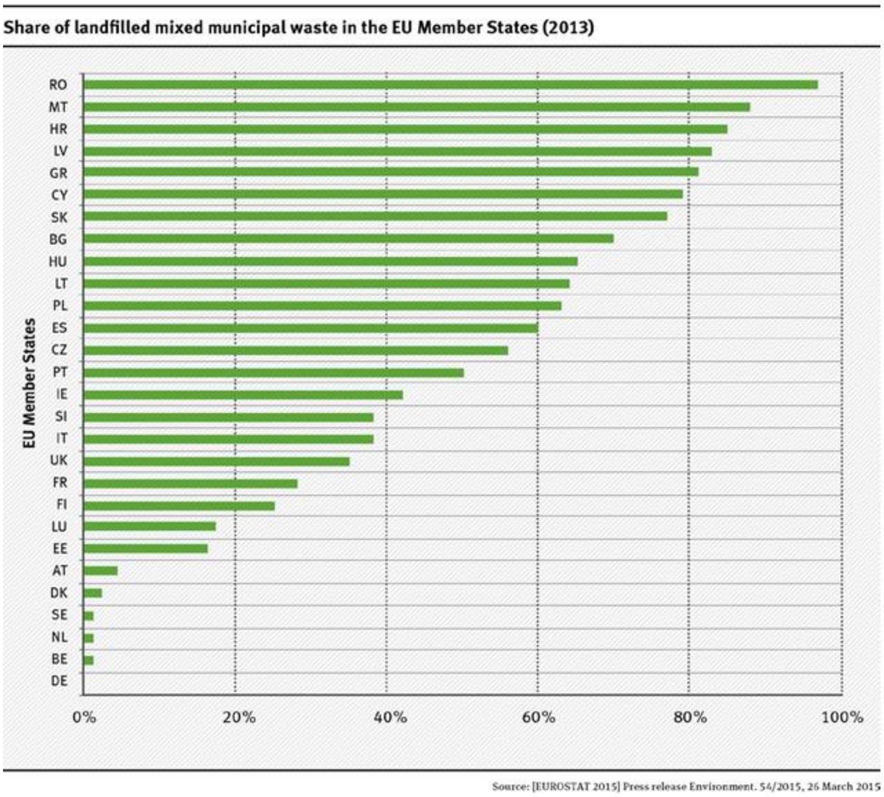

Figure 25: EU member status for landfilled municipal wastes

4. Requirements for compost production

4.1 Mechanical equipment

The following table presents typical mechanical equipment required for composting process:

STAGE	PROCESS	EQUIPMENT	PROCESS CODE
Incoming-Entrance	Waste weighting	Weight bridge	P1
Pre-treatment	Wastes chopping-Sacks opening	Shredder, chipper, grinder mixer, inverter	P2, P3
Composting pre-treatment	Mixing-homogenization	Mixer, inverter, loader	P5, P6
Composting, maturing	Mixing, ventilation, waste gas treatment, stacks wetting, weather protection, process control	Inverter, loader, ventilation systems, biofilters, nebulizer, wetting reel, shelters, semi-permeable membranes,	P7a, P7b, P9, P10

		instruments for temperature, oxygen, other gas, and pH control	
Refinery	Admixtures separation, compost standardization	Sieves, air separator, magnetic separator, bagging machine,	P4, P11, P12
All stages	Cleaning, washing, materials transfer	high pressure cleaner, loader, sweeper	

4.2 Final product

4.2.1 Determination of compost as final product

According to Greek and European legislation framework the final product could be nominated as compost in case it has the following properties or standards or according to the following criteria

- The material could be used for specific purposes
- There is a pre-existed requirement for this material
- The material fulfils specific standards for specific purposes and its properties are according to directives and standards applied for such products
- The use of the produced material is safe for public health and for the environment.

4.2.2 Uses and applications of compost

The compost could be used as soil improvement because its use improves the physical, chemical, and biological properties of soil. The use of compost increases the organic material of soil, decreases the soil erosion, improves the soil humidification, increases the soil pH, improves the soil structure, and improves the soil biological activity. The compost could be also used for organic fertilizers production because on its own it could not be a fertilizer. Finally, compost could be used as cultivation substrate. Nowadays, substrates with peat is up to 80-90% of the global market while compost substrates are of 5%. British directives which are included to WRAP suggest the use of compost as substrate with a fraction of 33% v/v at most and in combination with peat and wooden wastes. Higher compositions of compost have negative effects because of its high conductivity.



Agriculture **Architecture** **Landfill covering**


Soil material **Biofilter**

Figure 26: Compost uses and applications

4.2.3 Bio-waste management and QAS for compost and digestate in Germany

In Germany, the separate bio-waste collection and subsequent production of compost started already in the mid-1980s on a voluntary basis. However, the acceptance of compost was low. To increase the quality of the compost and thereby its acceptance and in the end its marketability, composting plant op- erators founded the state-independent quality assurance organisation BGK in 1989. In the following years, bio-waste management was introduced step- wise by relevant German legislation. Since 2015, the separate collection of bio-waste is required by law and has already been successfully implemented in many municipalities. This has enabled an effective recycling of bio-waste through composting or anaerobic digestion.

Today, the BGK is the responsible organisation for the quality assurance of compost and digestate produced by certified composting or digestion plants. The requirements for the certification are defined by a standard setting institution, the RAL. The BGK implements these requirements and awards qualified products (compost and digestate) the respective RAL labels. Further tasks of the BGK are, inter alia, advising its members, public relations, and the promotion of research and development. In order to review the quality of compost and digestate according to defined quality requirements, the BGK accredits and approves independent sample takers and laboratories. Therefore, an accreditation procedure for both, the sample takers and the laboratories, has been established by the BGK. Plant operators wishing to depict a RAL label have to pass the quality assurance process conducted by the BGK. This includes sample taking during a site visit by a BGK sample taker and subsequent analysis of the sample by an accredited laboratory. The objective is that the operator proves to the BGK quality advisor that he is able to ensure the self-control during the plant operation. Once the production process, the intermediate and final products, as well as the plant itself fulfil all RAL requirements, the compost and digestate produced by the plant can be awarded the RAL label.

4.2.4 General steps towards a QAS

When thinking of introducing a QAS and reflecting, which properties and experiences of the QAS and its QAO of Germany may be of interest for designing and establishing a QAS, it is recommended to focus first on functions, which a QAS shall perform, and then on organisational aspects. The range of possible functions could comprise: developing quality standards for compost and digestate that at least meet the requirements of the respective acts and ordinances to increase the acceptance of compost and digestate as new products

Figure 27: Biowaste management and QAS

5. Systems for compost quality assurance to European countries

Following will be presented in short some of the established standards for compost quality assurance in some european countries.

5.1 ÖNORM -Austria

Austrian standards and technical guidlines for compost quality assurance are described in the following directives:

- ÖNORM S 2206-1: Requirements for a quality assurance system for the production of composts, Part-1: Principles for quality assurance of a company and of the internal technical processes (Austrian Standard).

- ÖNORM S 2206-1: Requirements for a quality assurance system for composts – Part-2: Determination of tasks and conditions for a quality assurance organisation.
- ONR 192206 Technical Guideline: Implementation of quality assurance on composting Plants.

The national offices which are responsible for compost products and units certification are the following two:

- The Compost Society of Austria (KGVÖ)

- The COMPOST & BIOGAS ASSOCIATION – AUSTRIA (ARGE KOMPOST & BIOGAS – ÖSTERREICH)

Figure 28: Austrian logo

5.2 RAL Compost Quality Label – Germany

In Germany, the quality standard RAL GZ 251 is applied. This standard is an integrated system for quality and process control of composting units for pre-selected bio-wastes. This system inspects the input biowastes, the composting processes, the sanitation of materials, and the quality of the final product.

Figure 29: German logo

5.3 BSI PAS 100 - UK

British Standard Institution has been published the BSI PAS 100 standard for composting units and for anaerobic digestion units. This standard is a national reference point and it cavers the minimum requirements for:

- the composting process

- the incoming materials choice

- the product label

5.4 European system for compost quality assurance, ECN -QAS

The European Compost Network (ECN) at 2010 established a european system for compost quality assurance based on the experience of countries which are having quality assurance systems. The main target was to develop a system which could be applied from countries like Greece which did not had similar system. This system covers the following requirements:

- the coice of incoming materials for composting
- the operational procedures of a unit
- the final product quality

Figure 30: European logo

6. Sugested Compost Quality Standards

The minimum requirements and the limited values for compost quality are described below:

1. Minimum organic content, 15% w/w dry base, (is the minimum requirement content of organic matter into the final compost before the mixing with other materials).

2. Minimum stability of material, max 25 mmolO2/kg organic material/h or 16mgCO2/gr of organic material/day (EN 16087-1 std.)

3. Minimum stability of material, minimum Rottegrad degree III, IV, V, autoheating test to max 30°C (EN 16087-2 std.)

4. Pathogenic microorgnism content, zero content of salmonellasp. Per 25gr of sample, 1000CFU/gr fresh E.coli mass

5. Viable weeds content, 2 viable seeds of weeds per lt of compost

6. Macroscopic admixture content, 0.5% w/w of dry mass could contain glass, metal, or plastic particles over 2mm (dry sieving method is the testing method)

7. Limited content values for heavy metals and organic polutants as follows: Cd 1.5 mg/kg (dry base), Cr 100 mg/kg (dry base), Cu 200 mg/kg (dry base), Hg 1 mg/kg (dry base), Ni 50 mg/kg (dry base), Pb 120 mg/kg (dry base), Zn 600 mg/kg (dry base), PAH_{16} 6 mg/kg (dry base)

PAH_{16} is the total content of several organic polutants such as naphtalene, acenaphthylene, acenaphthene, fluorene, e.t.c.

Literature Sources

Cornell Waste Management Institute. 1996.*Cornell Composting.* [Online] 1996. http://compost.css.cornell.edu/.

ADEME. 2012.*The ADEME Research Programme on Atmospheric Emissions from Composting, Research findings and literature review.* s.l. : French Environment and Energy Agency (ADEME), 2012.

Air Pollution Control Division. 2012.*Composting: VOC Emissions & Best Management Practices (Memo).* s.l. : Colorado Department of Public Health and Environment, 2012.

Amlinger F., Peyr S., Hildebrandt U., Musken J., Cuhls C., Gilbert J. 2005.*Stand Der Technik der Kompostierung, Grundlagenstudie.* s.l. : Lebensministerium, 2005.

2009.*The State of the Art of Composting a guide to good practice.*s.l. : Austrian Ministry For Agriculture and Forestry, Environment and Water Management, 2009.

Athens Biowaste (LIFE 10 ENV/GR/605). 2014.www.biowaste.gr. [Online] 2014.

Binner, E., 2002. *Kompostierung von biogenen Abfällen. Skriptum zum ÖWAW Kurs, Fachkraft Abfallwirtschaft. 22-26 April 2002.*

Binner, E., 2003.*Biologische Behandlung, Kompostierung Faulung, aerob–anaerob, Folien zur LV Nr. 520.338. ABF, Boku,Wien.*

BSI. WRAP, Association for Organics Recycling. 2011. PAS 100:2011, Specification for Composted Materials. s.l. : BSI, 2011.

Cooperband, Leslie. 2002.*The Art and Science of Composting, A resource for farmers and Compost producers.* s.l. : Center for Integrated Agricultural Systems, 2002.

DEFRA. 2010.*Odour Guidance for Local Authorities.* UK : Department for Environment, Food and Rural Affairs (DEFRA), 2010.

ENVIRON I.C. 2013.*Compost Facility Air Quality Technical Report.* s.l. : Lenz Enterprises, 2013.

Environment Agency. 2013. 17 Technical Guidance Note (Monitoring). *Monitoring Particulate Matter in Ambient Air around Waste Facilities.* UK : s.n., 2013.

Epstein, Eliot. 2011.*Industrial Composting, Environmental Engineering and Facilities Management.* s.l. : CRC Press, Taylor & Francis Group, 2011.

European Compost Network ECN e.V. 2010. Quality Assurance Scheme, Quality Manual. s.l. : European Compost Network ECN e.V., 2010.

Evans, Gareth. 2001.*Biowaste and Biological Waste Treatment.* s.l. : James & James (Science Publishers) Ltd., 2001.

Hösel, Bilitewski, Schenkel, Schnurer. *Mullhandbuch Band 3.*

IPCC. 2006.*Guidelines for national greenhouse gas inventories. Volume 5: waste, pp. 4.1 4.8.* s.l. : IPCC, 2006.

IPTS. 2014.*End of waste criteria for biodegradable waste subjected to biological treatment (compost & digestate):Technical proposals, Final Report.* s.l. : European Commission, Joint Research Centre, Institute for Prospective Technological Studies, 2014.

Kompostverordnung, 2001. *Verordnung des Bundesministers für Land und Forstwirtschaft, Umwelt und Wasserwirtschaft über Qualitätsanforderungen an Komposte aus Abfällen*, StF: BGBl. II Nr. 292/2001.

L.F.Diaz, M.de Bertoldi, W. Bidlingmaier and E.Stentiford. 2007.*Compost Science and Technology.* s.l. : Elsevier, 2007.

Northern Ireland Environment Agency. 2012. End of waste criteria for the production and use of quality compost from source segregated biodegradable waste. *Quality Protocol.* s.l. : Environment Agency, 2012.

ORBIT e.V./European Compost Network ECN. 2008.*Compost production and use in the EU, Final report of ORBIT e.V. /European Compost Network ECN to European Commission.* s.l. : DG Joint Research Centre/IPTS, 2008.

Ottow, J., Bidlingmaier, W., 1997 *Umweltbiotechnologie der Umwelt, Gustaf Fischer Verlag, Stuttgart, 174 S.*

Rynk, R. 1992. *On Farm Composting Handbook.* s.l. : Northeast Regional Agricultural Engineering Service, 1992.

Sowka, Izabela. 2010. Assessment of Air Quality in terms of Odour according to selected European Guidelines: Grid and Plume Meausurements, Vol.36. s.l. : Institute of Environmental Engineering, Wroclaw University of Technology, 2010.

Technische Anforderungen an Kompostierungsanlagen. *ÖNORM S 2205,* ON Österreichisches Normungsinstitut 2008.

German directives

AGROLAB Labor GmbH (2017): Information provided by Eleonore Marciniszyn. March 2017.

BMUB (Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit) (2016): Bioabfälle – Statistik. Available at: http://www.bmub.bund.de/themen/wasser- abfall-boden/abfallwirtschaft/statistiken/bioabfaelle/. Access 21.02.2017.

BGK (Bundesgütegemeinschaft Kompost e. V.) (2010): Composting and Quality Assurance in Germany. Presentation by Siebert, Stefanie and Thelen-Jüngling, Maria. Available at: http:// www.kompost.de/uploads/media/Compost_Course_ gesamt_01.pdf. Access 08.02.2017.

BGK (Bundesgütegemeinschaft Kompost e. V.) (2015): H&K aktuell 04/2015, Seite 5 –7 Maria Thelen-Jüngling (BGK e. V.). Available at: https://www.kompost.de/fileadmin/news_ import/Verwertung_auf_hohem_Niveau_HUK_4_2015.pdf. Access 22.03.2017.

BGK (Bundesgütegemeinschaft Kompost e. V.) (2016a): Establishment and Registration, Structure and Responsibilities of QAO in Germany. Presentation by Lausterer, Wolfgang and Hommel, Ulrich on 02.11.2016.

BGK (Bundesgütegemeinschaft Kompost e. V.) (2016b): Control relations with accredited laboratories and other institutions. Presentation by Lausterer, Wolfgang and Hommel, Ulrich on 02.11.2016.

BGK (Bundesgütegemeinschaft Kompost e. V.) (2016c): Contractual relations with accredited laboratories and other institutions. Presentation by Lausterer, Wolfgang and Hommel, Ulrich on 02.11.2016.

BGK (Bundesgütegemeinschaft Kompost e. V.) (2017a): Gütesicherung Kompost. Available at: https://www.kompost. de/guetesicherung/guetesicherung-kompost/. Access 22.02.2017.

BGK (Bundesgütegemeinschaft Kompost e. V.) (2017b): Wer wir sind. Available at: https://www.kompost.de/de/ueber-uns/ wer-wir-sind/. Access 06.03.2017.

BGK (Bundesgütegemeinschaft Kompost e. V.) (2017c): Written consultation of Lausterer, Wolfgang. 06.03.2017.

BGK (Bundesgütegemeinschaft Kompost e. V.) (2017d): Qualitätsanforderungen für Fertigkompost. Available at: https://www.kompost.de/fileadmin/user_upload/Dateien/ Guetesicherung/Dokumente_Kompost/Dok._251-006-2_ Qualitaetskrit._K.pdf. Access 19.06.2017

BGK Methods Book (2002): Methods Book for the Analysis of Compost. Bundesgütegemeinschaft Kompost e. V. (BGK). Available at: https://www.kompost.de/fileadmin/ docs/shop/Grundlagen_GS/Methods_Book_2002.pdf. Access 19.06.2017

BiPRO GmbH (2016): Policy Framework for Bio-Waste and Compost. Presentation by Zettl, Elisabeth on 02.11.2016.

EAP (Energy Agency of Plovdiv) (2016): Techniques and experience in compost sampling and analysis in Bulgaria. Presentation by Piscova, Elka on 02.11.2016

EC (European Commission) (2015): Assessment of separate collection schemes in the 28 capitals of the EU. By BiPRO GmbH Munich.

EC (European Commission) (2016a): Biodegradable waste. Available at: http://ec.europa.eu/environment/waste/compost/. Access 20.02.2017.

EC (European Commission) (2016b): Circular Economy: New Regulation to boost the use of organic and waste-based fertilisers. Available at: http://europa.eu/rapid/press- release_MEMO-16-826_de.htm. Access 20.02.2017.

EC (European Commission) (2016c): Environmental Action Programme to 2020. Available at: http://ec.europa.eu/ environment/action-programme/. Access 21.02.2017.

Ganser Entsorgung (2016): Verfahrensbeschreibung Bioabfallvergärungsanlage. Available at: http:// www.ganser-gruppe.de/entsorgung-muenchen/ bioabfallvergaerungsanlage/verfahren.html. Access 21.03.2017.

INFU mbH (2016a): Compost and digestate sampling under practical conditions. Presentation by Marciniszyn, Eleonore on 03.11.2016.

INFU mbH (2016b): Acceptance procedure and requirements for laboratories. Presentation by Marciniszyn, Eleonore on 03.11.2016.

INFU mbH (2016c): Acceptance procedure and requirements for sample takers. Presentation by Marciniszyn, Eleonore on 03.11.2016.

INFU mbH (2016d): Product quality and test criteria. Presentation by Marciniszyn, Eleonore on 03.11.2016.

Fricke, K.; Kosak, G.; Meier-Ploeger, A.; Turk, T.; Wallmann, R.M Vogtmann, H. (2003): Die Getrenntsammlung und Verwertung von Bioabfällen – Bestandsaufnahme 2003.

In: Fricke et al. (2003): Die Zukunft der Getrenntsammlung von Bioabfällen. 20 Jahre Biotonne Witzenhausen – eine Standortbetimmung. S. 64.

LUBW (State Institute for the Environment, Measurements and Nature Conservation of Baden-Württemberg) (no year a): Vergärung von Bio- und Grünabfällen. Available at: http:// www4.lubw.baden-wuerttemberg.de/servlet/is/209620/. Access: 28.02.2017.

LUBW (State Institute for the Environment, Measurements and Nature Conservation of Baden-Württemberg) (no year b): Kompostierung von Bio- und Grünabfällen. Available at: http://www4.lubw.baden-wuerttemberg.de/servlet/ is/209540/. Access: 28.02.2017.

UBA (German Environment Agency) (no year): Europäische Gemeinschaft erlässt Abfallrahmenrichtlinie. Available at http://fuer-mensch-und-umwelt.de/1975/europaische-gemeinschaft-erlasst-abfallrahmenrichtlinie-2/. Access 27.02.2017.

UBA (German Environment Agency) (2015): Waste classification sampling and analysis. Dessau-Rosslau. Germany. Available at: https://www.umweltbundesamt.de/publikationen/ waste-classification-sampling-analysis. Access 21.02.2017.

UBA (German Environment Agency) (2016a): Organic waste treatment. Available at: https://www.umweltbundesamt.de/ en/topics/waste-resources/waste-disposal/organic-waste-treatment. Access 28.02.2017.

UBA (German Environment Agency) (2016b): Legal framework on the German Bio-Waste Ordinance. Presentation by Hermann, Tim on 02.11.2016.

UBA (German Environment Agency) (2016c): Bioabfälle. Available at: https://www.umweltbundesamt.de/daten/abfall- kreislaufwirtschaft/entsorgung-verwertung-ausgewaehlter- abfallarten/bioabfaelle#textpart-1. Access 28.02.2017.

Laws, directives and regulations cited:

DE BBodSchG (Bundes-Bodenschutzgesetz – German Federal Soil Protection Act) (1998): Gesetz zum Schutz vor schädlichen Bodenveränderungen und zur Sanierung von Altlasten (Bundes-Bodenschutzgesetz – BBodSchG). Available at: https://www.gesetze-im-internet.de/bundesrecht/ bbodschg/gesamt.pdf (in German only). Access 06.03.2017.

DE BBodSchV (Bundes-Bodenschutz- und Altlastenverordnung – German Federal Soil Protection Ordinance) (1999): Bundes- Bodenschutz- und Altlastenverordnung (BBodSchV). Available at: http://www.gesetze-im-internet.de/ bundesrecht/bbodschv/gesamt.pdf (in German only). Access 06.03.2017.

DE BioAbf V (Bioabfallverordnung – German Bio-Waste Ordinance) (1998): Verordnung über die Verwertung von Bioabfällen auf landwirtschaftlich, forstwirtschaftlich und gärtnerisch genutzten Böden (Bioabfallverordnung – BioAbf V). Available at: https://www.gesetze-im-internet.de/bundesrecht/bioabfv/gesamt.pdf (in German only). Access 06.03.2017.

DE DüngG (Düngegesetz -German Fertiliser Act) (2009): Düngegesetz. Available at: https://www.gesetze-im- internet.de/bundesrecht/d_ngg/gesamt.pdf (in German only). Access 06.03.2017.

DE DüMV (Düngemittelverordnung – German Fertiliser Ordinance) (2012): Verordnung über das Inverkehrbringen von Düngemitteln, Bodenhilfsstoffen, Kultursubstraten und Pflanzenhilfsmitteln (Düngemittelverordnung DüMV). Available at: http://www.lfl.bayern.de/mam/cms07/zentrale_analytik/dateien/d_ _ngemittelverordnung.pdf (in German only). Access 06.03.2017.

DE KrWG (Kreislaufwirtschaftsgesetz – German Circular Economy Act) (2012): Gesetz zur Förderung der Kreislauf wirtschaft und Sicherung der umweltverträglichen Bewirtschaftung von Abfällen (Kreislaufwirtschaftsgesetz – KrWG). Available at: https://www.gesetze-im-internet.de/bundesrecht/krwg/ gesamt.pdf (in German only). Access 06.03.2017.

DE TierNebG (Tierische Nebenprodukte-Beseitigungsgesetz – German Animal By-Products Disposal Act) (2004): Tierische Nebenprodukte-Beseitigungsgesetz (TierNebG). Available at: http://www.gesetze-im-internet.de/bundesrecht/tiernebg/ gesamt.pdf (in German only). Access 06.03.2017.

DE TierNebV (Tierische Nebenprodukte-Beseitigungsverordnung – German Animal By-Products Disposal Ordinance) (2006): Verord-nung zur Durchführung des Tierische NebenprodukteBeseitigungsgesetzes (Tierische NebenprodukteBeseitigungsverordnung – TierNebV). Available at: http://www.gesetze-im-internet.de/ bundesrecht/tiernebv/gesamt.pdf (in German only). Access 06.03.2017.

EU WFD (Waste Framework Directive: DIRECTIVE 2008/98/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 19 November 2008 on waste and repealing certain Directives. Available at: http://eur-lex.europa.eu/LexUriServ/ LexUriSer v.do?uri=OJ:L:2008:312:0003:0030:en:PDF (in English). Access 22.09.2017.

EU LD (Landfill Directive): Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste. Available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ. do?uri=OJ:L:1999:182:0001:0019:EN:PDF (in English). Access 22.09.2017.

EU Animal By-Products Regulation: REGULATION (EC) No 1069/2009 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 21 October 2009 laying down health rules as regards animal by-products and derived products not intended for human consumption and repealing Regulation (EC) No 1774/2002 (Animal By-Products Regulation). Available at: http://eur-lex.europa.eu/LexUriServ/ LexUriSer v.do?uri=OJ:L:2009:300:0001:0033:EN:PDF (in English). Access 22.09.2017.

EU Fertiliser Regulation: REGULATION (EC) No 2003/2003 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 13 October 2003 relating to fertilisers. Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/ PDF/?uri=CELEX:32003R2003&from=EN (in English). Access 27.02.2017.

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