INTERNATIONAL COMPARISON OF THE AUSTRALIAN STANDARD FOR COMPOSTS, SOIL CONDITIONERS AND MULCHES (AS4454 – 2012)

Australian Organics Recycling Association (AORA)
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NOTE

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KEY FINDINGS

- A five-year research and development project provided the basis for establishing the first quality standard for compost made from source separated garden and food organics (FOGO) in Germany in 1989. The standard contained maximum allowable contaminant levels to differentiate FOGO compost from municipal solid waste (MSW) based compost.
- The Australian Standard for composts, soil conditioners and mulches (AS 4454 – 2012) is a voluntary quality standard and testing of compost products against some or all quality requirements is entirely at the discretion of individual composting companies. Likewise, compost manufacturers can decide if they want to have any of their products certified through third (*Product or Quality System Certification)* second *(Customer - Supplier Assessment)* or fist party *(Self-Declaration)* assessment. Commercial consideration result in a low proportion of third-party certified bulk compost, mulch and soil products. However, as compost supplies increasingly target high value commercial agricultural and horticultural markets where food safety and biosecurity requirements become ever tighter, it is expected that the pressure will grow for compost production systems and compost products to be independently audited and certified by a third party.
- Criticism of AS4454 - 2012 from sectors of the compost industry is unwarranted as it in no way prevents manufacturing of superior products that far exceed AS4454 quality requirements. AS4454 - 2012 is not the problem – it is the lack of clear and uniform regulations that create a level playing field, for example by incorporating uniform product quality requirements, including contaminant limits, for all organic soil amendments or fertilisers (e.g. EU fertilizer regulation).
- The legal status of AS4454 – 2012 is vague and weak. State regulatory bodies often reference the standard in license conditions for composting facilities, although they do not have the Head of Power to do so. The AS4454 – 2012 document states that *it is not appropriate for regulators to specify compliance with this Standard as a mandatory requirement for facility operations, licensing or application to land of production outputs*.
- Contaminant limits in AS 4454 – 2012 and international (European / North American) standards for composts and digestates do not vary markedly for 'regular' compost. In fact, very few countries have set limits for organic contaminants in compost and more organic contaminants are tested for under AS4454 - 2012 than in all other standards, although there is a need to overhaul the list of organic contaminants that are tested under AS4454 - 2012, as many refer to pesticides that have been banned a long time ago.
- The legal / regulatory status of compost quality criteria specified in European countries is often very different to the situation in Australia, as is the way in which regulations and quality management and quality assurance schemes are integrated into the regulatory framework. Most European countries identify and tightly control which feedstocks can and cannot be composted and therefore largely avoid having to deal with the issue of organic contaminants in compost products. Some countries do not require the measurement of organic contaminants in compost and digestate when they are derived from source-separated materials.
- The long-standing position of the USA, Canada and other countries that there is no conclusive evidence that the levels of organic contaminants typically found in recycled organic materials is hazardous to soil quality, human health or the environment, have prevented determination of organic contaminant limits in composts and associated products.

KEY FINDINGS

- Area-based limits of impurities, in addition to a weight-based limit, offers a means of applying pressure that composts that contain large quantities of low density plastic to be cleaned up. The German compost quality standard requires that impurities do not exceed 15 cm^2 per litre of compost.
- Microplastics in compost, digestate and soil are new fields of scientific investigation where much has yet to be learned. The composting industry needs to keep a watching brief on developments in this field. The same applies to so-called 'emerging contaminants', which is particularly relevant where biosolids and non-traditional industrial residues are co-composted.

COMPOST STANDARDS

History

Large scale commercial composting as we know it today began in the 1930s in Europe, where unsorted municipal solid waste (MSW) was processed and converted into compost for agricultural use. This occurred primarily in Germany and Holland where it was used to support development of the horticultural industry (Barles 2014). Those systems worked reasonably well as MSW in those days comprised primarily wood/coal ash and biodegradable residues, with very little glass, metal and plastic (Barles 2014). Large scale MSW composting in Europe peaked in the 1970's and 80's, a time when increasing concerns about contaminants and impurities in MSW compost and soil, together with a disruptive innovation, resulted in the decline and phasing out of MSW composting in many European countries.

The 'disruptive innovation' was the introduction of source segregated organics collection systems for residential and commercial organic residues, production of high quality compost from source segregated organics, and the beneficial use of the generated compost in agriculture and horticulture. This new approach to managing and utilising urban and commercial organics was not developed by the waste management sector. Instead it was developed at the agricultural faculty of the University of Kassel (Germany).

Even with elaborate processing steps, use of MSW compost had become unacceptable for farmers. However, it had been shown that quality of compost made from municipal and commercial organic residues could only be improved significantly if the feedstock material was segregated at source and collected and processed separately (Fricke *et al.* 1990). The difference in contaminant levels between compost made from MSW and source segregated organics was significant (Table 1), and justified abandoning the production and use of MSW compost. Production of MSW compost was therefore gradually replaced with source segregation of municipal and commercial organic residues, combined with the production and beneficial use of high quality compost products in agriculture and horticulture.

The range of contaminant levels that were found in compost generated from source segregated municipal garden and food organics during the 1983-86 pilot project, which was conducted in a small town of 20,000 people, provided the basis for establishing maximum allowable contaminant concentrations in compost as part of the first German compost quality standard in 1989 (Fricke and Vogtmann 1990). These original compost quality standards expanded on and specified Government guidelines for composts made from source segregated organic residues that were issued in 1982 (Bidlingmaier 1993).

The formulation of the first German compost quality standard was informed by considerable research and development work over a five-year period and provided the blue-print for many successive compost quality standards that were established around the globe, anecdotally including Australia's first version of the Australian Standard for Composts, Soil Conditioners and Mulches, AS 4454 - 1997. The early versions of the Australian standard did not contain specific contaminant limits, but instead required all materials comply with chemical and organic contaminant provisions of State or Federal guidelines for use of biosolids products that are for unrestricted use (Standards Australia 1999).

Table 1: Contents of impurities, heavy metals and organic contaminants in compost made from MSW and from source segregated organics in Germany in the 1980's [Source: modified from Vogtmann et al. 1989]

Product Characteristic	Unit	Source Segregated Organics Compost 1983 – 1986			MSW Compost Average 1984
Impurities	% (w/w) dm	0.33 (0 – 24 mm) 0.1% (0 – 10 mm)			1.0 - 11.0 (fine)
Heavy metals (Average / Range / first German compost quality standard)					
Cadmium	mg / kg dm	0.5	(0.3 – 1.6)	2.0	5.5
Chromium (Total)	mg / kg dm	28	(23 – 38)	100	71.4
Copper	mg / kg dm	40	(26 - 90)	100	274
Lead	mg / kg dm	86	(44 - 170)	150	513
Mercury	mg / kg dm	0.17	(0.06 – 0.48)	1.5	2.4
Nickel	mg / kg dm	17	(16 – 26)	50	44.9
Zinc	mg / kg dm	255	(140 – 360)	400	1,570
Organic contaminants (Average)					
Aldrin (insecticide)	ng / kg dm	0.1			114
Dieldrin (insecticide)	ng / kg dm	0.3			592
Hexachlorobenzene (fungicides incl Lindane)	ng / kg dm	< 1			Not available
Heptachlor (insecticide)	ng / kg dm	0.2			462
Sum HCH (insecticides)	ng / kg dm	9.5			1,263
Sum DDT/DDE/DDD (insecticides)	ng / kg dm	33.5			2,681
Sum polychlorinated biphenyls (PCB)	ng / kg dm	140			1,493
Sum polyaromatic hydrocarbons (PAH)	ng / kg dm	850			4,412

Australia

Several State Governments in Australia have published composting guidelines. Composting guidelines published in Queensland (Department of Environment and Heritage Protection 2013) and NSW (NSW Department of Environment and Conservation 2004) address primarily siting, operational and regulatory matters. These guidelines deal with feedstock quality aspects to some extent but do not stipulate contaminant quality requirements of finished products. This however is done in the Victorian (Environment Protection Authority Victoria 2017) and South Australian Composting Guidelines (Environment Protection Authority South Australia 2019) , which include contaminant limits for compost products that are aligned with limits stipulated in the *Australian Standard for Composts, Soil Conditioners and Mulches* (AS4454 - 2012).

The Australian StandardAS4454 - 2012 is the benchmark standard for compost quality in Australia. It specifies minimum processing standards for the elimination of pathogens and weeds and stipulates reporting requirements on a range of analytical tests for both pasteurised and fully composted products. It is the key reference for industry when assessing and classifying compost quality.

AS4454 – 2012 is a voluntary quality standard, as are the associated standards for *Soils for Landscaping and Garden Use* (AS4419 – 2018) and *Potting Mixes* (AS3743 – 2003). The testing of compost products against some or all quality requirements stipulated in AS4454 - 2012 is entirely at the discretion of individual composting companies, as there is no legal requirement to do so. However, government agencies responsible for regulating composting operations (regulators) may require compliance with the standard, although the legal status of doing so is not clear. Section 2 General Requirements – Containment of Disease, of the AS4454 – 2012 document states that *it is not appropriate for regulators to specify compliance with this Standard as a mandatory requirement for facility operations, licensing or application to land of production outputs*. Regardless of this statement regulators do reference the standard in license conditions for composting facilities. Local government tenders and contracts often require contractors to make AS4454 compliant products, or at least provide a facility capable of manufacturing AS4454 conforming products.

AS4454 – 2012 presents minimum requirements for physical, chemical and biological product properties, which provide assurance for users that certified products are free of viable plant propagules and will not cause adverse effects if used appropriately. In addition, products certified to AS4454 – 2012 quality requirements must also comply with State or Federal chemical and organic contaminant guidelines for products suitable for unrestricted use in land application of products derived from organic wastes, compostable organic materials or biosolids, whichever is the more stringent.

AS4454 - 2012 contaminant limits and pathogen reduction requirements are shown in Table 2. They are aligned with the NSW Biosolids Guidelines for unrestricted use of Grade A biosolids products (NSW EPA 2000), but allow higher copper and zinc concentrations where this can be justified by agronomic considerations and where none of the other metal limits are exceeded. The new Queensland End of Waste Code Biosolids (QLD Department of Environment and Science, 2019) followed this lead and established also maximum copper and zinc concentrations of 150 mg/kg and 300 mg/kg for Grade A biosolids products that can be used without restrictions.

AS4454 – 2012 differentiates products and minimum quality requirements according to product maturity (pasteurised product – composted product – mature compost) and particle size distribution (soil conditioner – fine mulch – coarse mulch), and in that way defines nine broad product types.

Unlike biosolids quality and end-use guidelines and codes, the AS4454 – 2012 compost standards do not differentiate between various contaminant classes and allowable uses, but stipulate only one class of allowed chemical, physical and biological contaminants for composted products (Table 2), and places no restriction on use. This implies that, if a Regulator does not stipulate end product contaminant criteria, and if the allowable land use criteria for biosolids are assumed to apply, compost that exceeds AS4454 – 2012 contaminant requirements, could still be utilised in line with biosolids restricted use specifications. This means the compost can be used everywhere except for home lawns

and gardens. In practice, only a small proportion of bulk compost products made from urban derived residues is utilised on home lawns and gardens. Based on this reasoning, there is no need for most compost products to comply with AS4454 – 2012 contaminant requirements for unrestricted use.

Table 2: Impurity, pathogen, heavy metal and organic contaminant limits for compost products for unrestricted use according to AS 4454 – 2012

Product Characteristic	Unit	Compost Quality Criteria AS 4454
Impurities		
Glass, metal and rigid plastic	% dm	≤ 0.5
Plastic – light, flexible or film	% dm	≤ 0.05
Stones and lumps of clay	% dm	≤ 5
Pathogens#		
Faecal coliforms	MPN/g	< 1000
Salmonella spp		absent in 50 g dry weight equivalent
Heavy Metals#		
Arsenic	mg / kg dm	20
Boron*	mg / kg dm	100
Cadmium	mg / kg dm	3
Chromium (Total)	mg / kg dm	100
Copper	mg / kg dm	100 (150)**
Lead	mg / kg dm	150
Mercury	mg / kg dm	1
Nickel	mg / kg dm	60
Selenium	mg / kg dm	5
Zinc	mg / kg dm	200 (300)**
Organic Contaminants#		
DDT/DDE/DDD	mg / kg dm	0.5
Aldrin	mg / kg dm	0.02
Dieldrin	mg / kg dm	0.02

Product Characteristic	Unit	Compost Quality Criteria AS 4454
Chlordane	mg / kg dm	0.02
Heptachlor	mg / kg dm	0.02
HCB	mg / kg dm	0.02
Lindane	mg / kg dm	0.02
BHC	mg / kg dm	0.02
PCBs^	mg / kg dm	Not detected

Pathogen, heavy metal and organic contaminant limits are largely aligned with NSW Biosolids Guideline values for Grade A product

* Testing for boron is generally only necessary for products that are based on seaweed, seagrass or unseparated solid waste that have a component of cardboard packaging.

** A product that contains levels of copper between 100 mg/kg and 150 mg/kg and/or zinc between 200 mg/kg and 300 mg/kg whilst not exceeding the limit values for all other contaminants, shall provide a warning label in accordance with labelling requirements.

^ The detection limit for PCBs shall be 0.2 mg/kg dm

As noted above, AS4454 is a voluntary standard. Most manufacturers of composts, soils and potting mixes (composters) will follow selected elements of AS4454 or other relevant standards and may claim to comply with the standards. Achieving third party certification against the standards imposes significant additional costs which are generally not considered commercially viable.

Most composters base their decision whether to certify or not certify their products against Australian Standard requirements, on commercial considerations (i.e. whether the Standards Mark is recognised and valued in the market place), and whether or not a price premium can be achieved for certified products. For most composters, certification is not commercially viable unless they are selling bagged products for retail sale and niche markets. There are very few third-party certified bulk compost, mulch and soil products.

Wilkinson *et al*. (2002) described four methods which compost manufacturers can use to demonstrate compliance to the Australian Standard, namely

- *Product Certification (Third Party Assessment)*
  The manufacturer's capability to produce a product consistently to the Standard is assessed on an ongoing basis by an independent third party certification body.
- *Quality System Certification (Third Party Assessment)*
  The manufacturer's quality management system is assessed against one of the international standards that describe models for quality assurance (AS/NZS ISO 9001 to 9003).
- *Customer - Supplier Assessment (Second Party Assessment)*
  A purchaser of a product may wish to assess a supplier to ensure that the product they buy meets their particular requirements. This would be a commercial arrangement between purchaser and supplier.
- *Self-Declaration (First Party Assessment)*
  The manufacturer declares that the products and/or production methods meet recognised standards. The manufacturer can state on labels and brochures that a product complies with the relevant standard, but since it is not a 'third party assessment', no recognisable symbol such as the Standards logo can be applied.

It is generally recognised that quality assurance schemes incorporating regular independent third party assessment and product or system certification provide the highest level of credibility. At present, the vast majority of bulk compost producers in Australia only offer the weakest form of guarantee, 'Self Declaration', or none at all, and certainly not third party auditing and certification (Hazeldine 2019). The acceptability to customers of this approach depends on the reputation and past performance of the manufacturer.

As compost suppliers increasingly target commercial agricultural and horticultural markets where food safety and biosecurity requirements become ever tighter, it is expected that the pressure will grow for compost production systems and compost products to be independently audited and certified by a third party. However, as long as raw manures and biosolids, the main competing products in these markets, are unregulated or have higher contaminant loads and risks, compliance with AS4454 – 2012 via 'self-declaration' can be seen as appropriate for agricultural markets, although not necessarily for horticultural markets.

AS4454 – 2012 is often criticised by a range of stakeholders, including composting businesses themselves. However, it must not be forgotten that it provides only minimum requirements for properties of composts, soil conditioners and mulches in order to facilitate the beneficial recycling and use of compostable materials with minimal adverse impact on environment and public health. It is important to recognise that the Australian Standard AS4454 - 2012 does in no way prevent individual composters or the composting industry as a whole from producing superior products that far exceed AS4454 quality requirements, i.e. have low contaminant and impurity levels, are fit for purpose and deliver all the outcomes promised to users.

The main barrier to the wider adoption of third party quality assessment and assurance, and potentially improved compost product quality in Australia is the high cost of producing a certified compost relative to the low sale price achieved, or more accurately, the low margin between cost of production and achievable sales revenue. This, in turn, is due to three main factors:

- The wide availability and market acceptance of low quality, low cost products claiming to be composted, meeting AS4454 requirements or claiming to deliver equivalent (or greater) benefits
- The high costs of third party product certification compared to self-declaration
- The high cost (relative to product value) and complexity of evaluating and communicating compost attributes, particularly aspects such as stability and maturity
- Low levels of consumer/customer knowledge regarding how to judge compost quality and the additional value/lower risk it delivers.

To date, many Australian composters operating under these constraints have chosen either to sell low quality, low cost products, or invest in building their own trusted brand and customer base for higher value and higher quality products (or occasionally both). Admittedly, the last National survey of the organics recycling industry in 2012 indicated that only around 21% of generated recycled organic products were supplied into agricultural and horticultural markets, while the majority was utilised by the urban amenity sector (Recycled Organics Unit 2013).

Comparison with overseas requirements

In order to provide a comparison to AS4454 – 2012 product quality requirements and the Australian quality assurance scheme, Annexe A provides information about compost quality assurance schemes in various European countries and Annex B about compost use regulations in these countries. Compost quality standards in several overseas countries differentiate product classes (e.g. A+, A, B) according to contaminant levels (e.g. Austria, Czech Republic, Spain, Ireland and Canada) or there are a range of different standards with sub-categories that are differentiated depending on raw materials used, product type and end-uses. The Compost Quality Assurance Association in Germany for example has established the following quality standards and administers associated quality assurance programs:

1. compost (pasteurised, mature, component in growing media),
2. digestate from organic residues (liquid, solid),
3. digestate from energy crops (liquid, solid),
4. products containing biosolids (fully composted, partially composted, blend containing raw biosolids),
5. biosolids for direct land application, and
6. ash from wood and plant fired boilers.

Table 4 provides a comparison of physical (impurities), biological (pathogens) and chemical (heavy metals and organic contaminants) contaminant limits according to compost quality standards or regulatory requirements in Australia and selected overseas countries where organics recycling activities are widespread. Annex C provides a more detailed comparison of impurity limits in AS4454 and European countries, and Annex D does the same for heavy metal limits.

The comparison shows that maximum contaminant limits in AS 4454 are similar to overseas requirements, except for the very stringent requirements the Austrian regulation demands for grade A+ compost, which is for certified organic farms. However, it can be also seen that AS4454 heavy metal limits are significantly lower than those for Canadian B grade compost (restricted use) and those that are required in the USA. Biosolids quality requirements for land application were used both in the USA and Australia to establish contaminant limits for compost products. Probably the only difference is that the risks posed by contaminants in organic soil amendments are seen differently in the two countries. An extensive risk assessment that considered 25 potential pollutants in biosolids and 14 possible exposure pathways, which was the basis for developing EPA Rule 503 concluded that cumulative levels of pollutants added to land by 'Exceptional Quality (EQ)' or 'Pollutant Concentration (PC)' biosolids (see Table 4) do not have to be tracked because the risk assessment has shown that the life of a site would be at least 100 to 300 years under the conservative parameters assumed (US EPA 1994). The fact that maximum contaminant concentrations for unrestricted use of biosolids (Grade A) and compost (AS4454) are lower by factors between two and twenty (see Table 4) shows that Australian authorities are more cautious in their assessment of risks associated with the use of biosolids and compost.

It is worth noting that, for the first time, the 2012 version of the Australian Compost Standard stipulated contaminant limits that are closely aligned to limits stipulated in the NSW Biosolids Guidelines for unrestricted use. Previous versions of AS4454 just referred to Federal or State regulations, which generally were biosolids guidelines or regulations.

Organic contaminants

Very few countries have set limits for organic contaminants in compost and related products. Table 3 and Table 4 show that overseas compost standards and regulations (for regular compost) tend to stipulate limits for organic contaminants only very sparsely. The long-standing position of regulators in the UK, USA and Canada and many other countries is that there is no conclusive evidence that the levels of organic contaminants typically found in recycled organic materials are hazardous to soil quality, human health or the environment. The large number of potential contaminants, the relatively low levels of contaminants in recycled organic products, and the gap in knowledge about the chronic effects of contaminants on human health and the environment contribute to this position (Tremblay et al. 2014). For example, the Italian standards contain a limit for polychlorinated biphenyl (PCB) only, and only for products that are co-composted with biosolids (Table 3). The German standard for regular compost (No. 1 in the above list) contains limits for perfluorooctanoic acid (PFOA) and perfluorooctanesulfonate (PFOS), and also for total dioxine and dl-PCB, while standards for biosolids based compost require testing for various other contaminants (Bundesgütegemeinschaft Kompost, undated).

Since the presence or absence of organic contaminants in compost is mainly related to the characteristics of the processed feedstock material, most European countries identify and tightly control which feedstocks can and cannot be composted (Bernal et al. 2017) and therefore largely

avoid having to deal with the issue of organic contaminants in compost products. Some countries like the Netherlands, Austria and Germany do not require the measurement of organic contaminants in compost and digestate when they are derived from source-separated materials (Saveyn and Eder, 2014). In the UK, the PAS 100 compost quality standard and the PAS 110 standard for digestate and related products do not require analysis of organic contaminants, but again, strict feedstock controls apply. The PAS Standards can only be applied to products derived from source-separated "biowaste (FOGO) and biodegradable" materials (BIS 2010, 2011). However, composters must take care "to avoid any potentially polluting wastes, products or materials from becoming included with the input materials".

Nevertheless, organic contaminant limits for composts and related products do apply in some European countries (Table 4). In several EU member countries, legislation is specific to the feedstock being processed. For example, the German Sewage Sludge Regulation prescribes limits for biosolids products/composts, *viz*: 0.2 mg/kg dm for every of the PCB_6 congeners and 100 ng I-TEQ/kg dm for 17 priority PCDD/Fs. Austria also has a different set of limits for AWT composts that are only approved for use in landfill capping and biofilter applications: 1 mg/kg dm for PCB_6, 50 ng I-TEQ/ kg dm for PCDD/F and 6 mg/ kg dm for PAH_6 (Saveyn and Eder, 2014).

The US EPA Part 503 Rule for use of biosolids (US EPA 1994) does not contain limits for organic contaminants. Limits were considered when the regulation was developed (i.e. prior to 1993) but in the end no limits were included because the results of the sewage sludge survey in combination with the risk assessment to determine what limits would be required showed that none of the biosolids generated at the time would fall above those limits (Brown, 2019). A contributing factor to this decision was the fact that most of the compounds that were being considered had been banned by that time. A subsequent risk assessment of biosolids contamination with dioxins came to the same conclusion, i.e. not to establish limits and not to monitor for dioxin contamination.

There are no compost quality standards enforced by regulators in the US, though there has been a significant effort to harmonise testing standards through the development of the Testing Methods for the Evaluation of Composting and Compost (TMECC). Whilst the TMECC outlines standardised testing methods, including for some organic contaminants, it does not specify limits.

The Canadian Guidelines for Compost Quality (PN 130) recognises that "trace amounts" of persistent or bio-accumulating organic contaminants can be present in some compost feedstocks, and recommends that special attention should be given to avoiding feedstocks with "high contents" of these contaminants (Canadian Council of Ministers for the Environment 2005). However, they consider that, given the low content of dioxin and furans in compost feedstock in Canada, routine analysis under the Guidelines for Compost Quality is not necessary. The same also applies to PCB and polycyclic aromatic hydrocarbons (PAHs), though composters are encouraged to seek specific advice from their provincial or territorial regulator.

Nevertheless, a degree of vigilance is always recommended to monitor and determine the significance and implications of 'emerging' organic contaminants that may be present in land-applied organic materials (e.g. see Clarke and Smith, 2011 with respect to biosolids).

Table 3: Organic contaminant concentration limits for compost and related products in selected EU countries [adapted from Saveyn and Eder 2014]

Chemical	Austria	Belgium/ Wallonia[a]	Germany	Denmark	France	Luxembourg[b]	Slovenia	Switzerland[b]
PAH (mg/kg)	6[c]	5 (PAH_{16})		3[d]	Note[e]	10 (PAH_{16})	3	4 (PAH_{16})
PCBs (mg/kg)	0.2 (PCB_6)	0.15 (PCB_7)	Note[f]	0.08 (PCB_7)	0.8 (PCB_7)[g]	0.1 (PCB_6)	0.4 (PCB_6)	
PCDD/F[h]	20	100	Note[f]			20		20
PFC (mg/kg) (PFOS + PFAS)	0.1		0.1					
AOX (mg/kg)	500	250						
LAS (mg/kg)		1500[i]		1300				
NPE (mg/kg)		25[i]		10				
DEHP (mg/kg)		50[i]		50				

[a] For digestate in the state of Wallonia; [b] Guide values for Luxembourg and Switzerland; [c] sum of benzo[a]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[ghi]perylene, fluoranthene and indeno[1,2,3-cd]pyrene; [d] sum of acenaphthene, phenanthrene, fluorene, fluoranthene, pyrene, benzo[b]fluoranthene, benzo[j]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, benzo[ghi]perylene and indeno[1,2,3-cd]pyrene; [e] individual limits for 3 cogeners; [f] Maximum sum of PCDD/F and dl-PCB: 30 ng WHO-TEQ/kg dm, in some cases additional restrictions for PCDD/F only of maximum 5 ng WHO-TEQ/kg dm; [g] Only for biosolids compost; [h] PCDD/F= sum of 17 polychlorinated dibenzo-p-dioxins/furans expressed in International Toxicity Equivalents; [i] Guide value; PAH_{16}= sum of US EPA 16 priority listed PAHs; PCB_6= sum of PCBs 28, 52, 101, 138, 153 and 180; PCB_7= sum of PCBs 28, 52, 101, 118, 138, 153 and 180;

Table 4: Impurity, pathogen, heavy metal and organic contaminant limits for compost products in Australia and selected overseas countries

Product Characteristic	Country & Compost Quality Standard / Ordinance						
	Australia AS 4454	**Europe** Quality Assurance Scheme [a)]	**Austria** Compost Ordinance [b)]	**Italy** CIC [c)]	**UK** PAS 100 [d)]	**USA** EPA Part 503 Rule (EQ or PC biosolids) [e)]	**Canada** Guide Compost Quality [f)]
Impurities [g)]							
Glass, metal and rigid plastic [% dm]	≤ 0.5	≤ 0.5 (all impurities)	See Annex C	≤ 0.5 (plastic, glass metals > 5mm)	≤ 0.25 with ≤ 0.12 plastic		≤ 1/2 pieces foreign matter > 25 mm in 500 ml
Plastic – light, flexible or film [% dm]	≤ 0.05						
Stones and lumps of clay [% dm]	≤ 5			≤ 5	≤ 8 [h)] (no mulch) ≤ 10 [h)] (mulch)		
Pathogens							
Faecal coliforms [MPN/g]	< 1000			< 1000 (*E. coli*)	< 1000 (*E. coli*)		< 1000
Salmonella spp	absent in 50 g dry weight equiv.	absent in 25 g dry mass		absent in 25 g	absent in 25 g fresh mass		absent in 4 g dry mass
Heavy Metals [mg/kg dm]							
Arsenic	20					41	75 (B) 13 (A)

Product Characteristic	Country & Compost Quality Standard / Ordinance						
	Australia AS 4454	**Europe** Quality Assurance Scheme [a)]	**Austria** Compost Ordinance [b)]	**Italy** CIC [c)]	**UK** PAS 100 [d)]	**USA** EPA Part 503 Rule (EQ or PC biosolids) [e)]	**Canada** Guide Compost Quality [f)]
Boron	100						
Cadmium	3	1.3	3.0 (B) 1.0 (A) 0.7 (A+)	1.5	1.5	39	20 (B) 3 (A)
Chromium (Total)	100	60	250 (B) 70 (A) 70 (A+)	0.5 (Cr VI)	100		1060 (B) 210 (A)
Copper	100 (150) [i)]	110 (300) [j)]	500 (B) 150 (A) 70 (A+)	230	200	1500	750 (B) 400 (A)
Lead	150	130	200 (B) 120 (A) 45 (A+)	140	200	300	500 (B) 150 (A)
Mercury	1	0.45	3.0 (B) 0.7 (A) 0.4 (A+)	1.5	1	17	5 (B) 0.8 (A)
Nickel	60	40	100 (B) 60 (A) 25 (A+)	100	50	420	180 (B) 62 (A)
Selenium	5					100	14 (B) 2 (A)

Product Characteristic	Country & Compost Quality Standard / Ordinance						
	Australia AS 4454	**Europe** Quality Assurance Scheme [a)]	**Austria** Compost Ordinance [b)]	**Italy** CIC [c)]	**UK** PAS 100 [d)]	**USA** EPA Part 503 Rule (EQ or PC biosolids) [e)]	**Canada** Guide Compost Quality [f)]
Zinc	200 (300) [i)]	400 (600) [j)]	1800 (B) 500 (A) 200 (A+)	500	400	2800	1850 (B) 700 (A)
Organic Contaminants [mg/kg dm]							
DDT/DDE/DDD	0.5						
Aldrin	0.02						
Dieldrin	0.02						
Chlordane	0.02						
Heptachlor	0.02						
HCB	0.02						
Lindane	0.02						
BHC	0.02						
PCBs	Not detected			0.2 [k)]			

a) European Compost Network, 2018
b) Austrian Ministry for Agriculture and Forestry, 2010
c) Italian Compost & Biogas Association, 2018
d) BIS, 2011
e) US EPA, 1994
f) Canadian Council of Ministers of the Environment, 2005
g) see Annex C for detailed description of impurity limits European countries
h) stones > 4mm
i) see Table 2
j) Values exceeding 110 mg Cu kg^{-1} and 400 mg Zn kg^{-1} must be declared
k) For compost made from feedstock that contains up to 30% biosolids

End of Waste Code

Several of the European compost standards and regulations are very comprehensive and go well beyond the stipulation of product quality requirements, and could be easily seen and used as End-of-Waste codes. This is made very clear in the European Compost Network's quality assurance framework which specifically references End of Waste Criteria (Figure 1). The Compost Quality Protocol for England, Wales and Northern Ireland in fact represents *end of waste criteria for the production and use of quality compost from source-segregated biodegradable waste* (WRAP 2012).

Figure 1: Integration of End-of-Waste criteria into European Compost Network quality assurance scheme [Source: Siebert 2019]

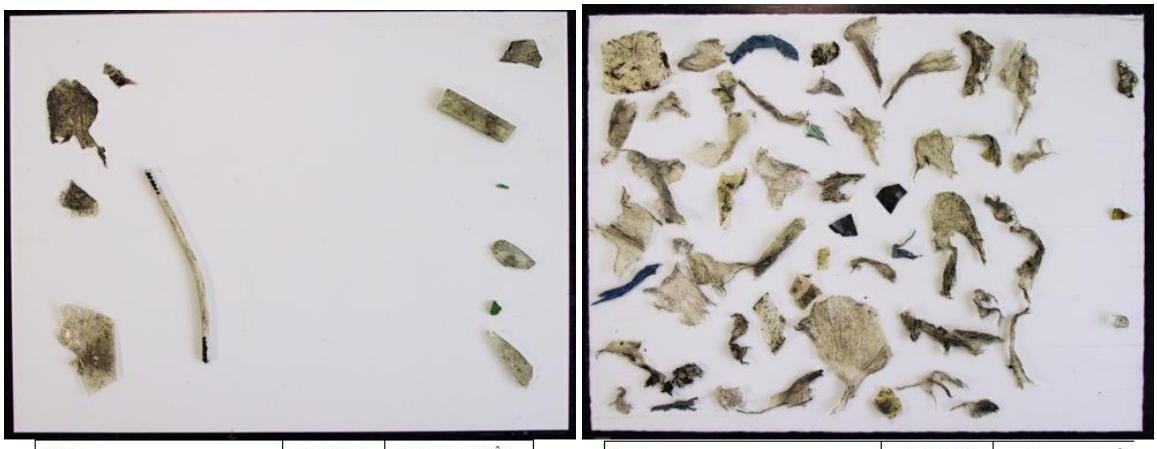
Impurities (physical contaminants)

As plastic pollution is increasingly becoming a topic of conversation and concern, it is prudent to briefly discuss area based measurements of impurities, and provide an overview of the state of knowledge concerning microplastics in soil and organic soil amendments.

Area based measurement

Virtually all compost quality requirements related to impurities, including the Australian Standard AS4454, quantify physical contamination based on the mass of impurities in relation to total (dry) mass of product. One of the main limitations of mass based methods is that products contaminated with large quantities of low density plastic (e.g. plastic bag pieces) will show very low impurity levels if expressed as percentage of total mass, as is demonstrated in Figure 2. Impurities dominated by heavy particles have relatively low surface area, while impurities dominated by lightweight materials have a relatively high surface area.

These circumstances prompted the German Compost Quality Assurance Association to establish an area-based limit for impurities in addition to the existing weight-based limit (0.5% dm). The new threshold was introduced in 2007 and set at a surface area of 25 cm^2 per litre of compost (Thelen-Jüngling 2008). The limit was tightened to 15 cm^2 per litre in July 2018 in a bid to further reduce plastic contamination in compost products (Bundesgütegemeinschaft Kompost 2016). To date, the German standard is the only one that has adopted area-based measurements of impurities.



Fraction	weight-% DM	surface area [cm²/l]
Impurities > 2 mm [total] in 1 L	0,47	8,60
light weight fraction [plastics] on the left	0,03	5,51
heavy fraction [glas, metal] on the rigth	0,44	3,09

Fraction	weight-% DM	surface area [cm²/l]
Impurities > 2 mm [total] in 1 L	0,17	68,91
light weight fraction [plastics] on the left	0,13	67,53
heavy fraction [glas, metal] on the right	0,04	1,38

Figure 2: Physical impurities (> 2 mm) in compost expressed on the basis of weight and surface area, dominated by heavy particles (left) or lightweight particles (right) [Source: Thelen-Jüngling 2008]

Microplastics

Microplastics are very small plastic fragments that measure less than 5mm in length and can enter ecosystems from a variety of sources. Primary microplastics are any plastic fragments purposely made to be that size (≤ 5.0 mm) before entering the environment and include for example microbeads used in cosmetic products and plastic pellets. Secondary microplastics are created from the degradation of larger plastic products once they enter the environment through natural weathering and degradation processes. A third group is emerging which comes from the human use of an object that gives off microplastics, for example from the road wear of synthetic tyres, washing synthetic clothes, or synthetic grass pitches and sports grounds. Plastics degrade very slowly, which increases the probability of microplastics being ingested and incorporated into, and accumulated in, the bodies and tissues of many organisms.

Nizzetto *et al.* (2016) have outlined why the presence of microplastics in soil can be problematic, stressing that these materials can potentially impact soil ecosystems, crops and livestock either directly or through the toxic and endocrine-disrupting substances added during plastics manufacturing. These substances include short/medium-chain chlorinated paraffins (candidates for inclusion in the Stockholm Convention) and plasticizers, which can represent up to 70% of the weight of plastics. Endocrinologically active alkylphenols, such as bisphenols, and flame retardants including several banned brominated compounds comprise up to 3% by weight of some plastics. The same authors also claim that, during use, plastic polymers efficiently accumulate other harmful pollutants from the surrounding environment, including a number of persistent, bioaccumulative and toxic substances, such as PCBs, dioxins, DDTs and PAHs.

Concerns about plastics and microplastics in the environment have undoubtedly focused on the marine environment in the past, although in 2012 Rillig already saw the occurrence of microplastics in soil as eminently plausible and called for a systematic examination of soil as well as increased attention of policy makers and regulatory bodies to this matter. In that regard, use of biosolids products on agricultural land came under scrutiny first, as over 90% of microplastics contained in sewerage are retained in the sludge (Nizzetto *et al.* 2016).

Based on high level estimates, Nizzetto et al. (2016) suggested that between 125 and 850 tons of microplastics per one million inhabitants are added annually to European agricultural soils through land application of sewage sludge or as processed biosolids. They estimated furthermore that these quantities equate to average and maximum area per-capita microplastic loading rates of 0.2 and 8

mg/ha/yr, respectively. However, He *et al.* (2018) pointed out that pollution of farmland with microplastic can also originate to a large degree from use of plastic mulch (and other plastic products) in agricultural practice. Yet, there is still a significant lack of data regarding concentrations, volumes, types and composition of microplastics in soil environments to allow analysis of the current pollution status of microplastics in the soil on a regional, National or global scale (He *et al.* 2018).

Work has been published recently that looked at the presence of microplastics in farmland soils. For example, the abundance of microplastics in twenty vegetable fields on the outskirts of Shanghai amounted to 78 ± 12.91 and 62.50 ± 12.97 pieces per kg in shallow and deep soils, respectively (He *et al.* 2018). The majority of microplastics found were made of polypropylene (50.5%) and polyethylene (43.4%), indicating that plastic mulch was the main contributor to microplastic contamination in soil. In another study that was conducted in China (Zhang *et al.* 2018), all fifty samples of arable soils contained plastic particles (10 - 0.05 mm), numbering between 7,100 and 42,960 particles per kg of soil, with 95% of plastic particles found being categorised as microplastics (1.00 - 0.05 mm).

Contamination levels found in Germany were significantly lower, yet still present. Piehl *et al.* (2018) found 206 pieces of macroplastic per hectare and 0.34 ± 0.36 particles of microplastic per kilogram dry weight in arable soil where microplastic-containing fertilizers and agricultural plastic applications were never used previously. They saw polyethylene as the most common polymer type, followed by polystyrene and polypropylene, and noted that microplastics were dominated by plastic films and fragments, whereas macroplastics were comprised predominantly of plastic film. The authors did point out that contamination levels are probably higher in fields where agricultural plastic is used (e.g. greenhouses, mulch, or silage films) or where organic soil amendments that contain plastic fragments such as biosolids or urban derived composts are applied.

In France, Watteau *et al.* (2018) developed and applied novel analytical methods to determine the level of microplastics in a long-term experimental field, where municipal solid waste (MSW) composts were applied every other year over 10 years. Their results showed that plastics and microplastics were present in the soil that was amended for 10 years with MSW compost, while not in the control soil. Microplastics were mostly observed as individual particles, present in the coarsest fractions as well as some of the fine soil fractions, but they were little associated with the soil matrix. Most plastic particles did not show any signs of degradation (e.g. microbial lysis), which suggests that fragmentation is the main pathway of particle size reduction.

It should be understood that microplastics in soil is a new field of scientific investigation where much has yet to be learned. Bläsing and Amelung (2018) for example stated that “nearly nothing is known about plastic pollution of soil; presumably, because awareness is either not existent or because no standardised methods are available for plastic quantification in soil” and Scalenghe (2018) pointed out that plastic polymers found in the soil are not made of a homogeneous material but are different from each other and hence degrade differently in soil over different time spans.

Researchers in Germany investigated the content of microplastics > 1 mm in a range of products generated from various source separated organic residues that were processed either via composting or anaerobic digestion (Weithmann *et al.* 2018). Both the composting and the anaerobic digestion facilities processed FOGO material blended with vegetation residues, yet there were some important operational differences that affect impurity levels in the finished product.

All analysed product samples contained plastic particles, but quantities differed significantly depending on feedstock type and mix and efforts to remove impurities before processing. Composted FOGO contained markedly less plastic particles than digested FOGO, but this has nothing to do with the processing technology as such, but rather with differences in the feedstock mix (higher proportion of vegetation residues used in composting (Table 5) and the lack of pre-treatment (removal of packaging) in the anaerobic digestion facility. The level of degradation of the organic material, which affects particle size distribution and the mesh size chosen for screening also affects the content of plastic particles in the finished product.

Unfortunately the authors did not report if the feedstock material (FOGO and vegetation residues) processed in the two facilities had similar impurity levels or not. Liquid digestate from an AD facility

that processes primarily commercial residues from the food and beverage industry contained by far the highest number of plastic particles. No information was provided about measures to remove impurities in this operation. As a comparison, the authors also assessed digestates generated at facilities that process agricultural residues and energy crops and found very few plastic particles in those products.

Table 5: Comparison of microplastic particles >1mm in products generated from source segregated organics in Germany (Source: modified from Weithmann et al. 2018)

Parameter	Composting	Dry anaerobic digestion	Wet anaerobic digestion
Feedstock	FOGO + vegetation residues	FOGO + vegetation residues	Commercial organic residues (food and beverage industry)
Proportion vegetation residues	High (more than 50%)	Low (about 20%)	Unknown, probably none
Removal of impurities from feedstocks	Screening (80mm), material < 80mm => ferrous metal separation, material > 80mm => manual sorting, shredding	None	Unknown
Removal of impurities from finished product	Compost is screened to < 8mm and < 15mm	After digestion (28 days) the material is screened (20mm) and subsequently composted and matured	Unknown
Products assessed and microplastic particles (> 1mm) found per kg of product	Compost < 8mm: 20 Compost < 15mm: 24	Mature digestate A: 70 Mature digestate B: 122 Immature digestate C: 146 Percolate D: 14	Liquid digestate: 895

OUTLOOK

A team of international researchers recently assessed *Current Approaches and Future Trends in Compost Quality Criteria for Agronomic, Environmental, and Human Health Benefits* (Bernal *et al.* 2017). Their conclusions were as follows:

The waste hierarchy that underlies EU waste legislation is leading progressively to adoption of the preferred options of waste prevention, preparation for reuse and recycling, and discourages landfilling (which should be eliminated by 2030), in line with the circular economy model. In Europe, the Bioeconomy Strategy promotes the sustainable and integrated use of biological resources and waste streams for the production of food, energy, and bio-based products. Turning waste into a resource is part of "closing the loop" in circular economy systems.

Nowadays, the treatment technologies for organic waste management aim at providing safe methods to humans and environment to deal with the wastes, turning waste into a resource, and promoting sustainable ways of waste management such as composting. For composting, the final product (compost) should ensure enough quality for its use to ameliorate soil without significant risk of environmental pollution (soil, water, and atmosphere) and, at the same time, ensuring food safety. So, any organic or inorganic contaminant present in the input material must be controlled, as well as the microbiological contamination. Limits for inorganic contaminants (heavy metals) are well established in the different countries, although establishment of uniform limits at international level is necessary for unrestricted compost marketing across borders.

Knowledge of the persistence of organic contaminants in compost is not very well established worldwide. In Europe, work associated with establishing the end-of-waste criteria for organic residues have revealed the necessity to establish such controls. Composting strategies should ensure the degradation of specific contaminants present in certain wastes, such as pharmaceutical medicines in biosolids or veterinary products (hormones, antibiotics, etc.) in livestock manures, in order to produce safe composts. Recently, special attention has been paid to study the efficiency of composting for the degradation of veterinary antibiotics. Wastewater and biosolids are possible vehicles for the entrance of pharmaceutical compounds into agroecosystems. Since a large list of organic compounds, including pharmaceuticals, have been detected in wastewater derived from treatment plants, there are concerns about the safety of biosolid applications to the soil. Different degradation rates of such compounds were found during aerobic treatment of sewage sludge and wood waste at constant temperatures (35 or 50°C). But there is a need for greater knowledge about the transformation of pharmaceutical pollutants during composting to ensure compost quality and safety, providing the necessary confidence in the safety of compost products in competitive economic markets and the acceptance of current and potential future users.

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APPENDIX

Annex A - Compost quality assurance schemes in European countries [adapted from Saveyn and Eder, 2014]

Country & quality label	Status of quality assurance activities and certification/quality assurance organisation
Austria	Fully established quality assurance system based on Austrian Standards ÖNORM S2206 Part 1 and 2 and Technical Report ONR 192206 published by the Austrian ÖNORM Standardisation Institute. Up to now two non-profit associations have adopted these standards for granting a compliance certification with the QAS: 1. the Compost Quality Society of Austria KGVÖ (Kompostgüteverband Österreich) 2. the Compost & Biogas Association – Austria (ARGE Kompost & Biogas – Österreich) The certification schemes comprise both, operational process and quality management and final product approval. Thereby the most important references are the requirements set by the Austrian Compost Ordinance which provides for a comprehensive documentation and monitoring programme. Compost can get product status if it meets one of the 3 classes based on precautionary requirements (class A+ (top quality for organic farming), class A "Quality compost"(suitable for use in agriculture, horticulture, hobby gardening and Class B (minimum quality for "compost" restricted use in nonagricultural areas). Under the roof of **Compost Quality Society of Austria (KGVÖ)** large scale compost producers supplemented by experts, grant an additional quality seal for the marketing of high-quality composts on the basis of the officially acknowledged quality assurance system. External labs collect the samples and analyses. Evaluation of the results, documentation and granting of the label is carried out by an independent quality committee with expert members of the KGVÖ. (16 members - 300.000 t capacity) **Compost & Biogas Association Austria** (ARGE Kompost & Biogas) was founded to establish the decentralised composting of separately collected bio-waste in cooperation with agriculture (on-farm composting). Nowadays the association has grown to a full-scale quality assurance organisation on the basis of the common Austrian standards. ARGE uses external auditors for sample taking, plant inspection, evaluation, documentation and certification of the plants. (370 members - 300.000 t capacity),
Belgium	Fully established statutory quality assurance system for compost in the Flanders region operated by the non-profit **Flemish compost organisation VLACO vzw** with its members from municipalities, government and composting plants. (Around 40 green and bio-waste plants with 840.000 t of capacity). Based on the Flemish Regulation on Waste Prevention and Management VLAREA act VLACO vzw show a very unique but effective integrated approach and a broad range of tasks. The organisation executes: 1. Waste prevention and home composting programmes 2. Consultation and advice for process management incl. co-composting and co-digestion 3. Sampling, organisation of the analysis and evaluation of the results 4. Organisation of field trials and development of application information 5. Marketing and Public Relation for organic waste recycling and first of all

	for the compost. So by means of this integrated approach the whole organic loop from source material to the use of the final product is in one hand. Nevertheless, some modifications are made lately in order to include elements of ISO 9000 and the Total Quality Management TQM the quality assurance of anaerobic digestion residuals and of manure into the system. Not only the end-product is controlled but the whole process is followed up. In TQM the input (the bio or green waste), the process and the output are monitored and analysed. The reason to put standards on the input is that this allows no dilution. Depending on source materials and product characteristics up to 15 different products can be certified (statutory) and labelled (voluntarily) by VLACO vzw.
Czech Republic	Voluntary quality assurance scheme proposed by the **regional Environmental and Agricultural Agency ZERA** is in preparation for a quality assurance scheme for 2008 after new bio-waste Ordinance is in force. Main task is to create a compost market by certifying compost products and organise a practical inspection and control of compost. The certification scheme is based on requirements of the Czech institute of accreditation in the agreement with international norm CSN EN ISO/ IEC 45011:1998
Germany	Fully established voluntary quality assurance system for compost and anaerobic digestion residuals in which the **Compost Quality Assurance Organisation (Bundesgütegemeinschaft Kompost BGK)** organisation is the carrier of the RAL compost quality label. It is recognised by RAL, the German Institute for Quality Assurance and Certification, as being the organisation to handle monitoring and controlling of the quality of compost in Germany. The BGK was founded as a non-profit organisation in order to monitor the quality of compost. Through consistent quality control and support of the compost producers in the marketing and application sectors, the organisation promotes composting as a key element of modern recycling management. 425 composting and 67 digestion plants with 5.9 mio t capacity plants take part in the quality assurance system and have applied for the RAL quality label. Besides the central office, a quality committee works as the main supervision and expert body in the quality assurance system. In addition, BGK runs a database with all indicators of the composting plants and analyses results of the products. Meanwhile it includes more than 35.000 data sets. The BGK has defined a general product criteria quality standard (the RAL quality label GZ 251 for fresh and mature compost as well as for compost for potting soil compost and for different types of digestion residuals RAL GZ 245 (new since 2007 RAL GZ 246 for digestion products residuals from treatment renewable resources (e.g. energy crops)) and established a nationwide system for external monitoring of plants and of compost and digestion products. The quality assurance system comprises the following elements: 1 Definition of suitable input in accordance with bio-waste and fertiliser regulation. 2 Operation control by plant visits of independent quality managers. 3 External and internal monitoring 4 Quality criteria and quality label do demonstrate the product quality;

	5 Compulsory declaration and information on correct application; 6 Documentation for the competent authorities. The successful work is respected by the authorities in Germany by exempting member plants from some control requirements which are subject to the waste legislation. By means of that procedure quality assured compost show a "quasi" product status in Germany.
Denmark	A quality assurance system for compost (quality criteria, standardised product definition, analysing methods) is prepared by **DAKOFA (Danish Association on waste management)** but is not applied. No further progress expected for the moment because separate collection of kitchen waste will not increase before the present legal background. Green waste collection and composting is very well diffused but not subject to any waste and quality standards regulation in Denmark.
Spain	Draft statutory Spanish standard on compost legislation, laying down standardised, nationwide rules concerning the production, marketing and labelling of compost as a product prepared by the Ministry of Environment. A lot of studies confirmed for Spain the need to improve the compost quality in order to open up markets. This was in the outcome of a LIFE Project too deemed to investigate the production and use of quality compost in Andalusia. Based on the results **the Andalusia´s Regional Ministry of Environment** has designed and registered a trademark “Environmental Accreditation of Compost” that allows - on a voluntary basis - companies producing compost to show its quality. The Order 20/07/07 Environmental Accreditation of Compost Quality. BOJA nº 156 8/8/2007 explains how to get and use it. Compost should fulfil some limits according to the Real Decree 506/2013, 8/7/05, about fertilisers. It is the Andalusia´s Regional Ministry of Environment who will control the label use and define accredited laboratories to analyse compost samples. There is no independent sample taking.
Hungary	Voluntary Hungarian Compost Quality Assurance System is prepared (but not implemented) by the Hungarian Compost Association and waiting for the revision of the existing regulations which are intended for sewage sludge and fertilisers and are not applicable for composting. The **Hungarian Compost Association** has completed in 2006 the framework of the assurance system (similar to the German BGK and Austrian KGVÖ examples) and is now waiting for the new Hungarian Statutory rule about production, nominating, marketing and quality assurance for composts. Basic elements of the future Compost Quality Assurance Systems (implementation in 2009) are: 1. Raw material list (permissive list) 2. Compost Classes The Ordinance will define three different quality classes for compost based on the contaminant content. Will also define ways of utilisation. The classes (similar to the Austrian ones) will be: 1 Class A - top quality (suitable for organic farming use) 2 Class B - high quality (suitable for agricultural use) 3 Class C - minimum quality (not suitable for agricultural use)

	3. Quality control End-product controlling and process controlling. Independent sample taking and analysis is intended.
Ireland	A first draft for a voluntary compost quality standard was presented in Ireland (2007). This task and the follow up establishment of a quality assurance system are elements of the national Market Development Plan - intended to create market for recyclables - have recently started. The **Irish Composting Association CRE** supports is involved in these developments. Limits for pollutants, stability, etc. are specified in waste authorisations (e.g. EPA Waste licences and Local Authority waste permits).
Italy	Voluntary quality assurance on operated by the **Italian Compost Association CIC**, the Italian National Association for the compost industry. It started as certification system for compost products in order to show compliance with the national fertiliser regulation and the statutory quality standards for green and mixed compost are laid down there. No monitoring of the standard is proposed. Basically, the quality label ensures fulfilment of statutory standards (assessment of compliance is usually an issue due to the rather poor performance of controlling authorities, hence CIC aims to reinforce the “declaration of compliance”). Within the scheme samplings are made by certificated personnel from the Italian Composting Association (CIC) and analyzed at a single accredited laboratory. Now the scheme turns step by step into a quality assurance system e.g. with preparation of certifying the entire production process and above all (as requested by consumers) the traceability of compost. The CIC Quality Label is considering this to be a very important initiative for the industry because it provides an independent element of security upon which consumers and operators can make their choices. Currently, the quantities of compost that can be certified amount to approx. 250,000 tons /y, which represents approximately 20% of the Italian production
Luxembourg	Statutory system which relies on the German Quality Assurance System and on the German Organisation (**Bundesgütegemeinschaft Kompost e.V. BGK**). The request to execute a "quality assurance system like the one of BGK or similar" is part of the licensing procedure for every composting plant. Missing alternatives have established the BGK system in Luxembourg as the one and only. All independent sampling, control functions and documentation functions will be executed by the BGK representatives. (5 compost plants with around 50.000 t/y total capacity are part of the scheme)
Latvia	On the starting stage (from Nov. 2006), quality assurance organization Environmental Agency.
Netherlands	After 10 years of experiences the Dutch Government decided that not the quality, but the nutrients are the primary precautionary problems with compost. Less strict heavy metal thresholds and no obligations for control

	any more is one result. In addition, no longer is the applied amount of compost but the nutrient load limited. All compost which is used for crops which grow in the soil must be independently certified with a very strict threshold for glass. Because the sales area of compost is not predictable while the production, more or less all bio-waste composts, will be certified in future and compost certification will become quasi statutory. As of 2012, there is one certification type for both VFG and green waste. The BVOR Dutch Association of Compost Plants and Dutch Waste Management Association DWMA/VA manage the certification system in both the green waste and VFG sectors which doesn't require external sampling but independent institutes/auditors for the evaluation of the process and the analysis results.
Poland	Quality Assurance refers only to the final product. The Ministry of Agriculture and Rural Development gives the certificate of organic fertiliser based on its chemical properties and pathogen status after the compost receives a positive expertise from the designated institution (depending on planned application area).
Sweden	Voluntary quality assurance system for compost and digestion products is operated by the **Swedish Waste Management Association Avfall Sverige** together with Swedish Standardisation Institute SP. For the moment Sweden has no statutory standard, but the necessity of standards is seen clearly by involved parties and the government. Producers and users are of the opinion that sustainable recycling of organic wastes demands clear regulations regarding what is suitable to be recycled and how it should be managed and controlled. A well-founded quality assurance programme definitely increases sustainable recycling of organic wastes. The regulations for the voluntary Swedish certification of compost and digestion residues are based on purely source-separated organic waste, with special emphasis on the acceptability of raw materials for input, the suppliers, the collection and transportation, the intake, treatment processes, and the end product, together with the declaration of the products and recommendations for use. 6 digestion and 1 composting plant are included in the certification system and have applied for the certificate.
United Kingdom	Voluntary standard BSI PAS 100 and the supplementing Quality Compost Protocol (QCP) set criteria for the production and minimum quality of quality composts. The **UK Composting Association** owns a certification scheme aligned to BSI PAS 100, which has been upgraded to incorporate the additional requirements of the QCP. Composting plants and compost particle size grades that meet all the requirements can get their composts certified and use the Composting Association's quality mark. Around 150 composting producers are under assessment, treating more than 2 mio t of source segregated bio and green waste, and 40 % of the compost they produce is already certified. BSI PAS 100:2005 specifies the minimum requirements for the process of composting, the selection of materials from which compost is made, minimum compost quality, how compost is labelled and requires that it is traceable. It also requires Hazard Analysis and Critical Control Point assessment, the implementation of a compost Quality Management System and correct compost labelling and marking. Compliance with requirements of the QCP is considered sufficient to ensure that the recovered bio-waste may be used without risk to the environment or harm to human health and therefore without the need for waste regulatory

control. In addition, The Quality Compost Protocol requires compost certification to PAS 100 and also imposes restrictions on materials from which quality composts can be made and in which markets they can be used as 'product'. The QCP also requires the producer to supply customers with contracts of supply, and if Quality Compost is stored and used in agriculture or field horticulture, this must be done in accordance with the Codes of Good Agricultural Practice and that soil PTE concentrations do not exceed the Sludge Use in Agriculture Code's limits.

The Quality Protocol further aims to provide increased market confidence in the quality of products made from bio-waste and so encourage greater recovery of source-segregated bio-waste. In England and Wales, compost must be independently certified compliant with both PAS 100 and the Quality Compost Protocol for it to be supplied to the designated market sectors as a 'product'. In Scotland, for compost to be supplied as a 'product' it must be certified to PAS 100 (or an equivalent standard), have certainty of market, be used without further recovery, not be subjected to a disposal activity and not be mixed with other wastes, materials, composts, products or additives. Northern Ireland's position is currently similar to Scotland's.

Compost can be placed on the market as a recovered waste material in any of the countries of the UK; in this circumstance, waste management licensing regulation requirements must be adhered to.

A number of local authorities have required PAS 100 certification in contracts with compost producers, and in England and Wales in particular, may start requiring certification to the Quality Compost Protocol as well.

Annex B - Compost use regulations in European countries [adapted from Saveyn and Eder 2014]

Country	Regulation	Requirements or restriction for the use of compost
Austria	Compost Ordinance	• Agriculture: 8 t d.m. /ha*y on a 5-year basis • Land reclamation: 400 or 200 t d.m. /ha*y within 10 years depending on quality class • Non-food regular application: 20 or 40 t d.m. /ha*y within 3 years dep. on quality class • El. Conductivity > 3 mS/cm: excluded from marketing in bags and for private gardening
	Water Act	Specific application requirements pursuant to the Action Programme following the EU Nitrate Directive (e.g. limitation to 210 or 170 kg total N per hectare an year)
Belgium **Flanders** **Wallonia**	Royal decree for fertilisers, soil improvers and substrates Fertiliser Regulation (nitrate directive) VLAREA waste regulation Arrêté du Gouvernement wallon favorisant la valorisation de certains déchets	• An accompanying document with user information is obligatory. • Fertiliser Regulation limits N and P, partly more compost use possible because of beneficial soil effects compared to manure. • VLAREA require VLACO Certificate for use and limits max. level of pollutants and show conditions for max application rates • Not specifically for organic waste, so all the conditions are laid down in the certificate of use
Bulgaria	No data available	n.d.
Cyprus	No data available	n.d.
Czech Republic	Bio -waste Ordinance, Waste Act (2008)	According to the coming Bio-waste Ordinance (2008) for the first class there are restrictions according to Ordinance on hygienic requirements for sport areas, the 2nd best can be used with 200 t dm/ha. in 10 years.
	Fertiliser law	Fertiliser law requires application according to good practice.

Germany	Bio -waste Ordinance (BioAbfV 1998) Soil Protection Ordinance (BbodSchV 1999) Fertiliser Ordinance (DÜMV, 2003)	• The Bio-waste Ordinance regulates agricultural use with compost Class I 20 t dm in 3 years, Class II 30 t dm in 3 years. • Soil Protection Ordinance for non-agricultural areas between 10 and 65 t dm compost depending on use. • Fertilising with compost according to good practice
Denmark	Stat. Order 1650 0f 13.12.06 of the use of waste (and sludge) in agriculture	• 7 t d.m. /ha*y on a 10-year basis • Restriction of nitrogen to 170 kg /ha*y • Restriction of phosphorus to 30 kg /ha*y average over 3 years • The levels for heavy metals and organic compounds are restricted in the INPUT material for the composting process
Estonia	No compost restrictions	Only restrictions for the use of stabilized sludge "sludge compost"
Spain	Real Decree 506/2013 on Fertiliser Products	Class C compost (mixed waste compost) 5t d.m./ha*y
Finland	Decree of the Ministry of Agriculture and Forestry on Fertiliser Products 12/07	• Maximum Cd load/ha 6 g during 4 years (crop growing area), 15 g during 10 years (landscape gardening), 60 g during 40 years (forestry); • Soluble phosphorus load per 5 years 400 kg (farming), 600 (horticulture) and 750 (landscape gardening); soluble nitrogen load during 5 years in landscape gardening max. 1250 kg.
France	Organic soil improvers - Organic amendments and supports of culture NF U44-051	From the moment a compost meets the standard NF U44-051 there is no rule for the use. In the standard, flows in heavy metals, and elements are restricted to the maximum loading limits: <u>Per year g/ha:</u> As 270, Cd 45, Cr 1,800, Cu 3,000, Hg 30, Ni 900, Pb 2,700, Se 180, Zn 6,000

		Over 10 years g/ha: As 900, Cd 150, Cr 6,000, Cu 10,000, Hg 100, Ni 3,000, Pb 9,000, Se 600, Zn 30,000 Application should follow good agrarian practices, and agronomical needs which are taken into account for the use of composts.
Greece	Common National Ministerial Decision 114218/1997 Hellenic Ministerial Decision	Upper limits for amounts of heavy metals disposed of annually in agricultural land Cd 0,15, Cu 12, Ni 3, Pb 15, Zn 30, Cr 5, Hg 0,1, kg/ha/y
Hungary	49/2001 Statutory Rule about the protection of the waters and ground waters being affected by agricultural activities 10/2000. (VI. 2.) KöMEüM-FVM-KHVM - Water protection rule	• Compost application on agricultural land is limited by the amount of nutrient with 170 kg/ha Nitrogen. • Dosage levels depending on background contamination and nutrient content level in the soil laid down in the National Statutory Rule about the threshold values for the protection of the ground- and subsurface waters and soils.
Ireland	Statutory Instruments SI No. 378/2006 Good agricultural practice for protection of waters: Statutory instrument 253 of 2008	IE Nitrate regulation: Compost has to be included in the Nutrient Management Plan. Availability of nutrients calculated like cattle manure. There are specific waiting periods to consider for animal access to land fertilised with bio-waste compost based on the Animal-By-Product Regulations. • Catering waste: 21 d for ruminant animals; 60 d for pigs; • Former foodstuff & fish waste compost: 3 years (under revision)
Italy	National law on fertilisers L. 748/84 (revised in 2006 with the new law on fertilisers, D.lgs. 217/06) Regional provisions	• Compost has to be considered a product to be used according only to Good Agricultural Practice as long as it meets the standards. No restriction is set on loads for unit area • Some regions have codified approaches for low grade materials applications and landfill reclamation, building on

		the old regulation on “mixed MSW compost” (DCI 27/7/84)
Lithuania	Environmental Requirements for Composting of bio-waste, approved by the Ministry of the Environment on 25 January 2007, No. D1-57 Standards for sewage sludge use for fertilising and redevelopment LAND 20-2005 (Gaz., 2005, No. 142-5135)	• When compost used for improving the quality of the soil, the annual quantity of the heavy metals cannot exceed norms according LAND 20-2005. • Compost application in agriculture and or soil reclamation purposes, is restricted by contamination with pathogenic microorganisms, organic micropollutants and heavy metals (according to LAND 20-2005) • Compost application on agricultural land is limited by the amount of nutrient with 170 kg/ha Nitrogen and 40 kg/ha Phosphorous per year
Luxembourg	EU Nitrate Directive	• No specific regulations; advise (voluntary): 15 t d.m. /ha *y • Only record keeping about the compost use and send to the Ministry
Latvia	No regulations	only for sewage sludge compost
Malta	No data available	
Netherlands	Fertiliser Act (2008)	• Compost has to meet the national standard (heavy metals) • In the new fertiliser legislation limitations for application are only based on the nutrient content for agriculture, so called standard values of max. 80 kg P2O5 /ha*y, 100 kg N /ha*y, 150 K2O /ha*y, 400 kg neutralizing value /ha*y or 3000 kg organic matter /ha*y • For some crops which grow in the soil (e.g. potatoes) compost needs certification and a low glass content < 0.2 %
Poland	The Act of 10 July 2007 on	• Organic fertilisers and plant

	fertilisers and fertilisation (Journals of Laws No. 147, item 1033, as amended)	conditioners containing compost can be marketed and used on the Polish territory on the basis of a license from the Agricultural Ministry; • Products containing compost are used exactly as given in the instructions for using and storing the product, which is an integral part of the license; • A limit for nitrogen use of 170 kg of nitrogen (N) in the pure ingredient per ha and per year only applies to natural fertilizers
Portugal	No regulations available	-
Romania	No data available	n.d.
Sweden	The Swedish Board of Agriculture: SJV 1998:915 (sewage sludge regulation)	Fixed maximum heavy metal load Maximum heavy metal load (g/ha*y): Pb 25; Cd 0.75; Cu 300; Cr 40; Hg 1.5; Ni 25; Zn 600
	Nitrate directive	Agriculture: nitrogen: 150 kg/ha*y and phosphorus: 22 – 35 kg/ha*y
Slovenia	Decree on the treatment of biodegradable waste (Official Gazette of the Republic of Slovenia, no. 62/08)	Class I can be used without any restrictions. Class II can be spread with a special permission with a limited application rate considering the heavy metal content and load after an evaluation and risk assessment performed by a lab (but not more than 10 t d.m./ha /year).
	Decree concerning the protection of waters against pollution caused by nitrates from agricultural sources (Official Gazette of the Republic of Slovenia, no. 113/09)	Application of organic fertilizer on agricultural land is limited by the amount of nutrient with 250 kg/ha Nitrogen.
Slovakia	Act No. 220/2004 Col. on protection and using of agricultural soils	Lays down limit concentrations of risk elements in agricultural soils

	Ministry of Agriculture Decree No. 26/2000, on fertilisers.	Lays down fertiliser types, max. concentration of risk elements in organic fertilisers, substrates and commercial fertilisers, storage and take-off conditions, and methods of fertiliser testing
United Kingdom	Each country of the UK (England, Wales, Scotland, Northern Ireland) has different requirements Here is an example of parts of the regulations applicable for England and Wales	• Use in agriculture and applications to soil other than land restoration: A Waste Management Licence Exemption, Paragraph 7A, must be obtained by the land owner/manager before accepting and storing then spreading compost. The compost must be made from source segregated bio-waste. Per Paragraph 7A exemption: • 'Benefit to agriculture' or 'ecological improvement' must be demonstrated, which is done by spreading compost as per Nitrate Vulnerable Zone regulations if within a NVZ, and following the Codes of Good Agricultural Practice for the Protection of Soils and Water. Given the typical total nitrogen content of ‚Green compost ', the application rate would be approximately; • 30 - 35 fresh tonnes per hectare per year where a field NVZ limit of 250 kg total nitrogen per hectare applies, • 30 fresh tonnes per hectare per year if ‚Not NVZ' but as per good agricultural practice, or • 60 – 70 fresh tonnes per hectare once per two years if ‚Not NVZ' but as per good agricultural practice. • If the compost is classed as a waste, the Environmental Permitting Regulations apply (paragraph 7 exemption, U10 exemption or Standard Rules Permit) and a permit or exemption will be required by the land owner/manager before storing or spreading the compost. If the compost has ceased to be waste • Voluntary Code of Good

		Agricultural Practice for the Protection: limitation of nitrogen of 250 kg /ha/y (for all types of ‘organic manure’ used, including composts); compost can also be applied at a rate of 500 kg/ha once per two years

Annex C - Limits for impurities in compost in various European countries [Saveyn and Eder 2014]

Country	Impurities	Mesh size (mm)	Limit values weight % d.m.
Austria Compost ordinance	Total; agriculture	>2	≤ 0.5%
	Total; land reclamation	>2	< 1.0%
	Total; technical use	>2	< 2.0%
	Plastics; agriculture	>2	< 0.2%
	Plastics; land reclamation	>2	< 0.4%
	Plastics; technical use	>2	< 1.0%
	Plastics; agric. excl. arable land	>20	< 0.02%
	Plastics; technical use	>20	< 0.2%
	Metals; agriculture	-	< 0.2%
	Glass; agriculture	-	< 0.2%
Belgium Royal Decree for fertilisers, soil improvers and substrates	Total	>2	< 0.5%
	Stones	>5	< 2.0%
Czech Republic Act on fertilisers Biowaste Ordinance	Total, agriculture	>2	< 2.0%
	Total, land reclamation	>2	< 2.0%
Germany Biowaste Ordinance	Glass, plastics, metal	>2	< 0.5%
	Stones	>5	< 5.0%
Estland	Total impurities (glass, metals, plastic)	>2	< 3.0%
Finland Decree of the Ministry of Agriculture and Forestry on Fertiliser Products 12/07	Refuse (glass, metal, plastics, bones, rocks) In packaged products Sold in bulk	-	
France NF U44-051	Plastic films	>5	< 0.3%
	Other plastics	>5	< 0.8%
	Metals	>2	< 2.0%

Country	Impurities	Mesh size (mm)	Limit values weight % d.m.
Hungary	No restrictions	-	-
Ireland EPA waste license	Total; compost class 1 & 2	>2	≤ 0.5%
	Total; low grade compost/MBT	>2	≤ 3.0%
	Stones	>5	≤ 5.0%
Italy Fertiliser law d.lgs. 75/2010	Glass, plastics, metals	>2	< 0.5%
	Stones	>5	< 5.0%
Latvia Cabinet Regulation No. 530, 25.06.2006	Total (glass, metal, plastics)	>4	< 0.5%
Netherlands Fertiliser act + various certification systems	Total	>2	< 0.5%
	Glass	>2	< 0.2%
	Stones	>5	< 2.0%
	Biodegradable parts	>50	0
	Non-soil based, non-biologically degradable parts		< 0.5%
Slovenia Decree on the treatment of biodegradable waste (Official Gazette of the Republic of Slovenia, no. 62/08)	Glass, plastics, metal		
	1st class	<2	< 0.5%
	2nd class	<2	< 2.0%
	Stabilized biodegradable waste	<2	< 7.0%
	Minerals, stones		
	1st class	<5	< 5.0%
	2nd class	<5	< 5.0%
	Stabilized biodegradable waste	<5	-
United Kingdom PAS 100 voluntary standard	Total	>2	< 0.5%
	herein included plastic		<0.25%
	Stones: other than 'mulch'	>4	< 0.8%
	Stones: in 'mulch compost'	>4	< 10%

Annex D - Heavy metal limits (mg/kg dm) in Australian and European compost/digestate standards [adapted from Saveyn and Eder 2014]

Country	Regulation	Type of standard	Cd	Cr_{tot}	Cr^{VI}	Cu	Hg	Ni	Pb	Zn	As
Australia	AS4454 - 2012	Voluntary standard	3	100		100 (150)	1	60	150	200 (300)	20
Austria	Compost Ord.: Class A+ (organic farming)	Statutory Ordinance	0.7	70	-	70	0.4	25	45	200	-
	Compost Ord.: Class A (agriculture; hobby gardening)		1	70	-	150	0.7	60	120	500	-
	Compost Ord.: Class B limit value (landscaping; reclam.) (guide value) *		3	250	-	500 (400)	3	100	200	1800 (1200)	-
Belgium	Royal Decree, 07.01.1998, case by case authorisation, Compost	Statutory decree	2	100	-	150	1	50	150	400	20
	Royal Decree, 07.01.1998, case by case authorisation, DIGESTATE	Statutory decree	6	500	-	600	5	100	500	2000	150
Bulgaria	No regulation	-	-	-	-	-	-	-	-	-	-
Cyprus	No regulation	-	-	-	-	-	-	-	-	-	-
Czech Republic	Use for agricultural land (Group one)	Statutory	2	100	-	100	1	50	100	300	10

Country	Regulation	Type of standard	Cd	Cr_{tot}	Cr^{VI}	Cu	Hg	Ni	Pb	Zn	As
	Landscaping, reclamation (draft Bio-waste Ordinance) (group two)	Statutory Class 1	2	100	-	170	1	65	200	500	10
		Statutory Class 2	3	250	-	400	1.5	100	300	1200	20
		Statutory Class 3	4	300	-	500	2	120	400	1500	30
	Fertilizer law 156/1998, ordinance 474/2000 (amended)	DIGESTATE with dry matter > 13%	2	100		150	1	50	100	600	20
		DIGESTATE with dry matter < 13%	2	100		250	1	50	100	1200	20
Germany	Quality assurance RAL GZ - compost / digestate products	Voluntary QAS	1.5	100	-	100	1	50	150	400	1
	Bio waste Ordinance	Statutory decree (Class I)	1	70	-	70	0.7	35	100	300	-
		Statutory decree (Class II)	1.5	100	-	100	1	50	150	400	-
Denmark	Statutory Order Nr.1650; Compost after 13 Dec. 2006	Statutory decree	0.8	-	-	1000	0.8	30	120/60 for private garde ns	4000	25
Estonia	Env. Ministry Re. (2002.30.12; m° 87) Sludge regulation	Statutory	-	1000	-	1000	16	300	750	2500	-
Spain	Real decree 506/2013	Statutory	0.7	70	0	70	0.4	25	45	200	-

Country	Regulation	Type of standard	Cd	Cr_{tot}	Cr^{VI}	Cu	Hg	Ni	Pb	Zn	As
	on fertilisers: Class A										
	Class B		2	250	0	300	1.5	90	150	500	-
	Class C		3	300	0	400	2.5	100	200	1000	-
Finland	Decree of the Ministry of Agriculture and Forestry on Fertiliser Products 12/07	Statutory decree	1.5	300	-	600	1	100	100	1,500	25
France	NF U44-051	Standard	3	120		300	2	60	180	600	
Greece	KYA 114218, Hellenic Government Gazette, 1016/B/17- 11-97 [Specifications framework and general programmes for solid waste management]	Statutory decree	10	510	10	500	5	200	500	2,000	15
Hungary	Statutory rule 36/2006 (V.18)	Statutory Co: 50; Se: 5	2	100	-	100	1	50	100	-	10
Ireland	Licensing/permitting of treatment plants by competent authority stabilised MBT output or compost not meeting class I or II	Statutory	5	600	-	600	5	150	500	1500	-

Country	Regulation	Type of standard	Cd	Cr_{tot}	Cr^{VI}	Cu	Hg	Ni	Pb	Zn	As
	(Compost – Class I)	Statutory	0.7	100	-	100	0.5	50	100	200	-
	(Compost – Class II)	Statutory	1.5	150	-	15	1	75	150	400	-
Italy	Law on fertilisers (L 748/84; and: 03/98 and 217/06) for BWC/GC/SSC	Statutory decree	1.5	-	0.5	230	1.5	100	140	500	-
Luxembourg	Licensing for plants		1.5	100	-	100	1	50	150	400	-
Lithuania	Regulation on sewage sludge Categ. I (LAND 20/2005)	Statutory	1.5	140		75	1	50	140	300	-
Latvia	Regulation on licensing of waste treatment plants (n° 413/23.5.2006) – no specific compost regulation	Statutory = threshold between waste/product	3			600	2	100	150	1,500	50
Netherlands	Amended National Fertiliser Act from 2008	Statutory	1	50		90	0.3	20	100	290	15
Poland	Organic fertilisers	Statutory	5	100		-	2	60	140	-	-
Portugal	Standard for compost is in preparation	-	-	-	-	-	-	-	-	-	-
Sweden	Guideline values of QAS	Voluntary	1	100	-	100	1	50	100	300	-

Country	Regulation	Type of standard	Cd	Cr_{tot}	Cr^{VI}	Cu	Hg	Ni	Pb	Zn	As
	SPCR 152 Guideline values	Voluntary	1	100	-	600	1	50	100	800	-
	SPCR 120 Guideline values (DIGESTATE)	Voluntary	1	100	-	600	1	50	100	800	-
Slovenia	Decree on the treatment of biodegradable waste (Official Gazette of the Republic of Slovenia, no. 62/08)	Statutory: 1st class*	0.7	80	-	100	0.5	50	80	200	-
		Statutory: 2nd class*	1.5	200	-	300	1.5	75	250	1200	-
		Statutory: stabilized biodegradable waste*	7	500	-	800	7	350	500	2500	-
		* normalised to an organic matter content of 30%									
Slovakia	Industrial Standard STN 46 5735 Cl. 1	Voluntary (Mo: 5)	2	100		100	1	50	100	300	10
	Cl. 2	Voluntary (Mo: 20)	4	300		400	1.5	70	300	600	20
United Kingdom	UKROFS fertil. org. farming, 'Composted household waste'	Statutory (EC Reg. 889/2008)	0.7	70	0	70	0.4	2	45	200	-
	Standard: PAS 100	Voluntary	1.5	100	-	200	1	50	200	400	-
	Standard: PAS 110 (DIGESTATE)	Voluntary	1.5	100	-	200	1	50	200	400	-
EU ECO Label	COM Decision (EC) n° 64/2007 eco-label	Voluntary [Mo: 2; As: 10; Se: 1.5; F:	1	100	-	100	1	50	100	300	10

Country	Regulation	Type of standard	Cd	Cr_{tot}	Cr^{VI}	Cu	Hg	Ni	Pb	Zn	As
	to growing media COM Decision (EC) n° 799/2006 eco-label to soil improvers	200 [only if materials of industrial processes are included]									
EU Regulation on organic agriculture	EC Reg. n° 889/2008. Compliance with limits required for compost from source separated bio-waste only	Statutory	0.7	70	-	70	0.4	25	45	200	-