LIFE Project Number

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FULL PROJECT TITLE

‘Design and Application of an Innovative Composting Unit for the Effective Treatment of Sludge and other Biodegradable Organic Waste in Morocco, MOROCOMP’

Task 6:

Development of guidelines and specifications covering the sludge composting process Characterization and use of compost as soil improver

Deliverable 18B

Specifications concerning the quality and compost products and their possible uses

July 2008

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1 Introduction

The need for compost standards lies in the fact that without a suitable system of standards in place, it is questionable whether the market for composts can be developed in such a way as to ensure that waste strategy targets are met in a sensible manner, and that sustainable waste management techniques can be applied to a number of waste streams. This is not solely a question of a need to develop the market for compost in a 'positive' way, but a question of ensuring that the system of standards effectively generates confidence in the products of composting processes. A key issue here is to effectively eliminate from specific markets those materials which are unfit for their stated purpose. Therefore the aim of the project is to provide guidance to competent authorities in Morocco in focusing their efforts and resources in the development of a set of robust and commercially beneficial compost standards in Morocco based on the existing standards guidelines and experience worldwide.

Establishing standards specific to compost and the promotion of quality compost criteria aim to bolster compost industry and to aid growth of new compost markets. Several European countries have adopted specific standards and many other countries are in the process of doing so. There is no simple way to give a summary concerning compost quality standards as they exist in the world. Therefore this report aims to presents a variety of established and published standards for end product quality and compost applications that will provide the appropriate background information to Moroccan authorities for the development of compost quality standards and specifications for compost end use.

Many countries are now beginning to routinely publish compost guidelines with implied standards. Portions of these guidelines are required by certain laws; others are obscure. This makes it hard to distinguish legal as in the case of legislative from voluntary systems of standards. The purpose of this report is, however, not to determine standards purely on a statutory basis, but to present an overview of such standards in order to gain a better understanding of what common factors exist from which successful standards - whether mandatory or not - could be developed in Morocco.

The differences occuring in compost standards internationally lies in the fact that each situation has its own specific characteristics, and each system functions within a background 'policy framework' which implies that the approach undertaken in one country is not necessarily suitable for adoption in another. Furthermore, there are some differences in approach which exist, due, for example, to differences in scientific opinion. However, it seems fair to state that over time the trend has been a clear one towards development of composts which are ‘cleaner’ from the environmental perspective. Therefore limit values in compost should clearly define when a ‘compost’ can be considered as a product, and can therefore be marketed and used with no ‘waste-related’ restrictions.

2 Classification of compost internationally

Good knowledge of the differentiated quality of the various compost types (biowaste, mixed solid waste, sewage sludge etc.) led in some MSt to classification system of composts based on Potential Toxic Elements (PTEs) – heavy metal content the type of the feedstock material, the maturity level and the type of compost application as seen in Table 1.

Table 1: Categories of compost classification internationally

Category that is classified	Country
Heavy metals content	Austria, Canada, Germany, the Netherlands, Spain, Sweded and USA
Type of raw material	Austria, Belgium, Denmark, Germany, Italy, Spain and Sweden
Degree of maturity	Australia, Germany, Luxembourg and Spain (and to some degree in Canada)
Compost types based on application	Austria and Germany

Therefore the quality criteria upon which compost standards are based varies across the countries both in the range of criteria, the requirements, and the limit values. Table 2 presents the range of the different compost standards and classification of compost quality worldwide. Different countries have established different numbers of classes of composts. Whilst Austria recognises three classes, other countries have two and many only have one. The Second Draft EU Working Document on the Biological Treatment of Biowaste lays down standards for two classes of compost, both towards the high quality end, which would be considered as products under European Single Market legislation. This ‘product’ characteristic (allowing the material to be freely marketed) would distinguish composts from a third class of material, stabilised biowastes, which would still be considered as ‘waste’ (and subject to Member State legislation on wastes). All biologically treated material falling outside these classes would also be waste. The countries which have more than one standard are: Austria, Germany, Luxembourg, the Netherlands and Canada (as well as Catalunya in Spain). In the Netherlands, only one production plant currently reaches the limit values for ‘very good’ compost (because of the tight limits on zinc content), so in practice, there is really only one standard. Austria has three classes of compost :

- Class A+: top quality; limit values taken from Council Regulation (EEC) No.2092/91 on Organic Farming – EC eco-agric.
- Class A: high quality; suitable for use in agriculture.
- Class B: minimum quality; suitable for non-agricultural use.

In Canada, many organizations are involved in the development of standards and regulations. In the area of compost and composting, Agriculture and Agri-Food Canada (AAFC) (through the Plant Products Division), the provincial and territorial governments (through the Canadian Council of Ministers of the Environment (CCME)), and the Standards Council of Canada (through the Bureau de Normalisation du Quebec (BNQ)) are all concerned with developing quality criteria. Therefore the BNQ adopted two categories as well (Types AA or A and B) while AAFC presented one compost class all standards based on trace elements concentration limits. The revised CCME Guidelines for Compost Quality in 2005 (revising 1996 guidelines) attempt to integrate the concept that exposure is an integral part of risk by establishing two grades of materia based on the level the final end use and according to trace elements and foreign matter incorporated in compost.

- Category A which includes compost that has unrestricted use and can be used in any application, such as agricultural lands, residential gardens, horticultural operations, the nursery industry, and other businesses.
- Category B which includes compost that has a restricted use because of the presence of sharp foreign matter or higher trace element content. Category B compost may require additional control when deemed necessary by a province or territory.

Table 2: Classification of compost internationally

Country	**Types and quality classes**
Austria	Statutory: Class A+ (for organic farming), Class A (for food and fodder areas) and Class B (for non-food areas), based on different raw materials and heavy metal contents.
Belgium/Fl	Quasi Statutory: Yard waste compost and vegetable, fruit and garden VFG compost and humotex.
Denmark	Organic household waste compost with no classification up to now. No quality criteria for green/yard waste compost necessary.
Germany	Statutory: Biowaste Ordinance Type I and II with different heavy metal contents. Voluntary RAL Standard.: Fresh and matured compost, mulch and substrate compost, liquid and solid digestion residuals.
Italy	Statutory: One level. Voluntary: Composted amendments form source-separation (two types depending on the raw material) and compost from mixed MSW.
Luxembourg	Statutory: Fresh and matured compost.
Netherlands	Statutory: Compost and very good compost.
Sweden	Voluntary: Compost and digestion residuals.
Portugal	Three classes considering heavy metals, inert materials and pathogens
Spain	Source-separation or not.
UK	Voluntary: The Composting Association Standard defined by heavy metal content (and impurities and pathogens).

Canada	Voluntary: AAFC - one class based on heavy metal content. Voluntary: CCME - two classes based on heavy metal and foreign matter content. Voluntary: BNQ - three classes - heavy metals differentiate between top two and third; organic matter and foreign matter levels distinguish top two.
USA	Statutory: one class based on heavy metal content.
Australia	Voluntary: level of pasteurisation and particle size/stability.
New Zealand	Voluntary: range of parameters, not heavy metals.

From Tables 1 and 2 it can be seen that some countries opted for a complex system, integrating levels of quality (PTE) classes with categories of admissible input materials and differentiated restriction of application areas in order to fulfil the general principle of “the recycling measure has to be beneficial to the environment …”. The next sections are divoted to present in more depth the current condition of compost quality standards worlwide as well as the requirements/specifications of compost for its application on land.

3 Standards for end product/compost quality

As has been mentioned the compost quality standardization differentiates among countries even within a country standards may differ from state to state as in the case of U.S or Australia. For this reason it was considered appropriate to present and examine a variety of established and published standards worldwide based on three main categories which are considered fundamental for the characterisation of compost quality. Those categories include the concentration of Potential Toxic elements known as PTEs, the concentration of organic contaminants, the content of pathogens, impurities and weeds and the stability/maturity level of compost.

3.1 Potential Toxic elements [PTEs]

One of the most important causes of concern in the application of compost to land is the presence of high concentrations of heavy metals or Potential Toxic Elements – PTEs. The PTEs may have the effect of impairing the natural mechanisms through which soil microbes reproduce and therefore deplete the bio-potential of the soil ecosystem. Moreover, if the concentration is high enough heavy metals can penetrate the natural barriers in plant roots and end up in the edible part of vegetables. Some heavy metals can then accumulate in animal and human organs and cause poisoning effects, induce cancer or produce mutagenic changes. Therefore application to the soil of composted material can pose an indirect risk to human health; due to the possibility of pollutants migration to groundwater, or their accumulation in plants. According to the existing legal standards and requirements for composts, the following pollutants are considered as Potential Toxic Elements (PTEs): As, Cd, Cr, Cu, Hg, Ni, Pb, Zn while the following compost types were identified as source materials:

- Municipal solid waste (MSW) / mechanical-biological treated waste (MBT) compost / stabilised organic waste fraction (MSWC; MBTC)
- Biowaste compost (BWC): compost of source separated kitchen waste from private households and industrial origin if collected in a common system; mixed with the necessary proportion of structural or bulking material (chopped or shredded tree and bush cuttings)
- Green waste compost (GC): compost made of garden and park waste such as grass clippings, shredder material, chopped wood, leaves, flower residues etc.
- Manure compost (MC)

- Sewage sludge compost (SSC)

Since PTEs may affect plant health and growth, soil properties and micro-organisms, livestock and human health their concentration level in composts is considered as a basic parameter in the characterisation of the quality of compost. In Annex 1 potential sources of each PTE into compost and to soil are presented.
Usually, maximum allowable concentrations for a common range of heavy metals in composted materials are used for the characterisation of compost quality in different countries. However the range of limit values set (common or exceptional qualities) and the allowed excess (cut-off limits, or tolerances around target limits) have to be taken into consideration when examining the heavy metal lumit values in each country. Two different philosophies are the basis of the fixing of the limits for heavy metals:

- Fixing a very low, and strict level for the heavy metals, yet allowing a considerable variation (e.g. Austria, Denmark, the Netherlands); and
- Establishing a moderate limit level for heavy metals and relatively small allowed deviations (Germany).

According to Table 3 the heavy metal limits in the five countries with the strictest compost quality levels do not differ so much from each other. Countries such as Austria or the Netherlands with relatively severe guidelines e.g. concerning heavy metals on the one hand and on the other hand relatively high deviations (40 to 50%) from the guide values which are allowed for the single case. These are confronted with the German guide values with relatively moderate values, but relatively little deviations of only 25%. Hence, although the Dutch level is the lowest, for the most critical heavy metal element, zinc, the limit value effectively becomes 286 mg/kg dm, which is a strict, though achievable level. Equally, Italian standards may not be so tight in absolute terms, but there is an absence of any 'tolerance' band.
It is recommended that a level of tolerance should be allowed regarding exceedences on the quality criteria and limits that are set, since composting systems have only little influence on the quality of the raw material (e.g. Germany allows a tolerance of 25% and the Netherlands a deviation factor of 1.43 for single heavy metals in a single analysis). Particularly when limit levels are very tight, composting plants generally produce compost very close to these limits. When the composting process is finished it can be ascertained for the first time by the plant

whether the compost produced fulfils the quality requirements or not. An allowed variation gives the plants a level of security (and stability) in their compost production. To cope with this problem the standards set by the Composting Association in the UK incorporate tolerances within a weighted scoring system. Thus, compost samples which occasionally exceed one or more upper limits, or which more frequently exceed one limit but only by an insignificant amount, will not necessarily lead to the award of compliance being withheld.

Another important fact influencing the stringency of the limit values has to be the quality of sample taking and analysis. Experienced sample takers, mostly working for laboratories, will perform the sample taking to a higher standard and according to the regulations, especially when it comes to open profiles in the heap and the reduction of larger samples for the final sample. The level of errors in the orderly sample taking and analysis done by experienced personnel during the German inter-laboratory checks on a reference compost sample is around 40%. Hence, if strict limits and standards are to be imposed, these possible sources of failures have to be taken into consideration.

Table **3**: Heavy metal limits and allowed deviations (mg/kg dm) of common compost qualities in countries with strict quality levels

Country	Cr	Ni	Cu	Zn	Cd	Hg	Pb
Austria				(+30%)[1]			
Class A	70	60	150	500	1	0.7	120
+ 50%	105	90	225	650	1.5	1.05	180
Belgium							
Agriculture Ministry	70	20	90	300	1.5	1	120
Denmark							
Statutory Order	100	30	1000	4000	0.4	0.8	120
+ 50%	150	45	1500	6000	0.6	1.2	180
Germany + Lux.							
RAL and Biowaste Ordinance II	100	50	100	400	1.5	1	150
+ 25%	125	75	125	500	1.875	1.25	187
Netherlands							
Compost	50	20	60	200	1	0.3	100
x1.43	72	29	80	286	1.4	0.4	143

1 The 30% for Zn and 50% tolerance for the other PTEs are tolerances which only apply for controlled analyses by the responsible authority on the market or at the composting plant. This tolerance is not intended to be applicable for any batch investigated on behalf of the producer.

Table 4 presents the heavy metal limit values that have been set in various countries. By comparing these standards it can be seen that the Dutch quality level is noticeable, because it clearly sets an especially high quality standard, not in keeping with standards in the rest of Europe. EU initiatives with respect to the heavy metals maximum consentration in compost are also seen in Table 4. The second draft EU Working Document on the Biological Treatment of

Biowaste lays down heavy metal limit values for two classes of compost both towards the high quality end product while a third class of material, stabilised biowastes, which is still considered as ‘waste’. In addition according to the commission decision 2001/688/EC (EC Eco-label) on “*establishing ecological criteria for the award of the Community eco-label to soil improvers and growing media*” environmental performance in regard to the heavy metal concentration of soil improvers[1] and growing media[2] have been set. Figure 1 gives a comparative survey on heavy metal limit and guide values for composts in European countries expressed as relative mean limits as compared to the maximum concentration of the EC Eco-Label for soil improver (= 100 %). Finally for the utilization of compost as fertilizer or soil conditioner within organic farming (Eco-agric), specific compost quality standards for heavy metal concentration are also provided. Within the Eco-agric (EC 2092/91 - EC 1488/97) only composted source separated household waste containing only vegetable and animal waste is accepted.

[1] soil improvers: materials to be added to the soil in situ primarily to maintain or improve its physical properties, and which may improve its chemical and/or biological properties or activity

[2] growing media: material, other than soils in situ, in which plants are grown

Table 4: Heavy metal limits for European compost standards (mg/kg dm except where stated)

Country	Regulation	Type of standard	Cd	Crtot	CrVI	Cu	Hg	Ni	Pb	Zn	As
Austria	Compost Ordinance: Quality Class A+ (organic farming)	statutory decree	0.7	70	-	70	0.4	25	45	200	-
	Compost Ordinance: Quality Class A (agric,; hobby gardening)		1	70	-	150	0.7	60	120	500	-
	Compost Ordinance: Quality Class B (landscaping; reclaim.) limit value		3	250	-	500	3	100	200	1800	-
	Compost Ordinance: Quality Class B (landscaping; reclaim.) guide value (if exceeded to be marked within labelling)					400				1200	
Belgium	Ministry of Agriculture	statutory decree	1.5	70	-	90	1	20	120	300	-
Denmark	Compost after 01 06 2000	statutory decree	0.8			1000	0.8	30	120/60 for priv. gardens	4000	25
Finland	Fertilised growing media	statutory decree	3	-	-	600	2	100	150	1500	50
France	NF Compost Urbain	standard	3				8	200	800		
Germany	Quality assurance RAL GZ - compost/digestion	voluntary QAS	1.5	100	-	100	1	50	150	400	-
	Bio waste ordinance (Class I)	statutory decree	1	70		70	0.7	35	100	300	-
	Bio waste ordinance (Class II)		1.5	100	-	100	1	50	150	400	-
Greece	Specifications framework and general programmes for solid waste management	statutory decree	10	510	10	500	5	200	500	2000	15
Ireland	Licensing of treatment plants as agreed with EPA	voluntary	1.5	100	-	100	1	50	150	350	15
	Class I	voluntary	1	100	-	100	1	50	100	200	
	Class II	voluntary	1.5	150	-	150	1	75	150	400	
Italy	Technical regulation, DCI 27/07/84 (MSWC) - Limit values for solid organic fraction	statutory decree	10	500	10	600	10	200	500	2500	10
	Draft Decree on the use of MBTC 1st quality	DRAFT statutory	3	-	3	300	3	100	280	1000	-
	Law on fertilizers (L 748/84; amd: 03/98) BWC/GC/SSC	statutory decree	1.5	-	0.5	150	1.5	50	140	500	

Luxembourg	Licensing for plants		1.5	100	-	100	1	50	150	400	-
Netherlands	Compost	statutory decree	1	50	-	60	0.3	20	100	200	15
	Compost (very clean)		0.7	50	-	25	0.2	10	65	75	5
Portugal	Decree on sludge (limit values utilised also for MSW)	statutory decree	20	1000		1000	16	300	750	2500	-
Spain	Decr. 1310/1990 pH>7 (sewage sludge in agriculture)		40	1500	-	1750	25	400	1200	4000	-
	Decr. 1310/1990 pH<7 (sewage sludge in agriculture)		20	1000	-	1000	16	300	750	2500	-
	Order 28/V/1998 on fertiliser BO.E.n'm.131.2 June 1998	statutory decree	10	400	-	450	7	120	300	1100	-
Spanish draft on composting	Class AA	DRAFT statutory decree	2	250	-	300	2	100	150	400	-
	Class A (Stabilised Biowaste)	DRAFT statutory decree	5	400	-	450	5	120	300	1100	-
Catalunya draft on composting	Class A	DRAFT statutory decree	2	100	0	100	1	60	150	400	-
	Class B (Stabilised Biowaste)	DRAFT statutory decree	3	250	0	500	3	100	300	1000	-
Sweden	Guideline values of QAS	voluntary	1	100	-	100	1	50	100	300	
UK	ACOS (Former UKROFS) 'Composted household waste'	statutory (EC Reg. 2092/91)	0.7	70	0	70	0.4	25	45	200	-
	Composting Association Quality Label	voluntary	1.5	100	-	200	1	50	150	400	-
Canada	BNQ Types AA and A,		3	210	-	100	0.8	62	150	500	13
	CCME Category A		3	210	-	400	0.8	62	150	700	13
	BNQ Types B, CCME Category B and AAFC		20	1060*		757*	5	180	500	1850	75
USA	EPA CFR40/503 Sludge Rule		39	no ceiling	-	1500	17	420	300	2800	41
	NY Slate DEC* Class I		10	100	-	1000	10	200	250	2500	-
	WA State Dept of Ecology, Grade A		10	600	-	750	8	210	150	1400	20
	WA State Dept of Ecology, Grade AA		39	1200	-	1500	17	420	300	2800	20
	Texas TNRCC Grade 1 Compost		16	180	-	1020	11	160	300	2190	10

	Texas TNRCC Grade 2 Compost		39	1200	-	1500	17	420	300	2800	41
	Rodale Organic Seal of Compost Quality		4	100	-	300	0.5	50	150	400	10
Australia	NRMMC threshold limits for Grade C1 biosolids and biosolids products		1	100-400		100-200	1	60	150-300	200-250	20
	NRMMC threshold limits for Grade C2 biosolids and biosolids products		20	500-3000		2500	15	270	420	2500	60
New Zealand	DoH Values (1992)		15	1000	-	1000	10	200	600	2000	-
EC	Draft W.D. Biological Treatment of Biowaste (class 1)	DRAFT statutory decree	0.7	100		100	0.5	50	100	200	
	Draft W.D. Biological Treatment of Biowaste (class 2)		1.5	150		150	1	75	150	400	
	Stabilised Biowaste**		5	600		600	5	150	500	1500	
EC/'eco-label'	2001/688/EC	voluntary	1	100		100	1	50	100	300	10
EC/'eco-agric'	2092/91 EC-1488/97 EC	statutory	0.7	70	0	70	0.4	25	45	200	

* Set in BNQ standard only

** Normalised to an organic matter content of 30%

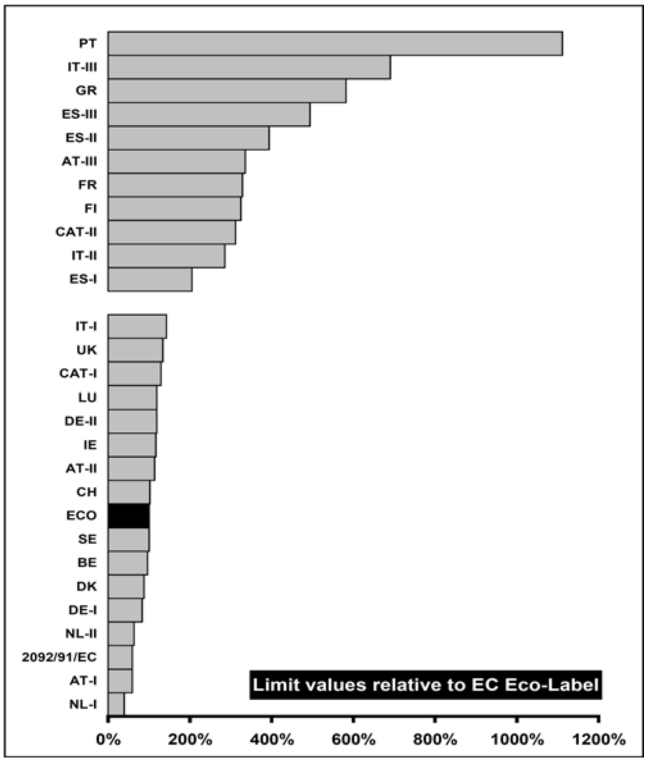

Figure 1: PTE limit values for compost in European countries [mean percentage relative to threshold values of the EC Ecolabel for soil improver]. Countries with more than one compost category or quality class referring to PTE thresholds are indicated with 'I / II /III']

The Austrian (Compost Ordinance: Quality Class A+) and the UK Advisory Committee on Organic Standards - ACOS (former United Kingdom Register of Organic Food Standards – UKROFS) standards, together with the German Biowaste Ordinance Compost Type I form a second group with strict limit values. For the UK and Austrian examples, the influence of Annex II/A of EC regulation 2092/91/EEC (Eco-agric) on organic farming is clear. This contains a positive list of admissible fertilisers and soil improvers. Included are – amongst others – pure plant and vegetable materials (plant compost, park and garden waste compost) and – with amendment from 29 July 1997 (EC regulation 1488/97/EEC) – composted household waste. The latter amendment is linked to limit values for heavy metals and the requirement that the raw material must be gained from a closed and controlled collection and processing system. The need of farms for the compost has to be recognised by the inspection body. Heavy metal limits are distinctly beneath the values of the Eco-label as shown in Table 4. These limit values do not apply for green compost from garden and park waste.

An issue that must be taken into consideration when diversifying compost qualities based on heavy metal content is that there are conflicting views. On the one hand, some perceive that it has been more or less well-established that when compost quality classes are set based on heavy metal contents (e.g. Austria), only the ‘best’ compost will be asked for. From this perspective, where more than one compost classification exists, large quantities of good quality compost which is sufficient for various uses might fail to find an end-use. Compost quality classes based on raw material (e.g. Belgium/Fl), on the properties or the ranges of utilisation (e.g. Germany) will more effectively meet the requirements of the compost market.

It sometimes happens that tests on compost where you would anticipate a higher level of heavy metals appear to show a relatively low concentration following measurement. This can often be traced to situations where such materials have not undergone proper maturation, and therefore the ‘concentration’ of heavy metals which occurs in parallel with process-related materials loss has not taken place. As organic matter is mineralised over time, but heavy metals may accumulate in soils, in order that the influence of maturation on the concentration of heavy metals is properly assessed, many regulatory schemes (as for instance in the German Biowaste Ordinance) provide for the assessment of heavy metals to be standardised at a specific level of Organic Matter (30% in Germany) whereas ‘fresh’ materials often show 60 to 70% organic matter. Standardising the heavy metal concentrations to a specific level of organic matter enables materials to be compared on a level playing field.

The effect of this is shown in Figure 2. This shows the effects of standardisation in this way on composts of different organic matter content whose concentration of Zinc is measured to be 300ppm in all the samples shown. It shows that a compost which shows concentrations of 300ppm at 70% organic matter would actually be equivalent (in its zinc concentration) to a compost with a concentration of 700ppm zinc if the organic matter content had been reduced to 30%. Clearly, without such standardisation of measurements, bogus claims for the low-level concentration of heavy metals in compost can be made simply by reporting measurements on immature products.

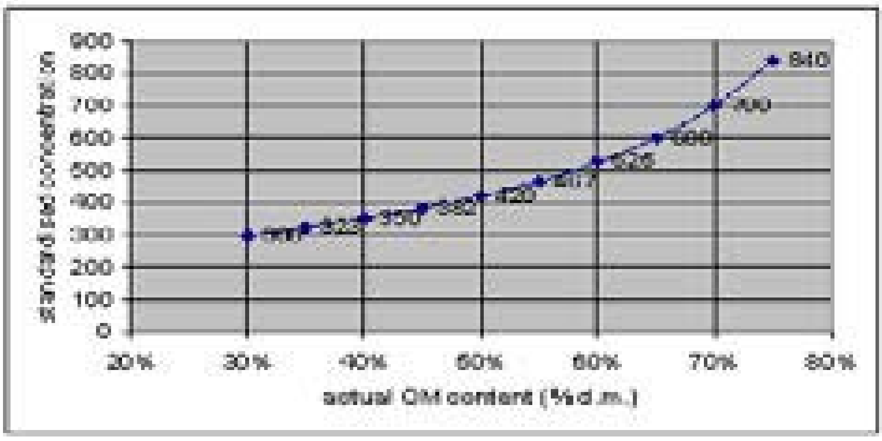

Figure 2: Effect of standardisation to 30% organic matter on reported zinc concentrations

3.2 Comparison of standards for organic contaminants

There are thousands of chemically synthesised compounds that are used in products and materials commonly used in our everyday life. Many of them are potential contaminants of biowaste, although, due to their low concentration or easiness to be broken down by micro-organisms, as to the buffering capacity of soils, they do not cause a threat to the environment. However, there are some organic compounds that are not easily broken down during waste treatment and tend to accumulate and be the source of concern due to their eco-toxicity, the eco-toxicity of the products resulting from their degradation or to their potential for bio-accumulation. There are usually three main reasons why an organic compound may be subject to preventive action:

(a) the break down by soil micro-organisms of the compound concerned is slow (from some months to many years) and therefore there is an actual risk of build-up in the soil;
(b) the organic compound can bio-accumulate in animals and therefore it poses a serious threat to man;
(c) the degradation products of the organic compound are more toxic than the initial compound.

Therefore there is likely a very high number of organic contaminants to be found in compost made from collected and treated biodegradable organic waste. Each year, the use of new compounds increases by a few thousand. Some of these compounds break down or undergo a transformation during the composting operations, while others remain stable. The presence of organic contaminants in compost used on soils could represent a potential risk to the environment and to the quality of crops intended for human or animal consumption. In Annex 2 organic pollutants that can be present into compost and to soil are presented.
Limits for organic contaminants were proposed only within the second draft of the Working Document on biological treatment of biowaste, concerning the polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs) only (Table 5), and their concentration was set to be in consistence with the Sewage Sludge Directive (86/278/EEC). In general, organic contaminants are expected to be at low levels in composts derived form source separated materials and therefore in most European countries there are no set limit values for organic contaminant in composts.

Table 5: Organic pollutants standards for compost and stabilised biowaste

Parameter (in mg/kg dm)	Compost Class 1*	Compost Class 2*	Stabilised Biowaste*
PCBs (mg/kg dm)	-	-	0.4
PAHs (mg.kg dm)	-	-	3

*Threshold values for these organic pollutants to be set in consistence with the Sewage Sludge Directive.

At the moment in EU only Austria, Denmark and Luxembourg are worried about organic pollutants in compost and have fixed limits (Table 6). The other countries have detected very low levels, so they don't analyse the contamination (Netherlands, Belgium) or they do a kind of observation in suspicious cases or on a voluntary basis (Germany).

It should also be noted that in Australian state guidelines for biosolids, limit values apear for PCBs and for a number of pesticide (usually herbicide) products. Typically, these limits cover lindane, heptachlor, DDT and derivatives, and the drins (aldrin, dieldrin, etc.). Indeed, a number of local regulations exist concerning the use of pesticides in gardens, partly related to concerns for the fate of these once composted. It is notable also that Denmark, with its high rate of composting of garden waste, has tight legislation concerning pesticides and recently implemented a ban on the use of garden pesticides.

Table 6: Limit values for organic contaminants and pesticides in compost

	Austria MSWC only	**Denmark Biowaste compost**	**Luxembourg Guide values for fresh and matured compost**	**Australia NRMMC**
PCB 1	1 mg/kg dm		0.1 mg/kg dm (4 analysis per year)	0.05-0.3 mg/kg dm
PCCD/F 2			20 mg/kg dm (4 analysis per year)	
Dioxins	50 ng ITEQ/kg dm			
PAH 3	6 mg/kg din	3 mg/kg dm	10 mg/kg dm (2 analysis per year)	
AOX 4	500 mg/kg dm			
Hydrocarbons	3000 mg/kg dm			
LAS 5		1300 mg/kg dm		
NPE 6		30 mg/kg dm		
DEHP 7		50 mg/kg dm		
OCPs 8				0.02-0.05 mg/kg dm
DDT/DDD/DDE 9				0.5 mg/kg dm

1 PCB: Polychlorinated biphenyls; 2 PCCD/F: Polychlorinated dibenzofuran; 3 PAH: polycyclic aromatic hydrocarbons; 4 AOX: Absorbable organic halogens; 5 LAS: linear alkylbenzene sulphonates; 6 NPE: nonylphenol; 7 DEHP: Di (2-ethylhexyl) phthalate; 8 OCPs: organochlorine pesticides;9 DDT/DDD/DDE: Dichloro-Diphenyl-Trichloroethane/ Dichloro – Diphenyl- Dichloroethane/ Dichloro – Diphenyl - Dichloroethylene

In Canada the BNQ, CCME and AAFC position on organic contaminants limit values states that there is no valid reason to support the inclusion of organic contaminant limits in compost standards and that organic contaminants should be considered for the standardisation of compost only of any information or scientific findings justify it.

In the US, the issue of banning chemicals that enter compost focuses on certain herbicides that are very persistent to degradation (e.g., chlorpyralid and picloram). Research into the fate of these chemicals in compost suggests they may decompose slower in compost than in natural soils. A perceived problem is that the chemicals being discussed are the same that are used elsewhere in farming systems. The question as to how these can be banned in one use and not in another similar use is one which has affected the debate around pesticides policy in Denmark and is now being asked in the United States.

3.3 Standards for pathogens, impurities and weeds content in compost

<u>Pathogens</u>

Much has been done to minimise the potential transmission of pathogens by waste through effective treatment processes and then matching efficiency of pathogen removal to operational restriction on application practices and land use. For solid wastes, the most important factor influencing pathogen die-off rate is the couple time-temperature during the treatment process.

All countries with statutory standards in place, with the exception of the Netherlands, where only a limited version exists, have testing criteria in place for the content of pathogens (see Table 9). Pathogen testing usually involves testing for the presence of specific micro-organisms, such as Salmonella and fecal coliform. Voluntary systems also often have such tests in place (Sweden, Netherlands, United Kingdom, Canada, Australia and, indirectly, New Zealand). These tests support the process-oriented ‘temperature–time’ regimes in seeking to ensure a hygienic product. In most of the countries surveyed a combination of a specified temperature–time regime and end product tests (typically using Salmonella spp and Escherichia coli) is used to guarantee sanitisation. There is no clear agreement on the regime, though a degree of convergence exists as shown in Table 7

Table 7: Temperature / Time regime for sanitization

Country	Minimum Temperature °C	Days
Austria		
Belgium	60	4
Denmark	55	14
France	60	4
Germany Biowaste Ordinance for	55	14

Compost	60 (in-vessel	7
	65 (not in-vessel)	7
Italy	55	3
The Netherlands	55	4
Sweden	55-77, depending on compost/digestion plant and risk potential of material	
UK Composting Association	60 (to be 'aimed for'but not required)	There is a time period for composting, but not related to the temperature attained
Canada (CCME)	55	3 in-vessel 15 for windrow 3 for aerated static pile
USA	55	5 in vessel 15 for windrow
Australia	55	3 requirements for three turns of windrow with internal temp reaching 55 for 3 days before each turn
New Zealand	55	3
EU working document on biowaste 2nd Draft	55 windrow composting	14 (5turns)
	65 windrow composting 60 in-vessel composting	1 week (2 turns)

Impurities

When developing an industry standard for compost quality, the presence of foreign matter in compost should be taken into consideration since it has a negative impact on consumers and on the composting industry in general. The consumers look for compost free of visible foreign matter or otherwise harmful foreign matter.

Testing for the presence of impurities is also necessary. All countries with standards have such a standard in place, with the exception of the US EPA standard as shown in Table 9. The standards allow for greater content of impurities in the form of stones than for plastic and glass. Table 8 presents the the classification of compost according to the level of impurities in compost as has been laid down by the second working document on Biological Treatment of Biowaste.

Table **8:** Impurities standards for compost and stabilised biowaste

Parameter	Compost Class 1*	Compost Class 2*	Stabilised Biowaste*
Impurities >2mm	<0.5%	<0.5%	<3%
Gravel and stones >5mm	<5%	<5%	-

Weeds

In respect of the presence of weeds, there is not such a uniform picture. Those countries with the most developed systems – Austria and Germany – have such a standard on a statutory basis, as does Belgium/Flanders and other regions of Belgium. Sweden, the Netherlands, Denmark and the UK each have voluntary standards in place.

Table 9: Requirements concerning pathogens, impurities and weeds

	Presence of pathogens	Presence of impurities	Presence of weeds
Austria	Statutory, dependent on area of application	Statutory, impurities >2mm, agric: max. 0.5%; non food: max. 1.0%	Statutory, horticulture/ hobby gardening/sacked compost: max. 3 plants/litre (germination test)
Belgium Flanders	Statutory, indirect process control	Statutory, stones >5 mm, max. 2%, impurities >2mm, max. 0.5%	Statutory, no weed seeds allowed (germination test)
Belgium Waloonia	Statutory, indirect process control	Statutory, stones >5 mm, max. 2%, impurities >2mm, max. 0.5%	Statutory, no weed seeds allowed (germination test)
Belgium Brussels	Statutory, indirect process control	Statutory, stones >5 mm, max. 2%, impurities >2mm, max. 0.5%	Statutory, no weed seeds allowed (germination test)
Denmark	Statutory	Statutory plastic, metal, glass portion >2 mm may not exceed 0.5% weight in dm	Voluntary 3 content levels: Very low (<0.5 seeds and plant parts/1), Noticeable content (0.5-2/1), Large content (>2/l)
Finland	Only remark may not contain to a harmful extent	Statutory: max 0.5% fin	No
France	Statutory no harmful micro-organisms which may endanger man, animals or the environment	Yes	No
Germany	Statutory process and product tests	Statutory, 0.5% weight/dm plastic, glass, metal; stones >5mm <5% weight statutory	Statutory, germinating seeds and sprouting plant parts must be more or less absent (<0.5 plants/1 compost for potting compost)
Greece	Statutory no Enterobacteria should be detectable	Plastic <0.3%dw; glass <0.5%dw	No
Ireland (licensing)	(under licensing regime) for human and plant pathogens	<1.5% of >25 mm in dry matter	No
Italy	Statutory	Statutory, plastics (mesh size <10 mm): <0.5% weight/dm; Inert materials (mesh size<10mm):<1% weight/dm Inert materials (mesh size >10mm): absent	Statutory, Fertiliser Law requires weed seeds to be absent Old Decree weed seeds absent in 50g
Luxembourg (licensing)	Statutory process test and product test	Statutory, plastic, glass, metal (>2mm) <0.5% weight/dm; stones (>5mm) <5% weight dm	Statutory, maximum 2 seeds/litre
Netherlands	Voluntary product tests	Voluntary, glass (>2mm) <0.2% dm, stones (>5mm) <2% dm, glass (>16m) absent	Voluntary, max 2 germinating seeds and sprouting plant parts per litre
Portugal	No	No	No

	Presence of pathogens	Presence of impurities	Presence of weeds
Spain	Statutory product test	Statutory, plastic particles and other inerts must not be over 10 mm	Statutory, Yes
Sweden	Voluntary product test	Voluntary, plastics, glass and metals (>2mm) <0,5% dm	Voluntary, 82 per litre
UK	Voluntary, Salmonella spp must be absent in 25gr fresh mass, Escherichia coli upper limit is 1000 $CFUgr^{-1}$	Voluntary, For total glass, metal, plastic and any 'other' non-stone fragments >2mm the upper limit is 0.5 % m/m 'air-dry' sample of which 0.25 is plastic. For stones>4mm in grades other than 'mulch' the upper limit is 8% m/m 'air-dry' sample while for stones>4mm in 'mulch' grades the upper limit is 8% m/m 'air-dry' sample	Voluntary, Germinating weed seeds or propagules regrowth upper limit is 0 mean number per litre of compost
Canada	**CCME** (Statutory) Specific temperature – time regime for yard waste according to the composting technology used. (I) Compost resulting from yard waste must acquire: Fecal coliforms < 1000 MPN / g of total solids calculated on a dry weight basis, AND No Salmonella sp. with a detection level < 3 MPN / 4g total solids calculated on a dry weight basis. (II) Compost resulting from all organic waste except yard waste must acquire: Fecal coliforms < 1000 MPN / g of total solids calculated on a dry weight basis, OR No Salmonella sp. with a detection level < 3 MPN / 4g total solids calculated on a dry weight basis. **BNQ** (Voluntary) set limits for faecal coliforms and absence of Salmonellae	CCME (Statutory) and BNQ (Voluntary) foreign matter defined as any matter over a 2 mm dimension that results from human intervention and having organic or inorganic constituents such as metal, glass and synthetic polymers (e.g. plaslic and rubber) that may be present in the compost but excluding mineral soils, woody material and rocks.). Three classes specified in terms of % oven-dried mass	No
USA	Statutory - product test	No	No
Australia	Through state or federal guidelines on biosolids	Voluntary – Glass, metal and rigid plastics >2 mm 50.5%dm; Plastics — light, flexible or film >5 mm, 80.05% dm**;** Stones and lumps of clay 85% dm Suppliers and their customers are advised lo agree upon an acceptable maximum level of visual contamination by light weight plastic	No
New Zealand	Voluntary - not explicitly set only through cross-reference to DoH regulations	100% passes through 15mm x 15mm orifice	No

3.4 Other compost characteristics

3.4.1 Stability/maturity standards for compost

Compost stability/maturity is increasingly recognised as an important characteristic. In specific situations, immature, poorly stabilised composts may be problematic. Continued active decomposition when these composts are added to soil or growth media may have negative impacts on plant growth due to reduced oxygen in the soil-root zone, reduced available nitrogen, or the presence of phytotoxic compounds. Consequently, tests have been developed to evaluate the maturity of compost materials. It should be mentioned, however, that no clear agreement on the best approach exists.

Compost maturity and stability are often used interchangeably. However, they each refer to specific properties of these materials. There have been and will continue to be efforts to develop and refine methods which evaluate stability and maturity, but no one universally accepted and applied method exists.

Stability refers to a specific stage or decomposition or state of organic matter during composting, which is related to the type of organic compounds remaining and the resultant biological activity in the material. The stability of a given compost is important in determining the potential impact of the material on nitrogen availability in soil or growth media and maintaining consistent volume and porosity in container growth media. Most uses of compost require a stable to very stable product that will prevent nutrient tie up and maintain or enhance oxygen availability in soil or growth media.

Maturity is the degree or level of completeness of composting. Maturity is not described by a single property and therefore maturity is best assessed by measuring two or more parameters of compost. Maturity is in part, affected by the relative stability of the material but also describes the impact of other compost chemical properties on plant development. Some immature composts may contain high amounts of free ammonia, certain organic acids or other water-soluble compounds which can limit seed germination and root development. All uses of compost require a mature product free of these potentially phytotoxic components.

Many countries have in place some form of measurement for stability within the domain of statutory or voluntary standards. These are shown in Table 10.

Table 10: Product stability tests in place

	Stability/Maturity test
Austria	As the only maturation parameter the cress test requires a minimum performance of Lepidiu sativum grown over a period of about 9 days. Parameters measured are biomass, germination rate and delay of germination.
Belgium Flanders	Statutory' - nitrate-ammonium ratio >1 for biowaste compost - this is expected to be changed to a stability degree of ´Rottegrad IV´[1].
Denmark	Voluntary - the degree of stability (on product sheet) is designated as either not-ready, fresh, stable or very-stable, and shall as a minimum be calculated on the basis of the analytical methods 'total oxygen demand in 96 hours' and the 'Solvita' compost test.
Germany	Voluntary, Rottegrad (degree of decomposition) [1].
Luxembourg	Statutory, Rottegrad (degree of decomposition) [1].
Netherlands	Voluntary, Rottegrad (max. temp, recording) [1].
Sweden	Voluntary self-heating or Solvita test.
UK	Method Microbial respiration rate. Upper limit 16mg CO_2/gr organic matter per day
Canada	<u>BNQ:</u> a compost is considered mature if it meets two of the following requirements: • C/N ratio < 25; • Oxygen uptake rate < 150 mg 02/kg volatile solids per hour; and • Germination of cress (Lepidium sativum) seeds and of radish (Raphanus sativus) seeds in compost must be greater than 90 percent of the germination rate of the control sample, and the growth rate of plants grown in a mixture of compost and soil must not differ more than 50 percent in comparison with the control sample. <u>CCME</u>: compost must be cured for a minimum of 21 days and meet one of the following three requirements: a) the respiration rate is less than, or equal to, 400 milligrams of oxygen per kilogram of volatile solids (or organic matter) per hour; or, b) the carbon dioxide evolution rate is less than, or equal to, 4 milligrams of carbon in the form of carbon dioxide per gram of organic matter per day; or, c) the temperature rise of the compost above ambient temperature is less than 8 °C .
Australia	Voluntary, none, but self-heating recommended.
New Zealand	Voluntary, testing of the following: pH, conductivity, nitrate, ammonium, maximum particle size[2]

1 The Rottegrad test can be regarded as a particular form of self-heating test.
2 Note several of the other standards include measurements such as these in addition to the tests for stability listed in this table – in most countries, we have concentrated on direct stability tests.

In the United States, there is no one standard approach to assessing stability/maturity. In recent work by the California Compost Quality Council (CCQC) in conjunction with the California Integrated Waste management Board (CIWMB), Woods End Laboratory and other peer-reviewers, maturity has been defined as the degree of completeness of composting. This is in contrast to earlier definitions used in America, and indicates that maturity is no longer viewed as a single property that can be tested for separately. Maturity must be assessed by measuring two or more parameters of compost, after the C:N ratio has been measured. The system proposed in California is as in Table 11.

Table 11: CCQC proposed compost parameter tier system to determine maturity index

Step 1: Measure Carbon Nitrogen Ratio (C:N)	
Step 2: If C:N <25, proceed to one each of A and B	
Group A parameters (select one)	**Group B parameters (select one)**
Respiration:	1. Ammonium: Nitrates Ratio (NH_4^+:NO_3^-)
1 CO2-evolution (includes lab CO2 or Solvita test)	2. Ammonia concentration (inc. Solvia ammonia)
2. O2-uptake	3. Volatile Organic Acids
3. Dewar Self Heating Test	4. Plant Test

According to Table 11 compost must first have a Carbon to Nitrogen (C:N) ratio of less than or equal to 25 in order to be rated as acceptable prior to additional maturity rating from results of tests in Group A and B. Then analyses of the compost is performed in one or more parameters listed in each of the two groups and the end product is rated based on the CCQC Compost Maturity Index as very mature, mature and immature based on the characteristics presented in Table 12.

Table 12: Compost Maturity Index as has been set by the California Compost Quality Council (CCQC)

Very mature	Mature	Immature
Well cured compost	Cured compost	Uncured compost
No continued decomposition	Odor production not likely	Odors likely
No odors	Limited toxicity potential	High toxicity potential
No potential toxicity	Minimal impacts on soil N	Significant impact on soil N

Apart for the stability/maturity standards the CIWMB has also set a range of compost quality standards for finished compost which are attached in Annex 3.

In Australia the maturation grade is measured by the degree of remaining putrscible organic material. The Australian Standard (AS4454 -2003) states that compost must comply with the reheat test to be classified as mature compost. The reheat test measures the ability of the material to compost itself after processing as a function of an increase in temperature resulting from the biological activity of the remaining biodegradable material.

3.4.2 Phytotoxicity standards for compost

The issue of stability is partly related to that of phytotoxicity. Usually, mature composts are less likely to cause problems for plant growth. Hence, the use of plants to indicate compost maturity is used in some countries (see Austria in Table 10). Other countries also have bio-assay tests to test for phytotoxicity. Others have tests for the presence of plant pathogens. The countries with standards in place are Austria, Germany, Italy, Luxembourg, the Netherlands, UK, Australia and New Zealand. All of the standards on phytotoxicity, with the exception of that in Italy, rely on some form of plant growth test. This may be a measurement of germination/growth using compost, or measurement of performance relative to a reference potting mix. In Italy and the Netherlands, the compost is assessed for potentially harmful organisms. These are, in the Netherlands, nematodes, Rizomanie virus, and Plasmodiophora brassicae, and in Italy, nematodes, cestodes and trematodes. Annex 4 shows how in New Zealand a seed germination test is assessed to detemine the phytotoxicity in compost samples.

4 Standards on compost end use

As in the case of end product standards, the regulations and standards for compost use vary considerably across countries. There are countries where compost use is included in a dense net of different regulations (Germany, Austria), and then there are countries where compost can be used without any legal directions (Sweden). These differences are partly a consequence of the history of these countries and partly relate to the stage of development with respect to organic waste treatment of the country concerned. For this reason this section will demonstrate standards of compost end uses (statutory or voluntary) from countries which have extensively exercised composting and have the benefit of several years experience in composting operation and marketing such as Austria and Germany while standards of compost uses from countries where composting market is developing, such as UK, Canada, Switzerland and Australia, will be also described. The aim is to present different compost end use specifications from countries acquiring different compost market development based on which potential users e.g. Moroccan authorities may benefit.

4.1 Compost application in Austria

Austrian Ordinance on quality requirements of composts from wastes (Compost Ordinance, FLG II Nr. 292/2001) enacted 1st September 2001with a transition period until 1 April 2002 has become the central and comprehensive legal instrument laying down standardised, nationwide rules concerning the production, marketing and labelling of compost as a product. It defines different quality classes of compost and includes detailed rules on the raw materials that are introduced into the product, exact specifications on safeguarding the quality of the finished product and labelling requirements for compost ensuring that the consumer is provided with specific information on how to use the compost in a safe and environmentally sound way.

The Compost Ordinance not only refers to the compost produced from separately collected biowaste (organic waste), but also to compost obtained from sewage sludge and from municipal solid waste (after removal of harmful waste materials).

The ordinance defines three different quality classes for compost based on the contaminant content:

- Class A+ (top quality; limit values taken from Council Regulation (EEC) No. 2092/91 on organic farming (Eco-agric)
- Class A (high quality; suitable for use in agriculture)
- Class B (minimum quality; suitable for non-agricultural use)

Due to the extremely low permitted values for individual parameters (e.g. nickel), it is very difficult to achieve Class A+ standards. However, this is the class, which must be achieved by farmers running organic farms in keeping with Council Regulation (EEC) No. 2092/91 on organic production of agricultural products and indications referring thereto on agricultural products and foodstuffs. Compost produced from separately collected biowaste generally achieves Class A quality. Class B quality can be achieved by the use of suitable sewage sludge.

Table 13: Maximum heavy metals concentration for composts and sewage sludge as input material (mg/kg d.m.)

Regulation	Cd	Crtot	Cu	Hg	Ni	Pb	Zn
Compost							
Quality Class A+ (organic farming)	0.7	70	70	0.4	25	45	200
Quality Class A (agriculture; hobby gardening)	1	70	150	0.7	60	120	500
Quality Class B (land reclamation)	3	250	400/500*	3	100	200	1200/1800*
Sewage sludge							
for quality sludge compost	2.0	70	300	2.0	60	100	1200
for compost	3.0	300	500	5.0	100	200	2000

* guide / limit value for Cu and Zn; if the guide value in the compost is exceeded the concentration has to be indicated in the labelling

Basically compost must be labelled as "Compost". In order to mark composts processed from high quality source materials, the ordinance allows the following terms:

- Quality Compost, suitable for use according to Council Regulation (EEC) No. 2092/91 'on organic production of agricultural products and indications referring thereto on agricultural products and foodstuffs (compost must be at least class A+ quality and produced from separately collected organic waste)
- Quality Compost (compost of at least class A quality, produced from separately collected organic waste)
- Quality Sewage Sludge Compost (compost of at least class A quality, produced from good quality sewage sludge and separately collected organic waste)
- Bark Compost (produced exclusively from bark)

Compost derived from non-hazardous household waste and similar commercial waste is to be labelled as municipal solid waste compost. The areas in which municipal solid waste compost may be used are restricted (landfill surface cover or biofilter). Municipal solid waste compost cannot be marketed freely but must be transferred from the producer directly to the user.

The admissible compost designation in the labelling and the area where the compost may be applied depends on the category of input materials used as well as on the applicable quality class (heavy metals). The basic system in Austria is shown in Table 14

Table 14: System of compost indication, quality classes, input category and area of application in Austria

Input Category		Quality Class (heavy metal class) A+	A	B
Only Category 1 *'Biowaste'*	*Designation*	**Quality Compost** *"suitable for organic farming acc. To 2092/91 EEC"*	**Quality Compost**	**Compost**
	*Application area***	any	agriculture ~~organic farming~~°	landscaping ~~agriculture~~°
Category 1 and 2 *(incl. sewage sludge)*	*Designation*	**Compost** or **Quality - Sewage Sludge-Compost** *	**Compost** or **Quality - Sewage Sludge-Compost** *	**Compost**
	*Application area***	agriculture ~~organic farming~~°	agriculture ~~organic farming~~°	landscaping ~~agriculture~~°
Only Category 3 *MSW Compost*	*Designation*	**MSW Compost**	**MSW Compost**	**MSW Compost**
	*Application area***	reclamation of landfill sites; biofilter; ~~agriculture~~		
Only Bark	*Designation*	**Bark Compost**	**Bark Compost**	**Bark Compost**
	*Application area***	any	agriculture ~~organic farming~~°	landscaping ~~agriculture~~°

*…The designation QUALITY-SEWAGE SLUDGE COMPOST is admissible, if the lower heavy metal limits for sludge of Table A2- 6 is achieved
**...only those application areas are indicated which require the highest degree of quality
° crossed out applications are not permitted to be used for the indicated compost qualities

Moreover the general application areas (agriculture, landscaping, reclamation on landfill sites, biofilter and constituents in substrates/manufactured soils) are split into several application cases for which specific restrictions for the use may apply (e.g. on maximum content of plastics, glass and other unwanted substances, hygiene, electrical conductivity, etc.). All other material is classified as waste and remains waste whatever is done with it (and it is subject to landfill taxes etc.).

4.2 Compost application in Germany

German ordinances

In Germany the Biowaste Ordinance (BioAbfV) from 1998 is the legal piece of work that covers the application of treated and untreated bio-wastes and mixtures on land used for agricultural, silvicultural and horticultural purposes as well as suitable raw material, quality and hygiene requirements, treatment and investigations of such bio-wastes and mixtures. Suitable raw material for composting are mentioned in annex 1 of the biowaste ordinance including the following groups of organic waste materials: separately collected biowaste from households, park and garden waste, residues from the food and animal feed industry and mineral composting additives. Heavy metal contents, harmful substances, hygiene aspects are pesented in annex 2 of the ordinance and sample taking and analysis in annex 3. The Biowaste Ordinance regulates - with a precautious intention - the waste side (e.g. heavy metals) of the application, where as the Fertiliser Law regulates the nutrient part. As has been mentioned in the early pages of this work compost standards can either establish a basic platform in that they lay down basic requirements e.g. heavy metal limits, or they can be an extensive framework as in the case of the Biowaste Ordinance in Germany where source-separation, collection, treatment, analysing, monitoring and application requirements are laid down so that the statutory standard covers the whole biological waste management cycle.

With respect to the Biowaste Ordinance composts (excluding sewage sludge compost) that fulfil the quality criteria presented in Table 15 can be applied on land for agricultural, silvicultural and horticultural purposes.

Table 15: German minimum criteria for compost application in agriculture, silviculture and horticulture (excluding sewage sludge compost)

Heavy Metal	Biowaste ordinance (Class I)	Bio waste ordinance (Class II)	Presence of pathogens	Presence of impurities	Presence of weeds
Cd	1	1.5	Statutory process and product tests	Statutory, 0.5% weight/dm plastic, glass, metal; stones >5mm <5% weight statutory	Statutory, germinating seeds and sprouting plant parts must be more or less absent (<0.5 plants/1 compost for potting compost
Cr	70	100			
Cu	70	100			
Hg	0.7	1			
Ni	35	50			
Pb	100	150			
Zn	300	400			

In Germany the sewage sludge ordincance sets the conditions according to which sewage sludge composting can be sefaly applied on land. According to the ordinance on sewage sludge, it is prohibited to apply sewage sludge composts for agricultural or horticultural purposes when sewage sludge and additives used prior to mixing as well as the produced composts or mixtures exceed the values given in Table 16. The parameters involved in setting the quality criteria for sewage sludge compost applications include the concentration of organic pollutants and heavy metals.

Table 16: German minimum criteria for sewage sludge compost application

Parameter	Unit	Maximum Value
PCBs		
2,4,4'-Trichlorobiphenyl	mg/kg of sludge dry matter	<0.2
2,4,4'-Trichlorobiphenyl	mg/kg of sludge dry matter	<0.2
2,2',5,5'-Tetrachlorobiphenyl	mg/kg of sludge dry matter	<0.2
2,2',4,5,5'-Pentachlorobiphenyl	mg/kg of sludge dry matter	<0.2
2,2',3,4,5,5'-Hexachlorobiphenyl	mg/kg of sludge dry matter	<0.2
2,2',4,4',5,5'-Hexachlorobiphenyl	mg/kg of sludge dry matter	<0.2
2,2',3,4,4',5,5'-Heptachlorobiphenyl	mg/kg of sludge dry matter	<0.2
Decachlorobiphenyl	mg/kg of sludge dry matter	<0.2
PCDD/PCDF [1]	ng TCDD/kg of sludge dry matter	<100
AOX [2]	mg/kg of sludge dry matter	< 500
PTEs - Heavy metals		
Lead	mg/kg of sludge dry matter	<900
Cadmium	mg/kg of sludge dry matter	<10, 5*
Chromium	mg/kg of sludge dry matter	<900
Copper	mg/kg of sludge dry matter	800
Nickel	mg/kg of sludge dry matter	200
Mercury	mg/kg of sludge dry matter	8
Zinc	mg/kg of sludge dry matter	2500, 2000*

[1] PCDD/PCDF: polychlorinated dibenzodioxins/dibenzofurans
[2] AOX: halogen organic compounds
*In the case of soils classified as light soils whose clay content is < 5% or the pH value is 5<x<6.

Sewage sludge composts may be applied within a period of 3 years at a rate of up to 10 tonnes of dry matter per hectare. The ordinance poses also a level of tolerance to the limit values by allowing sewage sludge composts to be applied in cases when heavy metals and organic pollutants exceed by one half the set limits.

Voluntary Standards RAL Quality Assurance System

During the last 20 years numerous companies have undertaken considerable and successful efforts in order to open necessary markets for compost in Germany. Contrary to other branches the compost industry is a branch which is not only profitable on account of their product sales but also on the treatment of biowaste. Compost and digestate products are produced from separately collected biodegradable waste materials. For the composting industry, which is preponderantly organised by the private and municipal waste industry in Germany, it was necessary to undertake a lot of efforts to provide consumer confidence for these secondary waste derived products.

In order to achieve this target the producers of compost and the marketing enterprises have founded in 1989 the Quality assurance organisation “Bundesgütegemeinschaft Kompost e.V. (BGK)”. BGK is recognised by RAL, the German Institute for Quality Assurance and Certification, as being the organisation to handle monitoring and controlling of all quality labels in Germany. The ‘RAL Compost Quality Label’ (RAL GZ 251) was awarded in January 1992. It was also registered in the trade mark register at the Federal Patent Office. In 2007 the RAL GZ 245 for digestion products and the RAL GZ 246 for digestion products produced from renewable energy crops was introduced while an additional quality assurance system for sewage sludge compost (RAL GZ 258) was set. Figure 3. The quality assurance system of BGK contains the definition of quality requirements, enables quality monitoring, and can enforce quality standards or discipline plants for failure to meet regulations and labelling of the quality standard. Today RAL-quality assured compost is the most analysed and documented soil improver and organic fertiliser in Germany which guarantee an environmental sound and successful use for soil improving and fertilising purposes.

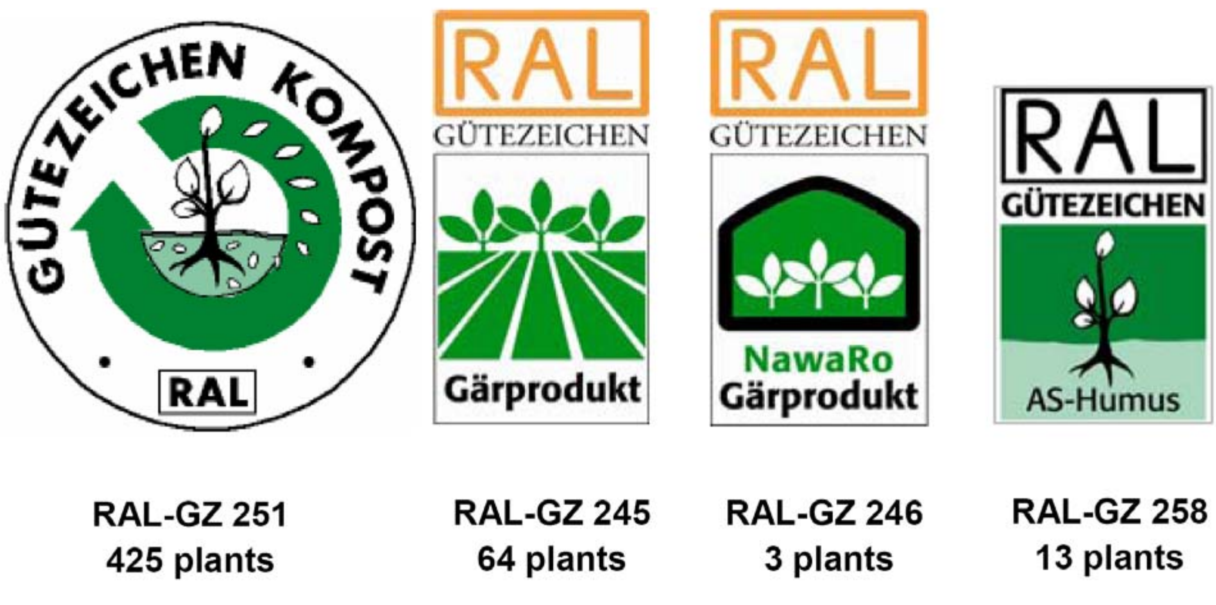

Figure 3: RAL quality assurance labels for compost and digestate products in Germany 2007

The importance of Quality Assurance Systems (QAS) for compost is that it is strongly connected with marketing of the product. Marketing of compost requires a standardised quality product. Composts which have been quality-tested in accordance with the procedures stipulated by the QAS fully meet these requirements and can be marketed under a ‘quality label’ brand.

The main elements of the BGK QAS for compost are process requirements for operation quality, product quality and application requirements.

Quality requirements for compost: The main requirements which describe the quality of compost are suitable input materials, process requirements and valuable and environmental product criteria. Compost types are defined according to their application fields.

Input materials for compost: Suitable raw materials for compost are listed in Annex 1 of the German Biowaste Ordinance (BioAbfV, 1998). The RAL quality composts are based to 98 % on separately collected biowaste from households as well as park and garden waste.

Process requirements: As a general rule the producers as well as the parties responsible for waste management should treat the biodegradable material in such a way, that the safety for use in terms of human, animal and plant health is guaranteed. The process requirements are laid down in the German Biowaste Ordinance (BioAbfV, 1998) and include following elements:

- Direct process validation (dumping and retrieval of test and indicator organisms)
- Indirect process supervision (continous temperature management)
- Final product analysis in respect to hygenic aspects (Salmonella and germinative seeds and reproducible plant parts).

Types of compost products: According to this quality standard compost producers today are producing and selling the following compost products:

- Fresh compost: a fractioned and hygienic decomposed material that is still in a decomposition process or is able for being intensively decomposed for soil improvement and fertilization. Fresh compost corresponds to a decomposition degree of II or III.
- Mature compost: hygienically and biologically stabilised and fractioned compost for soil improvement and fertilization. Mature compost has a decomposition degree of IV or V.
- Compost for potting soils: is a special mature compost with limited contents of soluble plant nutrients and mineral salts, suitable as mixing component for growing media.

The quality assurance of bio-wastes according to the German Institute for Certification and Standardization (RAL) system, concerning the persistent pollutant problematic, and the generation of a compost product with a constantly high, externally-monitored quality, has been proven successful for marketing purposes during more than 10 years. Based on this positive experience, a quality assurance system for sewage sludge compost was introduced in Germany recently (RAL GZ 258). The RAL GZ 258 for AS Humus (sewage sludge compost) was introduced in 2003. The aim is to generate goods with product status for the agricultural utilization. Advantages are:

• Defined high qualities

• Voluntary monitoring by independent organizations

• Improvement of the image and acceptance (marketing aspects)

• Specifications for use

The VGVA e.V. (Association for Quality Assurance of Sewage Sludge Products) has taken the task to assure the quality of compost and soils made of sewage sludge, in order to ensure their place within the closed loop waste management. Together with the German Compost Quality Assurance Organization (BGK), the VGVA, also member of the BGK, developed and presented in a proposal for quality assurance to the German Institute for Certification and Standardization, quality and test determinations with the purpose of documenting the product's quality of member companies. The RAL-quality label GZ 258 "AS-Humus" for products from waste water sludge has been confirmed by the RAL-Institute.

The manufacturers produce quality assured products (compost) with a defined quality. With the quality assurance for sewage sludge compost, the VGVA has proposed together with the German Compost Quality Assurance Organization (BGK) a voluntary quality control with much higher standards with respect to the current Sewage Sludge Ordinance. In order to obtain the desired product quality, the aerobic treatment of waste water sludge is required. The composted sewage sludge (AS-Humus) has to satisfy further special hygienic demands. A certain sanitation grade is additionally demanded, comparable to the sanitation in the bio-waste ordinance that provides continuous indirect process tests (temperature/time reports) and direct process tests of the treatment process employed in each case.

Threshold limiting values of the current Sewage Sludge Ordinance are halved, and in the case of heavy metals, also quartered. Additionally, a permanent quality improvement is necessary:

Due to possible contents of organic pollutants the analytical requirements are much stricter than those of the current sewage sludge ordinance (Table 16). These do not only concern dioxins/furans and PCBs, but also materials such as LAS (linear alkylbenzolsulphonate), DEHP (Di(2-ethylhexyl)phthalat), NPE (nonylphenol and NPethoxylate) and PAH. It has to be noted that many organic pollutants can be degraded by aerobic processes.

Composts of sewage sludge that comply with the demands of the new quality assurance "AS-Humus" are high quality soil improvement and fertilizing agents. Through quality assurance, the BGK and VGVA present a concrete example of how the material utilization of sewage sludge can be promoted.

4.3 Compost application in Australia

The "Australian Standards for Compost, soil conditioners and mulches" applies to organic products as well as to mixtures of organic products being used to improve physical and chemical properties of soils and vegetation. The standard is applicable for pasteurized3 or composted organic products. The Australian relevant compost standards are summarized in Table 17. There are three main sets of requirements for the product according to the standard and are based on physical contamination, pasteurization requirements and maturity of the compost.

Table 17: Physical and chemical requirements for biowaste (compost, mulches and soil conditioners)

Parameter	**Unit**	**Requirements**	
		Soil conditioners and fine mulch	Mulch
Nitrate – N	mg/lt in extract	≥10 if a contribution to plant nutrition is claimed	≥10 if a contribution to plant nutrition is claimed
Wettability	Minutes	< 7 for the <16mm fraction only	< 7 for the <16mm fraction only
Toxicity	mm	≥60 for all products except those labelled as manure or mushroom substrate, for which the EC criteria are more appropriate	No requirements
Chemical contaminants (includes PTEs), organic contaminants and pathogens		To comply with national or state guidelines whichever is the most the restrictive (see Table 20)	To comply with national or state guidelines whichever is the most the restrictive (see Table 20)
Self heating	^{o}C	≤40	No requirements
Plant propagules		-	-
Glass, metal and rigid plastics >2mm	% dry matter (w/w)	≤0.5	≤0.5
Plastics – light, flexible or film	% dry matter (w/w)	≤0.05	≤0.05

[3] Temperature/time regime during composting

>5mm			
Stones and lumps of clay ≥ 5mm	% dry matter (w/w)	≤5	≤5

* Suppliers and their customers are advised to agree upon an acceptable maximum level of visual contamination by light weight plastic

The National Water Quality Management Strategy (NRMMC) sets the Australian national guidelines and framework for the management of biosolids. The framework's classification system includes seven categories for biosolids application which are listed below:

- All land application uses, including residential;
- Agriculural;
- Institutional landscaping – recreational;
- Institutional landscaping – non recreational;
- Forestry, land rehabilitation;
- Municipal landfill;
- Controlled landfill or thermal processing

Factors such as stabilization grade and chemical contaminant levels determine category affiliation. The four stabilization grades, presented below are based on reduction in pathogens loads and controls to avoid attraction of vectors.

Grade P1: Very low pathogen levels with minimum regrowth potential
Grade P2: Low pathogens levels but with some pathogen regrowth potential
Grade P3: Established processes that achieve significant pathogen reduction
Grade P4: Minimum pathogen reduction

The contaminant considered are nine PTEs and persistent organic compounds (POPs) as listed in Table 18. These guideline contaminant values are to be used where Australian State/Territory guidelines are unavailable. The contaminant grade criterion is also used as soil contaminant ceiling concentration limits.

Table 18: Biosolids contamination grade values (mg/kg)

Parameter	Grade C1 – unrestricted use	Grade C2 – maximum level
PTEs - Heavy metals		
Arsenic - As	20	60
Cadmium - Cd	1	20
Chromium - Cr III	100-400	500-3000

Copper - Cu	100-200	2500
Lead -Pb	150-300	420
Mercury - Hg	1	15
Nickel - Ni	60	270
Selenium - Se	3	50
Zinc - Zn	200-250	2500
Organic compounds		
DDT/DDD/DDE	0.5	1
Other POPs	0.02-0.05	0.5
PCB	0.05-0.3	0.5

Table 19 shows the permitted use of biosolids based on pathogens grades, chemical contaminant grades/level and maximum soil contaminant levels in accordance with the above classification system.

Table 19: Biosolids grading and uses in Australia

Allowable biosolids use	Pathogens grades	Chemical contaminant grade/level	Maximum soil contaminant levels
Unrestricted all appropriate uses including residential	P1	C1	C1
Agriculture (salad plants and root crops)	P2	C2	C1
Agriculture (Crops consumed cooked /processed, grazing animals, dairy cattle pasture and fodder)	P3	C2	C1
Institutional landscaping – recreational;	P1	C2	C1
Institutional landscaping – non recreational;	P3	C2	Subject to approval by the regulator on case by case basis
Forestry, land rehabilitation;	P3	C2	Refer to state guidelines and regulatios
Landfill not including landfill final surface rehabilitation	P4	N/A	N/A
Controlled landfill or other disposal option e.g. incineration	P4	N/A	N/A

An overview of contamination threshold for biosolids is provided in Table 20 including the national guidelines as well as state guidelines. In addition to the contaminant concentration thresholds, the permissible end use is also dependent on pathogens and stabilization grade. A summary of permissible uses in Australian states is given in Table 21.

Table 20: Contaminant thresholds for Australian biosolids and biosolids products (mg/kg dry matter)

	National[1]		New South Wales[2]				Victoria[3]		Western Australia[4]		South Australia[5]		Tasmania[6]	
	Grade C1	**Grade C2**	**Grade A**	***Grade B***	**Grade C**	**Grade D**	**Grade C1**	**Grade C2**	**Grade C1**	**Grade C2**	**Grade A**	**Grade B**	**Grade A**	**Grade B**
Arsenic	20	60	20	20	20	30	20	60	20	60	20	20	20	20
Cadmium	1	20	3	6	20	32	1	10	3	20	3	11	3	20
Chromium	100-400	500-3.000	100	260	500	600	400	3.000	100	500			100	500
Copper	100-200	2.500	100	376	2.000	2000	100(150)	2.000	100	2,5	200	760	100	1.000
Lead	150-300	420	160	160	420	500	300	600	150	420	200	300	160	420
Mercury	1	16	1	4	16	19	1	6	1	15	1	9	1	16
Nickel	60	270	60	126	270	300	60	270	60	270	60	145	60	270
Selenium	3	60	6	8	60	90	3	60	3	50			5	60
Zink	200-250	2.500	200	700	2.500	3.600	200(300)[7]	2.600	200	2,5	250	1.400	200	2.500
DDT/DDO/DDE	0.6	1	0.6	0.6	1.00	1.00	0.5	1	0.6 (total)	1 (total)			0,5	1.00
Organochlorine pesticides	0.02-0.05	0.6					0.06							
Aldrin			0.02	0.2	0.5	1.00			0.02	0.6			0.2	0.6
Dieldrin			0.02	11	0.5	1.00			0.02	0.5			0.2	0.5
Chlordane			0.02	0.2	0.6	1.00			0.02	0.6			*2*	0.6
Heptachlor			0.02	0.2	0.6	1.00			0.02	0.6			*2*	0.5
HCB			0.02	0.2	0.5	100			0.02	0.5			*2*	0.5
Lindane			0.02	0.2	0.6	1.00			0.02	0.5			*2*	0.5
BHC			0.02	0.2	0.5	1.00			0.02	0.5			*2*	0.5
PCBs	0.06-0.3	0.5	0.3	0.3	1.00	1.00	0.2	1	0.3	0.5			0.30	1.00

1) NRMMC. (2004). National Water Quality Management Strategy - Guidelines for Sewerage Systems - Biosolids Management.

2) NSW EPA. (1997) Environmental Guidelines Use and disposal of biosolids products.

3) EPA Victoria. (2004). Guidelines for Environmental Management. Biosolids Land Application.

4) WA OEP et al. (2002). Western Australian Guidelines for Direct Land Application of Biosolids and Biosolids Products.

5) SA EPA. (1997) South Australian biosolids guidelines for the safe handling, reuse or disposal of biosolids

6) Tasmania DPIWE. (1999) Tasmanian Biosolids Reuse Guidelines.

7) Higher limit values for biosolids products composted to AS 4454 "*Australian Standards for Compost, soil conditioners and mulches*"

Table 21: Permitted uses for biosolids with different contamination thresholds

Contamination Grade	National[(1)]	New South Wales[(2)]	Victoria[(3)]	Western Australia[(4)]	South Australia[(5)]	Tasmania[(6)]
C1/A	-Unrestricted all appropriate uses including residential	Unrestricted use -Home lawns and gardens -Public contact sites -Urban landscaping -Agriculture -Forestry -Soil and site rehabilitation -Landfill disposal -Surface land disposal	Unrestricted use -Human food crops consumed raw in direct contact with biosolids -Dairy and cattle grazing/odder (also poultry), human food crops consumed raw but not in direct contact -Processed food crops -Sheep grazing and fodder (also horses, goats), on food crops. woodlots -Landscaping (unrestricted public access) -Landscaping (restricted public access), forestry, land rehabilitation	-Unrestricted (suitable for public sale and distribution)	-Home Garden -Urban landscaping -Agriculture (non-irrigated) -Forestry -Site rehabilitation -Irrigated agriculture (EPA approval required)	-Home lawns and gardens -Public contact sites -Urban landscaping -Agriculture -Forestry -Land rehabilitation -Disposal at a waste depot or landfill
C2/B	-Agriculture (Salad plants and root crops. Crops consumed cooked/pfocessed. grazing animals, dairy cattle pasture and fodder) -institutional landscaping recreational -Institutional landscaping non recreational -Forestry and land rehabilitation (e.g. landfill, mine, quarry and degraded land rehabilitation) or sub surface application	-Public contact sites -Urban landscaping -Agriculture -Forestry -Soil and site rehabilitation -Landfill disposal -Surface land disposal	-Human food crops consumed raw in direct contact with biosolids -Dairy and cattle grazing/odder (also poultry), human food crops consumed raw but not in direct contact -Processed food crops -Sheep grazing and fodder (also horses, goats), on food crops. woodlots -Landscaping (unrestricted public access) -Landscaping (restricted public access), forestry, land rehabilitation	-Urban landscaping (not household use) -Horticulture -Agricultural direct land application (root crops) -Agricultural direct land application (not root crops) -Forestry direct land application -Mine-site rehabilitation	-Urban landscaping -Forestry -Site rehabilitation -Agriculture (EPA approval required)	-Agriculture -Forestry -Land rehabilitation -Disposal at a waste depot or landfill
C3 /C	-Landfill not including landfill final surface rehabilitation -Secure landfill or other disposal options e g. incineration etc	-Agriculture -Forestry -Soil and site rehabilitation -Landfill disposal -Surface land disposal	----	-Municipal landfill disposal -Secure landfill -Thermal processing (incineration, oil extraction, metal smelting or use in building products	-Agriculture (EPA approval required) -Forestry (EPA approval required) -Site rehabilitation (EPA approval required)	-Disposal at a waste depot or landfill
D	----	-Forestry -Soil and site rehabilitation -Landfill disposal -Surface land disposal	----	----	----	----
E	----	-Landfill disposal -Surface land disposal	----	----	----	----

4.4 Compost application in Canada

As has been mentioned in Canada, several organizations are involved in the development of standards and regulations for compost. In the area of compost and composting, Agriculture and Agri-Food Canada (AAFC) (through the Plant Products Division), the provincial and territorial governments (through the Canadian Council of Ministers of the Environment (CCME)), and the Standards Council of Canada (through the Bureau de Normalisation du Quebec (BNQ)) are all concerned with developing quality criteria. However only CCME has taken initiatives to ensure that compost products are tailored to specific end uses. CCME sets two compost categories, A and B, based on the end use of the compost material. Table 22 summarizes the requirements of each category according to the PTEs concentration and the compost incorporation of sharp or other foreign matter.

Table 22: Specifications of Canadian compost categories A and B

PTEs - Heavy metals	Cd	Crtot	Cu	Hg	Ni	Pb	Zn	As
Category A	3	210	400	0.8	62	150	700	13
Category B	20	-	-	5	180	500	1850	75
Sharp Foreign Matter								
Category A	Compost shall not contain any sharp foreign matter of dimension greater than 3 mm per 500 ml.							
Category B	Compost shall have a sharp foreign matter content less than or equal to three (3) pieces of sharp foreign matter per 500 ml, and the maximum dimension of the sharp foreign matter shall be 12.5 mm. However, this compost shall not be used in pastures, parks or for residential purposes.							
Other Foreign Matter								
Category A	Compost shall contain no more than one (1) piece of foreign matter greater than 25 mm in any dimension per 500 ml.							
Category B	Compost shall contain no more than two (2) pieces of foreign matter greater than 25 mm in any dimension per 500 ml.							

Category A - Unrestricted Use: This category includes compost that can be used in any application, such as agricultural lands, residential gardens, horticultural operations, the nursery industry, and other businesses. Category A criteria for trace elements are achievable using best source separated MSW feedstock or municipal biosolids, or pulp and paper mill biosolids, or manure.

Category B - Restricted Use: This category includes compost that has a restricted use because of the presence of sharp foreign matter or higher trace element content. Category B compost may require additional control when deemed necessary by a province or territory. It is specified that for a compost to meet the unrestricted use category, it must meet the unrestricted (Category A) requirements for all trace elements and sharp foreign matter. If the compost fails one criterion of the guideline for unrestricted use but meets the criteria for restricted (Category B) use, then it is classified as a Category B product. Products that do not meet the criteria for either Category A or B must be used or disposed of appropriately.

4.5 Compost application in Switzerland

The main ordinance pertaining to waste management is the "Ordinance on the Treatment of Waste" (Technische Verordnung über Abfälle, TVA) which among others prescribes the separate collection of the recyclable fractions of MSW and that home composting must be encouraged by the cantonal authorities. Therefore biowaste which cannot be privately disposed of must be collected separately and recycled in centralised facilities. Nevertheless the TVA guidelines and prescriptions have resulted in the development of incineration as the main treatment mode for MSW while the revised TVA resulted in banning the landfilling of all combustible material after the 01.01.2000. In consequence, efforts were directed towards changing the image of compost, from a waste product to a valuable resource. Encouraged by the federal authorities, the Association of Swiss Composting and Methanisation Plants (ASCP) has developed quality guidelines, an inspectorate and a label (Figure 4), aimed at guaranteeing high standards of quality, both for the process management and its products while defining specifications for compost application. These system constitutes the quality assurance system initiated in Switzerland and composts fulfilling the criteria that are laid down by ASCP are awarded with the label shown in Figure 4.

Figure 4: Label awarded to composts that are in accordance ASCP specifiations

In Switzerland the minimal quality requirements for a product to be considered as compost incorporate three parameters, the concentration of PTEs - heavy metals, the hygienization level and the impurities content as presented in Tables 23, 24 and 25 respectively.

Table 23: The limit values for heavy metals as defined in the Ordinance on Environmentally Hazardous Substances (mg/kg d.w.)

Parameter	Limit Value
Lead	<120
Cadmium	<1
Chromium	<100
Copper	<100
Nickel	<30
Mercury	<1
Zinc	<400

Table 24: Hygienization requirements for compost

Requirements	Comments
At least 3 weeks over 55°C	Valid for the entire windrow, including the edges
or at least 1 week over 65°C	Applies mainly to in-vessel composting
or another equivalent process which guarantees the same hygienization	Such as pasteurisation, steaming etc

Table 25: Impurities limit values in compost

Parameter	Limit Value	Comments
Stones >5mm diameter	50 mg/kg d.w	Smaller stones and sand are not considered impurities
Impurities such as metals, glass, plastics>2mm diameter	5 mg/kg d.w	
Plastics and aluminium sheeting >2mm diameter	1 mg/kg d.w	

Besides the aforementioned minimal quality requirements ASCP has laid down further specifications for composts destined for horticulture, market and private gardening, landscaping and covered cultures. These specifications aim to guarantee that compost can be used with no adverse impact on the environment or human health whilst underpinning end user confidence that the compost is fit for purpose. Therefore composts which are destined for horticulture, market gardening or landscaping must comply with the ASCP guidelines for physical, chemical and biological parameters individually shown in Table 26 while composts specifications destined for covered cultures and private gardening are shown in Table 27.

Table 26: Physical, chemical and biological requirements for composts destined for horticulture, market gardening or landscaping (ASCP guidelines)

Parameter	Limit Value
DW in % of fresh weight	> 50 %
OM in % of dry weight	< 50 %
pH	< 8.2
Particle size	< 25 mm
Density	X
Colour of extract (humus number)	A simple determination method still needs to be developed
Salinity	< 4 mS/cm

Total N	> 10 g/kg DW
C/N ratio	X
NH4-N	< 300 mg/kg FW
NO3-N	> 40 mg/kg FW
NO3-N / NH4-N	> 2
NO2-N	< 5 mg/kg FW
Weed seed germination test	< 1 per litre of compost
Plant compatibility tests	
Cress (open)	> 70 % of reference
Cress (close)	> 25 % of reference
Salad	> 50 % of reference

X: must be specified

The criteria presented in Table 26 were set taking into consideration the following conditions for compost application in horticulture, market gardening and landscaping:

- Composts must demonstrate better plant compatibility and must not lead to nitrogen fixation in the soil since large quantities as soil improvement agents are applied for the aforementioned cases.
- The older the compost, the more nutrients are bonded into stable humic substances and accomplish slow release of nutrients
- The stable humic substances and particularly developed aggregate structure of composts having undergone prolonged maturation make them especially adapted to sandy or heavy soils.

Table 27: Physical, chemical and biological requirements for composts destined for covered cultures and private gardening

Parameter	**Limit Value**
DW in % of fresh weight	> 55 %
OM in % of dry weight	< 40 %
pH	< 7.5
Particle size	< 15 mm
Density	X
Water Holding capacity	X
Colour of extract (humus number)	A simple determination method still needs to be developed
Salinity	< 2.5 mS/cm
Total N	> 12 g/kg DW
NH4-N	< 300 mg/kg FW
NO3-N	> 50 mg/kg FW
NO3-N / NH4-N	> 20
NO2-N	< 2.5 mg/kg FW
Weed seed germination test	< 1 per litre of compost
Plant compatibility tests	
Cress (open)	> 90 % of reference
Cress (close)	> 50 % of reference
Salad	> 70 % of reference
Bean	> 70 % of reference
Ray grass	> 70 % of reference
Disease suppressivity test	X

X: must be specified

The criteria presented in Table 27 were set taking into consideration the following conditions for compost application in covered cultures and private gardening:

- Composts used in covered cultures must both be of excellent quality and highly stable.
- Must show perfect plant compatibility (no phytotoxicity).
- A positive biological activity (measured as disease suppressivity potential) is desirable.

Moreover, given the very diverse needs of the users ACPS did not set requirements for composts intended for the production of potting soils. Finally ACPS allows compost to be applied in agriculture when composts:

- comply with the minimal quality requirements set in tables 23, 24 and 25
- acquire a decomposition level that the feedstock is not recognizable (with the exception of woody residues)
- NH4-N level is lower than 300mg/kg FW (fresh weight).

However ASCP notes that several other parameters must be specified and incorporated for the standardization of compost for its application to agriculture including the level of important nutrients (N, P2O5, K2O, Mg, Ca) the DW, % of organic matter, pH, particle size, bulk density salinity, Total N, NO3-N. Table 28 summarizes the compost requirements according to the final end use.

Table 28: Summary of compost requirements for its application according to ASCP quality standards

	Agriculture	**Horticulture, Market gardening or Landscaping**	**Covered cultures and Private gardening**
PTEs - Heavy metals	Table 23	Table 23	Table 23
Hygienization	Table 24	Table 24	Table 24
Impurities	Table 25	Table 25	Table 25
Nutrients N, P2O5, K2O, Mg, Ca	X	X	X
Decomposition level	Feedstock unrecognisable, except wood		
DW in % of fresh weight	X	> 50 %	> 55 %
OM in % of dry weight	X	< 50 %	< 40 %
pH	X	< 8.2	< 7.5
Particle size	X	< 25 mm	< 15 mm
Bulk density	X	X	X
Colour of extract (humus number)		Recommended	Recommended
Salinity	X	< 4 mS/cm	< 2.5 mS/cm
Total N		> 10 g/kg DW	> 12 g/kg DW
C/N ratio		X	X
NH4-N	< 300 mg/kg FW	< 300 mg/kg FW	< 300 mg/kg FW
NO3-N	X	> 40 mg/kg FW	> 50 mg/kg FW
NO3-N / NH4-N		> 2	> 20
NO2-N		< 5 mg/kg FW	< 2.5 mg/kg FW
Weed seed germination		< 1 per litre of compost	< 1 per litre of compost
Plant compatibility			
Cress (open)		> 70 % of reference	> 90 % of reference
Cress (close)		> 25 % of reference	> 50 % of reference
Salad		> 50 % of reference	> 70 % of reference
Bean			> 70 % of reference
Ray grass			> 70 % of reference
Disease suppressivity test			Recommended

X must be specified

4.6 Compost application in UK

In the UK, the British Standards Institution's "Publicly Available Specification for Composted Materials" (BSI PAS 100:2005) is the leading standard that compost producers choose to comply with. It was developed by the Composting Association, with support from the government's Waste and Resources Action Programme (WRAP). The BSI PAS 100:2005 sets out a minimum compost quality baseline in the UK, upon which composters should build as appropriate to the product types and markets targeted. It requires the producer to establish a quality policy and management system to ensure that the compost is fit for purpose. Inputs are restricted to source-segregated biodegradable materials and materials which are composted must be traceable. BSI PAS 100:2005 also requires that customers are provided with information about where the compost was made and guidance on storing, handling and using the compost. The leading industry standard for composted source-segregated biowastes, BSI PAS 100:2005, has become well known within the waste industry. Its sustained promotion by the Composting Association and WRAP has strengthened demand for quality composts in landscape. horticulture, agricultural and other markets.

Compost that meets the BSI PAS 100:2005 requirements will guarantee an appropriate and safe product ensuring that compost can be used with no adverse impact on the environment or human health whilst at the same time it underpins end user confidence that the compost will be fit for purpose. BSI PAS 100:2005 encourages this by requiring compost compliance with a minimum quality limits on stones, weed seeds and physical and chemical contaminants for compost application as shown in Table 29.

Table 29: Minimum compost quality for general use in UK according to the BSI PAS 100:2005

Parameter	Unit	Upper Limit
Pathogens (human and animal indicator species)		
Salmonella spp	25g fresh mass	Absent
Escherichia coli	CFU g^{-1} fresh mass	1000
Potential Toxic Elements		
Cadmium (Cd)	mg kg^{-1} dry matter	1.5
Chromium (Cr)	mg kg^{-1} dry matter	100
Copper (Cu)	mg kg^{-1} dry matter	200
Lead (Pb)	mg kg^{-1} dry matter	200
Mercury (Hg)	mg kg^{-1} dry matter	1.0
Nickel (Ni)	mg kg^{-1} dry matter	50
Zinc (Zn)	mg kg^{-1} dry matter	400
Stability / Maturity		
Microbial respiration rate	mg CO_2/g organic matter /day	16
Plant response		
Germination and growth test	Reduction in germination of plants in amended compost as % of germinated plants in peat control	20

	Reduction in mass above surface in amended compost as % of plant mass above surface in peat control	20
	Description of any visible abnormalities	No abnormalities
Weed seeds and propagules		
Germinating weed seeds or propagule regrowth	Mean number per litre of compost	0
Physical contaminants		
Total glass, metal, plastic and any 'other' non-stone fragments >2 mm	% mass/mass of "air-dry" sample	0.5 (of which 0.25 is plastic)
Stones		
Stones > 4mm in grades other than coarse mulch	% mass/mass of "air-dry" sample	
Stones > 4mm in coarse mulch grade	% mass/mass of "air-dry" sample	16

Part of effective competition with other products and materials, is to tailor compost quality to the needs of customers in the markets targeted and that is accomplished by setting up compost specifications for specific end uses. Therefore complementary to the BSI PAS 100:2005 minimum quality baseline, the following key market specific standards, specifications and guidelines are also supporting compost market development:

1. HDRA's "Organic Standards for Amenity Horticulture and Landscaping";
2. The Apex specification for compost
3. "The Soil Association Standards for Organic Food and Farming".
4. The Waste and Resources Action Programme's (WRAP)

These standards and documents provide important information relating to the needs of customers in some of the key market sectors for composts. Recommendations for application have to be established through co-operation with acknowledged experts in the various ranges of application, who should define a product specification from the point of view of their specialist area. Each specific application area is likely to exhibit 'internal' standards too which have to be fulfilled.
The following sections are devoted to describe and present the aforementioned key market specific standards, specifications and guidelines implemented in UK.

HDRA is developing standards for non-food industries based on organic principles as originally devised for food under European Council Regulation (EEC) No. 2092/91. The aim is to introduce an independent accreditation scheme, covering amenity horticulture and landscaping projects and maintenance, nursery production of ornamentals and products suitable for use as inputs. Standards for products for use within the sector were launched August 2001 however investigations are ongoing in order to refine these standards and develop new ones.

Apex is mainly involved in formulating specifications for compost application for landscape and some horticultural purposes. According to Apex compost analysis should be undertaken on the finished compost on a monthly basis for elements and once a quarter for other parameters and impurities in order to meet the Apex specification shown in Table 30.

Table 30: Apex specifications for compost in UK

Parameter	Unit	Frequency	Lower	Upper
Chemical				
pH		Monthly	7.5	8.5
Electrical conductivity	µS/cm	Monthly	750	1200
Organic matter	%	Monthly	25	35
C:N ratio	N/A	Monthly	15	20
Total nitrogen	%	Monthly	0.5	1
Ammonia-N	mg/l	Monthly	1	5
Nitrate-N	mg/l	Monthly	15	120
Total phosphorus	%	Monthly	0.1	0.3
Water soluble Phosphorus	mg/l	Monthly	4	30
Total potassium	%	Monthly	0.5	0.9
Water soluble Potassium	mg/l	Monthly	650	1200
Water soluble Magnesium	mg/l	Monthly	10	30
Free carbonate	%	Monthly	1	5
Moisture content	%	Monthly	35	45
Bulk density	g/l	Monthly	450	550
Heavy metals				
Lead	mg/kg	Monthly		<200
Nickel	mg/kg	Monthly		<50
Zinc	mg/kg	Monthly		<300
Copper	mg/kg	Monthly		<130
Arsenic	mg/kg	Monthly		<10
Cadmium	mg/kg	Monthly		<2
Mercury	mg/kg	Monthly		<2
Chromium	mg/kg	Monthly		<100
Water soluble Boron	mg/l	Monthly		<3
Water soluble Chloride	mg/l	Monthly		<850
Water soluble Sodium	mg/l	Monthly		<200
Other				
Weed seeds		Quarterly		Absent
Plant pathogens		Quarterly		Absent
Herbicides		Quarterly		Absent
Fungicides		Quarterly		Absent
Insecticides		Quarterly		Absent
Salmonella spp		Monthly		Absent in 25 g
E. coli		Monthly		<1000 cfu/g
Impurities				
Stones >2mm		Quarterly		Absent
Plastic, glass, metal >2mm		Quarterly		Absent

The Soil Association Standards for Organic Food and Farming provides information fact sheets for compost production and application. In Annex 5 a fact sheet on green waste composts is attached explaining the processes for the production of green waste compost and use in a way that fits within the framework of the soil association organic standards.

The Waste & Resource Action Programme, WRAP, is a not-for-profit company created in 2000 as part of the UK Government's waste strategies. WRAP's mission is to help develop markets for material resources that would otherwise have become waste. WRAP also provides advisory services to local authorities and helps influence public behaviour through national level communication programmes. With respect to compost standardization for specific end uses WRAP has developed the following:

- "Compost Specifications for the Landscape Industry",
- "Guidelines for the specification of composted green materials used as a growing medium component", and
- "Putting Compost to Work!" Information Packages and Fact Sheets series (primarily agricultural and horticultural applications for composts as soil improvers).

The aforementioned programmes (specifications, standards, guidelines) are presented thoroughly below.

Compost application for Landscaping in UK industry

Compost has proven to be an important product to the landscaping industry in many countries. In many ways it fills a 'product void', providing a bulk soil ameliorant that can be supplied in large volumes, while maintaining product consistency. It is also unique in that it is manufactured under controlled and scientifically monitored conditions. Compost is also an extremely versatile product that can improve the physical, chemical and biological characteristics of the soil. It is often used in general soil preparation for garden and turf establishment, in outdoor planter media, as a turf top dressing (maintenance) and mulch, as well as a main constituent in manufactured topsoils. Also, the use of compost in landscaping and topsoil treatment practices, as a soil ameliorant, has been more thoroughly researched than any of its competing products.
Specific compost applications need different compost specifications. As has been mentioned the BSI PAS 100:2005 sets the minimum standards for compost producers in order to guarantee an appropriate and safe end product (Table 29). The BSI PAS 100:2005 specification lays down requirement limits on stones, weed seeds and physical and chemical contaminants. However

further requirements for the use of compost must be set for the specific application in addition to the BSI PAS 100:2005 standards in order to make compost fit for purpose while at the same time ensuring the human and environmental protection. According to WRAP the compost specifications for the Landscape Industry cover the following applications (for further details see Annex 6):

- Mulching: This task consists of applying a compost mulch to the soil surface following planting activities. This specification applies to the mulching of various types of plant materials, including trees, shrubs, herbaceous plants and bulbs.
- Preparation of planting beds: This task consists of applying and incorporating compost into the soil at a designated location. This specification applies to the installation of various types of plant including, trees, shrubs, bulbs and herbaceous plants.
- Preparation of topsoil for grass establishment: This task consists of applying and incorporating compost into the soil at a designated location. The specification applies to grass establishment using all types of methods, including seeding, turfing, and hydraulic seeding.
- Topsoil manufacture:
  - Manufacturing topsoil on site using compost (in-situ): This task consists of blending excavated soil, at its point of origin, with compost to create a soil media suitable for landscape establishment. This specification applies to the manufacturing of soil for the installation of various types of plant materials, including, grasses, trees and shrubs.
  - Manufacturing topsoil on site using compost (ex-situ): This task consists of excavating and stockpiling soil on a particular site, then blending it with compost to create a soil media suitable for landscape establishment. This specification applies to the manufacturing of soil for the installation of various types of plant materials, including, grasses, trees and shrubs.
- Preparation of backfill for planting pits: This task consists of excavating a planting hole and blending compost with the excavated soil. This specification applies to the installation (planting) of various types of plant materials, including bare root, containerized, and balled and burlapped stock.

Compost application standards/specification in Growing media in UK –Horticulture

WRAP has also worked with the horticulture industry to develop a set of guidelines for specifying composted green materials in growing media. The guidelines were developed in association with the Growing Media Association which is concerned with the development, production, marketing and sale of growing media and soil improvers in the UK and Ireland and the ingredients used to manufacture these products.
Growing media is defined by WRAP as specially prepared formulations designed to provide support to plant growth by delivering water, nutrients and oxygen to root systems in containers such as pots, trays, troughs, tubs or growing bags
According to UK recommendations the fundamental requirements of compost supplied as a component of a growing medium must:

- be produced only from green waste inputs;
- be sanitised, mature and stable;
- be free of all extraneous, hard mineral matter (other than glass or metal) that are greater than 4 mm in any one plane.
- contain no materials, contaminants, weeds, pathogens or PTEs that adversely affect the user, equipment or plant growth (in accordance to the limit values set in Table 31)
- be dark in colour and have an earthy smell;
- be free-flowing and friable and be neither wet and sticky nor dry and dusty;
- be low in density and electrical conductivity.

Composted green material (CGM) must be produced from separately collected green waste from parks, gardens and other amenity and privately owned areas. With the full knowledge and prior written agreement of the purchaser, CGM might include vegetable processing or wood waste from industrial sources but this can affect the processing requirements and/or increase the electrical conductivity. In any case CGM must not contain the following:

- sewage sludge;
- manure or any other added material of animal origin;
- kitchen or industrial catering waste;
- mixed municipal waste;
- post-consumer wood waste (for example window frames and other demolition waste that may be contaminated with metal, glass and PTEs).

Depending on the actual analytical values for any batch and its intended application, the appropriate rates of CGM use may be as low as 5 % but could be greater than 33 %. Furthermore, for some applications and where lower rates of incorporation are planned, purchasers of CGM may accept batches with values for parameters such as bulk density, electrical conductivity and stones outside the limits specified in this document. It is for the growing media formulator to evaluate for him or herself the suitability of any particular source of CGM and to determine the appropriate limits and rate of use according to technical and commercial factors.

Table 31 presents the recommended targets and limits for the principal quality parameters of composted green material, derived from green wastes that is to be used as a growing medium constituent

Table 31: UK Specifications for compost use in growing media

Parameter	Units	Target	Limits	Comments
Maturity/Stability				
C:N ratio	None	15	20 maximum	Established norm and preliminary indicator of degree of biodegradation that has been achieved
Self-heating test	Maximum temperature increase °C	0	10 i.e. maximum 30 °C at recommended 20 °C ambient	Conforms to Grade V, which is the highest level of maturation and that recommended for growing media use
Nitrogen Drawdown Index (NDI) [1]	None	1	>0.7	Indicates whether Compost has the potential to lock up nitrogen
Phytotoxicity:	Scoring for specific symptoms compared with known control	Zero	Zero	Plant mass is not the critical measure, but germination should be unaffected and root growth normal. Shoots and leaves shall exhibit no distortions, lesions, chlorosis or other abnormalities under the test conditions
Contaminants and Pathogens				
Weed seeds and propagules	Number per litre of composted green material	Absent	0.5/l maximum (taken to be zero)	No live plant material shall be visible on delivery
Sharps [2]	Presence or absence	Absent	Zero	There can be no tolerance for this safety parameter
Stones [3]	% w on dry matter basis retained on laboratory sieves	Absent	(I) < 2 % > 4 mm, 0 % > 12 mm (II) < 5 % > 4 mm, 0 % > 12 mm	None > 4 mm shall be found on visual inspection at delivery and a single presence suggests non-compliance with Class (I)
Metal, glass and plastic > 2 mm	% w on dry matter basis retained on laboratory sieves	Absent	< 0.25 % w metal < 0.15 % w plastic < 0.10 % w glass	None > 2 mm should be found on visual inspection at delivery and a single presence suggests potential non-compliance
Plasmodiophora brassicae (club root) [4]	Presence or absence	Absent	Zero	Test species should be Chinese cabbage for increased sensitivity
Fusarium oxysporum f.sp.	Presence or absence	Absent	Zero	Test species is tomato [5]

lycopersici				
Salmonella spp.	n/25 g fresh weight	Absent	Zero	Limit as per BSI PAS 100
E. coli	cfu/g	Absent	<1000	Limit as per BSI PAS 100
Pesticide residues	Symptoms	Absent	None detected by bioassay	It is not practical to screen for all pesticide residues and process control is therefore important
PTEs (Heavy metals)				
Cadmium (Cd)	mg/kg dry matter	<0.5	<1.5	Limit as per BSI PAS 100
Chromium (Cr)	mg/kg dry matter	<50	<100	Limit as per BSI PAS 100
Copper (Cu)	mg/kg dry matter	<50	<200	Limit as per BSI PAS 100
Lead (Pb)	mg/kg dry matter	<50	<200	Limit as per BSI PAS 100
Mercury (Hg)	mg/kg dry matter	<0.5	<1.0	Limit as per BSI PAS 100
Nickel (Ni)	mg/kg dry matter	<50	<50	Limit as per BSI PAS 100
Zinc (Zn)	mg/kg dry matter	<150	400	Limit as per BSI PAS 100
Physico-chemical parameters				
Bulk density (BD)	g/l on fresh weight basis	400 – 500	<600	Should be as near to 400 as possible
Particle size distribution (for a 0 - 12 mm grade)	% w on dry matter basis retained on laboratory sieves	0 % > 12 mm	Inorganic matter and plastic: 0 % > 12 mm Organic matter: < 2 % > 12 mm	Recommended for general, multipurpose use but customer may wish to specify other grades or limits
Moisture content	% w	<40	35-50	Should be low to minimise BD
pH	None	7.5-8.0	7.0-9.0	Lower levels considered best for professional use
Electrical conductivity (EC) in 1:5 water extract	mS/m	<60	(I) < 60 (II) < 100	Class (I) - Premium Class (II) - Standard
NH4-N (ammonium-N) in water extract	mg/l	<40	< 50	Should be as low as possible and below the NO3-N (nitrate-N) level where this is 50 mg/l or more. High levels of NH4-N are undesirable as they indicate immaturity
Sodium (Na) in water extract	mg/l	<100	(I) < 200 (II) < 300	Class (I) - Premium Class (II) - Standard
Chloride (Cl) in water extract	mg/l	<500	(I) < 750 (II) < 1,000	Class (I) - Premium Class (II) - Standard

[1] This test indicates whether the Compost for Growing Media incorporated into a fertilised growing medium is likely to decompose and lock up the added nitrogen causing storage and growth problems. If added nitrogen is locked up, it indicates that microbial activity and biodegradation in the composted green material had been limited by the absence of soluble nitrogen and that the stability test may have given a misleading result.
[2] Inorganic contaminants (such as glass fragments, nails and needles) that are greater than 2 mm in any one plane that may cause physical injury to the hands of a user of composted green material or a growing medium made from it when handled without protective gloves.
[3] Extraneous, hard mineral matter (other than glass or metal) including pebbles and pieces of aggregate, concrete, pottery etc. that are greater than 4 mm in any one plane.
[4] Club root is a particularly pernicious pathogen with considerable liability implications and until process validation assures its eradication, bsence should be demonstrated.
[5] The Fusarium species indicated is common and causes wilt in tomatoes. It is heat tolerant and absence of this indicates processing conditions that are likely to have controlled other important organisms such as Rhizoctonia and many plant viruses.

Information Packages and Fact Sheets series for good compost practices (UK – WRAP)

Apart from the specifications on compost application for the landscape industry and growing media WRAP has also released series of information packages and fact sheets involved in promoting compost standards for specific end uses and the good compost practice in agricultural and horticultural applications. This section presents some of the information that WRAP has published for the agricultural application of compost.

The use of quality compost can improve crop establishment and increase yields. Quality compost can be used in a variety of agricultural applications such as:

Arable crops - Compost is especially beneficial to clayey soils that are difficult to work into a seedbed, and for light soils that are low in organic matter and/or potassium. Up to approximately 30 – 35 tonnes per hectare of compost may be applied to soils on an annual basis. This is especially beneficial to clayey soils that are difficult to work up into a seedbed and for light soils that have low organic matter status and low potassium index.

Root crops & vegetables - Root crops are typically grown in lighter soil. Compost is a particularly good source of potash and so is especially beneficial for root crops that have a high potash requirement, such as potatoes. "Light" soil is responsive to the organic matter and the nutrients contained in compost. Up to approximately 30 - 35 tonnes per hectare of compost may be applied to soils on an annual basis.

Grassland - Adding compost to grassland areas is an excellent way of boosting the nutrients required for optimum root growth. Compost can be used to add nutrients to established grassland. The source of the feedstocks for the compost should be verified by the compost supplier to ascertain whether any catering wastes or animal by-products have been included. If any such wastes have, the Animal By-Products Regulations (2003) require a two month grazing ban for pigs and a three week grazing ban for other ruminants after the compost has been applied. Application records of composts derived from catering wastes or animal by-products are required. Using finer grades of composts, screened to less than 25 mm, will allow the compost to fall more readily into the sward towards the roots.

In organic farming – organic farms need to recycle nutrients to sustain and build soil fertility, and to achieve crop and livestock health. Composting results in a stabilised product, free of pests, pathogens and weed seeds – an excellent material for building soil organic matter and supporting soil microbial communities.

Top and soft fruit - when used as a deep mulch, especially in young orchards, compost can significantly increase yields (number of fruit per trees and fruit size), mainly by retaining moisture in soils. The rows of established fruit crops, whether top fruit or soft fruit, can be mulched with a 25 to 75 mm deep layer of compost. Nutrients will be washed down into the soil to feed the crop and the mulch will aid the suppression of weeds. Planting fruit trees and bushes with compost combats Replant Disease. Tables 32 and 33 present the recommended properties in UK for the beneficial application of compost in agriculture and fruit production respectively.

Table 32: Recommended properties of good compost for agriculture in UK

Compost Parameters	**Report as units of measure**	**Recommended Range**
pH	pH units (1:5 water extract)	7.0 – 8.7
Moisture Content	% m/m of fresh weight	35-55
Organic Matter Content	%, dry weight basis	>25
Screen aperture size	Mm	40 max for soil improvement 25 max for top dressing grassland 25 max for root crops and vegetables 15 max for finer seedbeds
C:N		20:1 max

Table 33: Recommended properties of good compost for use in fruit production

Compost Parameters	**Report as units of measure**	**Recommended Range**
pH	pH units (1:5 water extract)	7.0 – 8.7 for soil improvers and backfill mixes 6.0-9.0 for mulches
Electrical Conductivity	µS/cm or mS/m (1:5 water extract)	2000µS/cm max or 200mS/m for soil improvers and backfill mixes
Moisture Content	% m/m of fresh weight	35-55
Organic Matter Content	%, dry weight basis	>25 for soil improvers and backfill mixes >30 for mulches
Screen aperture size	mm	25 max for soil improvers and backfill mixes
		75 max but with at least 25% of the material <10mm in size for mulches
C:N ratio		20:1 max for soil improvers and backfill mixes

Compost is most easily applied with a spreader that has a moving floor and rear discharge. It is important to mix the compost into the soil and not to invert the compost into a buried layer with the plough. This will maximise the effects of the organic matter on soil structure. For crops with sensitive seeds, as with manures or NPK fertilizers, it is advisable to mix the compost with the soil at least two weeks prior to sowing in case the germination is affected by any temporary raised salt content of the soil. Unlike inorganic nitrogen fertilizers, the nitrogen in compost is slow release and less subject to leaching over winter. Compost may therefore be applied in the autumn and most of the nitrogen will remain in the soil to benefit crops in the following years.

<u>Soil improvement:</u> Compost can be used to improve soils prior to planting, or in established crops. Most grades of compost are suitable for use as a soil amendment, but the compost application rate will vary, depending on soil conditions. It is necessary to have a soil analysis carried out as this will help to determine optimal application rates. Typical rates are usually a 50mm layer, which is mixed into the top 150 – 200mm of the soil. This gives an incorporation rate of approximately 20 – 25% by volume. Lower inclusion rates may be necessary for salt-sensitive crops or where composts with higher soluble salt levels (expressed as Electrical Conductivity) are used. Higher inclusion rates, such as 100 mm or more, may be required if the recipient soil is particularly poorly structured or has been depleted of nutrients. Once the

compost inclusion rate is chosen, a blend of soil and compost can be produced and analysed. This will identify the new soil characteristics, including soluble salt and organic matter contents, as well as identify the appropriate fertiliser rates and pH adjustment necessary for optimum plant growth. Composts tend to contain the full range of minor nutrients and trace elements, e.g. zinc, copper, manganese and boron. Many conventional fertilisers do not contain trace elements and products which include them are relatively expensive. As they are needed in small quantities, supplementary trace element applications should not be required when using compost as a soil amendment in fruit production. In subsequent years, compost may be applied at 25 – 75mm depth as a mulch, or raked into the soil, replacing the need for any additional fertilisers and assisting with weed control.

Composts not only provide valuable organic matter to soils, but also act as slow-release fertilizers for Nitrogen, Phosphate, Magnesium and Iron and provide a readily available source of Potash. Other nutrients are also provided by composts such as Sulphur, and trace elements. Compost can also provide a valuable source of Calcium with a small liming effect (it has up to 10% of the neutralising value of limestone on a dry matter basis).

The rate at which Nitrogen is released from compost can vary depending on soil and climate conditions. Typically the Nitrogen provided by compost is released slowly through the process of mineralisation, which reduces the possibility of it leaching away. Between 5% and 10% of the total nitrogen provided by compost is released in the first year of application, which means that when applied at a rate of 250kg/ha total N, approximately 15kg/ha of N will be released in year one (Table 34).

Table 34: Typical application of 31.5 tonnes of compost (20 tonnes dry weight basis) will provide (approximate figures):

Nutrients	Total amount (kg/ha)	Available year 1 (kg/ha)	Available year 2 (kg/ha)
Nitrogen as N	250	25 (10%)	12 (5%)
Phosphate as P2O5	100		
Potash as K2O	200		
Magnesium as Mg	60		
Sulphur as S	33		

Repeated applications of compost can increase the level of Potassium in the soil over the long-term. Potassium is an essential nutrient as it controls the water content of cells, can help crops retain moisture for longer periods and supports increased crop growth. It is estimated that 80% of Potassium in compost is in water soluble and exchangeable forms which can be utilised by crops over one to three years, depending on crop uptake demand.

Compost can also help counter a general decline in Phosphorus in the soil. Phosphorus is vital for crops as it is associated with the transfer and storage of energy and is essential for successful crop establishment and early growth. Approximately 15% of the Phosphorus in compost will be available to the crop grown in the first year. The rest is slowly released over the rotation.

The total nitrogen in compost should be applied according to the needs of the next crop in conjunction with inorganic nitrogen fertilizer. The needs of the soil for the full crop rotation should be considered when assessing the other major nutrients.

As compost works differently to manures, it can have added benefits:

• Spring application is possible due to the slow-release nutrients in composts, not adversely affecting crop establishment and quality.

• Autumn application results in less nutrient leaching than from manures and slurries due to the slow-release forms of many of the nutrients in composts.

Time compost applications so that increased nutrient availability helps meet the nutrient requirements of your crop rotation programme. Include available nutrients supplied by compost applications in your inorganic fertilizer programme. Compost is most effectively used when it is well mixed with the soil so avoid burying it by only ploughing. Don’t sow salt sensitive seed crops less than two weeks after compost application and incorporation.

<u>Mulching fruit crop rows</u>: Established fruit crops can benefit from the nutrient value of compost plus weed suppression effects by applying compost in the row as a mulch 25 to 75 mm deep. Planting fruit trees/bushes with compost combats Replant Disease.

<u>Grassland and forage crops</u>: Compost can be used to add nutrients to established grassland. The source of the feedstocks for the compost must be provided by the compost supplier to ascertain the inclusion or not of any catering wastes or animal by-products. This is required under the Animal By-Products Regulations 2003 as this law requires a two month grazing ban for pigs and

a three week ban for other ruminants after the compost has been applied. These grazing ban periods also apply to crops used for animal feedingstuffs. Application records of composts derived from catering wastes or animal by-products are required. Using the finer grade of compost, screened to less than 25mm, will allow the compost to fall more readily into the sward towards the roots and so not affect silage or hay quality, and animals can return to graze the grass without undue delay.

<u>Use as a backfill mix in top and bush fruit production:</u> For use in backfill mixes the compost should be well decomposed. Composts can eliminate the need to add major nutrients during planting. In addition, composts tend to contain the full range of minor nutrients and trace elements, e.g. zinc, copper, manganese and boron. Many conventional fertilisers do not contain trace elements and products which include them are relatively expensive. As they are needed only in small quantities, trace element applications should not be required when using compost in backfill mixes. Plant tolerance of soluble salt levels are soil and species dependent. Soluble salts should not be a significant problem with most woody species. However, care should be taken when bare root and salt-sensitive crops are planted. Compost producers should supply details of recent chemical and physical analysis and this should be used in conjunction with an analysis of the site soil. The compost should have a moisture content between 35 and 55%. Compost with a high moisture content is expensive to transport and difficult to handle. Dry compost can be dusty, does not imbibe water effectively, and can induce water stress to the tree or bushon planting. The inclusion rate of compost in the backfill mix will vary, based on the species to be grown and the characteristics of the soil to be blended but the preferred inclusion rate is approximately one third compost by volume. Prepare the root-balled, containerised, or bare root plants in accordance with the industry standard methods before planting. The planting hole should be slightly deeper than the root ball and two to four times its width. The soil removed from the planting hole should be thoroughly mixed with compost at a rate of two parts soil to one part compost. Use this material to backfill around the root ball, firming occasionally to remove air pockets. The trees or shrubs should then be watered in and preferably mulched.

In Annex 7 two UK Case studies of good compost applications in agriculture are presented.

4.7 Restrictions for the use of compost on land

Utilisation restrictions exist for different end-use applications. Utilisation restrictions play an essential role in most of statutory regulations especially for agricultural applications therefore the application of compost is limited according to the PTEs and nutrients level. As far as PTEs are concerned the restrictions can be distinguished between:

- direct load limitation (g/ha/yr), in most cases calculated on a basis of 2 to 10 years
- restriction of the admissible dosage of dry matter compost per ha and year and
- restriction according to a maximum nutrient supply (phosphorus or nitrogen) of the agricultural crops

Table 35 reviews the restrictions and regulations for the use of composts and stabilised organic wastes from Municipal Solid Waste or Mechanical Biological Treated material. Table 35 summarises the maximum load of PTEs to the soil in European standards and regulations.

Table 35: Regulatory systems of restrictions for the use of composts

Country	Type of dosage or load restriction
Austria	• Agriculture: 8 t d.m.ha^{-1}y^{-1} on a 5 year basis • Land reclamation : 400 or 200 t d.m. ha^{-1}y^{-1} within 10 years depending on quality class layer class B quality: maximum of 200 tonnes DM per hectare over ten years; class A quality: maximum of 400 tonnes DM per hectare over ten years; if more than 400 tonnes DM per hectare over ten years is to be applied, class A+ quality has to be used • Agricultural recultivation and erosion prevention measures: a maximum of 160 tonnes DM per hectare as a one-off application • Non food regular application: 20 or 40 t d.m. ha^{-1}y^{-1} within 3 years depending on quality class class B quality: maximum of 20 tonnes DM per hectare over three years; class A quality: maximum of 40 tonnes DM per hectare over three years; if more than 40 tonnes DM per hectare over three years is to be applied, class A+ quality has to be used
Belgium	• Fixed maximum heavy metal load • Regulation with respect to manure application based on N and P content, Manure Action Programme (MAP).
Denmark	• Food production: 7 t d.m. ha^{-1}y^{-1} on a 10 year basis • Non food: 15 d.m. ha^{-1}y^{-1} on a 10 year basis • Restriction of nitrogen and phosphorus to 210 kg ha^{-1}y^{-1}and 30 kg ha^{-1}y^{-1}, respectively
Finland	• Fixed maximum heavy metals load (sewage sludge regulation)
France	• Fixed maximum heavy metals load (compost standard)
Germany	• Agriculture: 10 or 6.7 t d.m. ha^{-1}y^{-1} on a 3 years basis
Greece	• No regulation
Ireland	• No regulation
Italy	• Food production: fixed maximum heavy metal load (Techn reg. DCI 27/07/84 • Land reclamation: 100 t d.m. ha^{-1} or up to 300 t ha^{-1} ha and more where supported by risk assessments
Luxembourg	• No specific regulations: advice (voluntary): 15 t d.m. ha^{-1}y^{-1}

The Netherlands	• Agriculture *standard compost* / Arable land: 6 t d.m. $ha^{-1}y^{-1}$ on a 2 years basis Grassland: 3 t d.m. $ha^{-1}y^{-1}$on a 2 years basis *very clean compost* max. 80kg P_2O_5 $ha^{-1}y^{-1}$ new strategy: balance of supply and losses of heavy metals • Set-aside land: *standard compost* / Arable land: 6 t d.m. $ha^{-1}y^{-1}$ on a 2 years basis *very clean compost* max. 20kg P_2O_5 $ha^{-1}y^{-1}$
Portugal	• Fixed maximum heavy metals load (sewage sludge regulation)
Spain	• Fixed maximum heavy metals load on a 10 year basis
Sweden	• Fixed maximum heavy metal load (sewage sludge regulation) • Agriculture: restriction of nitrogen and phosphorus to 150 kg $ha^{-1}y^{-1}$and 22-35 kg $ha^{-1}y^{-1}$, respectively
Switzerland	• Agriculture: 8.3 t d.m. $ha^{-1}y^{-1}$ on a 3 year basis
UK	• No specific regulations: fixed maximum heavy metal load (sewage sludge regulation) • Voluntary Code of Good Agricultureal Practice for the protection: limitation of nitrogen to 250 kg $ha^{-1}y^{-1}$ (for all types of fertiliser used)
US	• Some states have compost standards which incorporate an application rate of 100-250 m³/ha in landscaping of 20–40% in horticulture mixtures (depending on salt, maturity, density and C:N ratio not in heavy metals content).

With respect to the nutrients level Table 36 presents the ranges of restrictions in EU countries for the amount of compost (on dry matter basis per ha) or plant nutrients to be applied.

Table 36: Limitations of compost application based on nutrients content

Quantity of compost*	Agriculture/regular Non food/regular Non food/once	3 t (pasture land) – 15 t (arable land) ha^{-1} 6.6 t – 15 t ha^{-1} 100 t – 400 t ha^{-1}
Quantity of N	Agriculture/regular	150 kg – 250 kg ha^{-1}
Quantity of P_2O_5	Agriculture/regular Set aside land	22 kg – 80 kg ha^{-1} 20 kh ha^{-1}

* in most cases quantity differentiation is depending on quality class obtained.

Following the ongoing discussion of the use of compost in the frame of good agricultural practice one can realise a clear trend towards a system that ensures a balanced nutrition of the plants. This clearly focuses on the wanted or beneficial effect of compost, more than a ban of related to heavy metal loads would. It is evident that this approach has to be based on the site-specific demands indicated by crop rotation, nutrient status, susceptibility to leaching of nutrients and mineralisation potential.

However, many of the maximum loads of PTEs to the soil defined in European standards and regulations and summarised in Table A2- 9 are stemming from traditional sewage sludge regulations or are calculated from quantitative compost limitations multiplied by heavy metal threshold values.

Table 37: Admissible maximum dosage of heavy metals to the soil in European legislation and standards and the USA (g ha^{-1} y^{-1})

Country	Cd	Crtot	CrVI	Cu	Hg	Ni	Pb	Zn	As	Mo
EC/'sewage sludge 10y basis *	0.15	3.0 (4)	-	12	0.1	3.0	15	30	-	-
Austria										
sewage sludge (1)	20	1250	-	1250	20	250	1000	5000	-	-
Fertiliser Ordinance/2 y basis	10	625	-	625	10	375	625	2500	-	-
Compost Ordinance agriculture/5 y basis (2)	8	560	-	1200	5.6	480	960	4000	-	-
Compost Ordinance: land reclamation Cl. A/3 y basis (2)	13.3	933	-	2000	9.3	800	1600	6665	-	-
Compost Ordinance: land reclamation Cl. B/3 y basis (2)	20	1668	-	3335	20	667	1334	12006	-	-
Belgium (6)										
VLAREA	12	500	-	750	10	100	600	1800	300	-
Denmark										
Agriculture	5.6	700		7000	5.6	210	840	28000	175	
Non food	12	1500		1500	12	450	1800	60000	375	
Finland	3	300		600	2	150	150	1500		
Goal for 1998	1.5				1	100				
France (3)										
sewage sludge/industrial waste	30(a)			1500	15	300	1500	4500		
pH<6	15			1200	12	300	900	3000		
Draft NF U 44 51	15	600		1000	10	300	900	3000	90	
Germany										
Sewage sludge	16	1500	-	1300	13	300	1500	4100	-	-
Biowaste Ordinance (I)/3 y basis (2)	10	700	-	700	7	350	1000	3000		
Biowaste Ordinance (II)/3 y basis (2)	10	667	-	667	7	334	1001	2668		
Italy										
DCI 27/07/84	15	2000	15	3000	15	1000	500	10000	100	
The Netherlands (2)										
Compost	6	300		360	1.8	120	600	1200	90	-
Portugal										
Degree on sludge/10 y basis	150	4500		1200	100	3000	1500	30000		
Spain										
Decr. 877/1991 (c)	150	4500		1200	100	3000	1500	3000	-	-
Sweden										
SNFS 1992:2	0.75	40		300	1.5	25	25	600		-
Switzerland										
StoffVo	6.2	333		2500	12.5	208	208	5000		-
USA (5)	1900			75000	850	21000	15000	140000	2000	0.9

*Directive 86/276/EEC; average within a period of 10 years (1) Sewage sludge Ordinance, Lower Austria (Class III) (2) from maximum compost dosage ha^{-1} y^{-1} (3) max. mean load per year within a period of 10 years; Cr+Cu+Ni+Zn: 6 kg ha^{-1} y^{-1} (pH<6.0: 4 kg ha^{-1} y^{-1}; Se on pasture land: 0.12 kg ha^{-1} y^{-1}) (4) planed (5) only sewage sludge that exceeds "high quality" limit values for h.m. (6) for secondary raw materials (a) 0,015 kg ha^{-1} y^{-1} from 2001 (b) Over a period of 10 years

5 Conclusions

The aim of the project is to provide guidance to competent authorities in Morocco in focusing their efforts and resources in the development of a set of robust and commercially beneficial compost standards in Morocco based on the existing standards worldwide and to provide information on the specifications of compost end uses so that the product will be applied on land safely without negative environmental and/or public health impacts.

The legal framework around compost standards differs widely in the composting countries of the world. In any one country, standards generally relate to the level of development of the recycling of biodegradable organic waste. The review on compost standards was preformed based on three main categories which are considered fundamental for the characterisation of compost quality. Those categories included the concentration of Potential Toxic elements known as PTEs, the concentration of organic contaminants, the content of pathogens, impurities and weeds and the stability/maturity level of compost.

The Potential Toxic Elements aspects of product standards are increasingly set on the basis of a desire to protect soil quality. These should be set with tolerances in place, the tolerance band being determined by the strictness of the standard. Certain deviation of the quality criteria has been proved in practice to be more efficient than the stipulation of absolute limited values (cut-off values). The standards set should be achievable using good practice composting methods, and they should be set in such a way that they can be standardised (e.g. using organic matter content) so that concentrations which are measured are comparable. Another issue of concern is the diversification of compost qualities based on PTEs content which may lead to the application of premium compost only, while the large quantity of good quality compost which is sufficient for various uses will fail to be used in most cases. Therefore quality classes based on raw material and/or on the properties or the ranges of utilisation will more effectively meet the requirements of the compost market.

In most of the countries a combination of a specified temperature–time regime and end product tests (typically using Salmonella spp and Escherichia coli) is used to for the sanitisation of the end product and to guarantee the absence of pathogens. As regards impurities, the details of the approach taken vary across countries. It is clear, however, that at least one such standard is desirable. Furthermore, depending upon the number of compost classes in the standard, there may be more than one threshold set for physical impurities according to the specifications of

compost end use. The same could be true of the presence of weeds. This is likely to be far more important in some applications than in others. With respect to phytotoxicity most countries perform plant growth test in order to measure whether composts are promoting or inhibiting seed germination.
In regard to the stability and maturity of compost there is no currently a clearly accepted approach to specify the stability and maturity of composts therefore among countries there are different methods such as the degree of decomposition (Rottergrad) the self-heating test (Solvita test) or throught the combination of compost parameters such as CO2 evolution, O2 uptake, ammonium to nitrate rate etc.

With respect to the end use specifications of compost a review was performed in several countries with different backround and level of compost market development so that the reader will have a view of different approaches on how end use specifications of compost are set. The general remarks that can be made is that the quality end use requirements are related to the agronomic value of the produced compost such as organic matter, stability, nutrients etc and consideration should also be given to the specific needs, the views of purchasers, local cropping techniques, and the evolution thereof. This means that standards on such parameters should be made flexible and mostly left up to sector-specific (voluntary agreements). It might be therefore advisable to include in statutory standards – besides health and safety issues – only some fundamental agronomic features which constitute a common background to define what is really beneficial in any single sector, while most agronomic standards ought to be left up to voluntary agreements such as, Quality Assurance Systems, regional labels or similar systems. The choice depends on the historical background; the need to promote quickly and widely the system (which requires a centralised control/certification/labelling system); the need to have a voluntary system which also performs controls under the scope of regulations.

ANNEX 1 : Potential Toxic Elements (PTEs) present in compost and soil

ARSENIC (As)

Properties and sources: Arsenic is a metalloid. With regard to its properties it belongs to the group of elements between the (heavy) metals and the non-metals. Of the US Environmental Protection Agency's hit list of the most toxic chemicals, arsenic ranks first. A low-dose exposure to arsenic may increase the risk of certain types of cancer, diabetes and vascular disease and it also may play a role in endocrine disruption. On average the earth´s crust contains a very low concentration of 2 mg arsenic per kg. However, arsenic is rather unevenly distributed. In addition to natural sources in metal ore deposits or extended areas of rocks with elevated arsenic concentrations, arsenic can be detected in landfills and on industrial sites. Contaminated sites often are related to urban gas production, the production of special glass, or extensive pesticide use. A further principal sources of arsenic pollution has been the mining and processing of mineral ore and gangue, predominantly as a by-product of the extraction of copper, lead, tin and silver. Arsenical compounds have also been used in the ceramics, electronics, textile and tanning industries and as a softening agent in PVC in alloys and in drugs. In addition, contamination has arisen from the widespread use of agrochemicals such as pesticides and wood preservatives in agriculture. Arsenic may also be released into the environment by atmospheric transport of arsenic containing fine dust.

The natural sources are sometimes considerably greater than the anthropogenic ones.

<u>As in composts</u>: Arsenic is easily rubbed off the surface of wood treated with cromated copper arsenate, also known as “pressure-treated “ lumber. Arsenic also leaches from the wood to contaminate the soil below.

<u>As in soils:</u> When an arsenic bearing formation is near the surface, weathering and erosion release substancial amounts of arsenic into the environment. Arsenic either accumulates in soils and sediments, or is diluted in natural waters.

Atmospheric deposition from copper smelting and the burning of fossil fuels is also an important input to the soil.

The quantity of soluble or potentially soluble arsenic in a soil varies widely with pH, redox potential and the presence of other components such as iron and manganese oxides, clay minerals and organic matter content. Both arsenate and arsenite are strongly adsorbed onto iron and aluminium oxides, clay mineral surfaces and soil organic matter. Under acidic conditions, the dissolution of iron oxides has been observed to increase the concentration of arsenic in solution. Arsenic as selenium and mercury can be reduced in soil into highly volatile forms, either through micro-organisms intervention or by extra-cellular enzymes.

CADMIUM (Cd)

Properties and sources: Cadmium resources are tied to those of zinc. The resources available are currently estimated to be approx. 9 million tons. Mean content in the earth crust estimated to be 0.1 ppm. Cadmium is a soft, ductile metal which is usually obtained as a by-product from the smelting of lead and zinc ores. The principal use of cadmium is as a constituent in alloys (low melting point alloys) and in the electroplating industry. Other uses of cadmium include paints and pottery pigments (mixtures of Cg- sulphide and Cd-selenide are used as thermally very durable dye pigments), corrosionresistant coating of nails, screws, etc, in process engraving, in cadmium-nickel batteries, and as fungicides. Cadmium is also naturally present in soils and mineral fertilisers. The general trend in the global cadmium consumption the last two decades has been a steep increase in the use of cadmium for batteries and a decrease in the use for other applications. Batteries accounted in 1990 for 55% of the total Western World consumption and for about 73% of the estimated EU consumption in 2000. Although the use of cadmium for pigments, PVC stabilisers and plating in some countries by the large has been phased out, these applications at the EU level still account for a significant part of the total cadmium consumption in 2000. Western World: 16500 t a-1; EU: 1930 – 1990 t a-1. Recycling of cadmium after private or industrial use of products containing Cd is hardly done so far. Exception: processing of used batteries. Possible substitutes for Cd: zinc or vapour deposited aluminium for plating, zinc stabilisers, zinc and iron pigments.

Cadmium as impurity: All heavy metals are present as trace element in fossil fuels, mineral raw materials, food, etc. and there will be an unintentional turn over of the heavy metals with nearly all products. Beside the intentional use of cadmium, the turnover of cadmium as impurity in zinc and fertilisers has been substantial but has decreased significantly by refining and changes in raw materials. Even in countries where the consumption of cadmium with pigments and stabilisers has decreased there may still be a large pool of cadmium accumulated in the technosphere with these products. Pigments and stabilisers in 1995 accounted for one third of the cadmium accumulated in the technosphere. It can be concluded that Cd can be seen as an indicator for industrial pollution.

Evaporation and long range transport: Cadmium can be transported by air over long distances. However, much higher air cadmium concentrations are found in areas close to major atmospheric sources of the metal. Studies of the particle size distributions of cadmium in urban aerosols generally show that the metal is associated with particulate matter in the respirable range. The enrichment of cadmium on these smaller particles can be linked to the behaviour of the metal in thermal facilities that are sources of airborne cadmium. In contrast to lead Cd is spread and imported via air and substantially by water.

Cd in sludge: Cadmium in sludge has mainly an industrial origin, but can also originate from household effluents: cadmium is present in cosmetic products and gardening pesticides. It also comes from the runoff of raining water, after atmospheric deposition of the metal.

Cd in composts: As Cd is an indicator for industrial pollution, composts of industrial regions show significantly higher Cd-loads. The average Cd-loads are caused by a specific regional “baseload”. As observed for lead, composts originating from industrial centres do contain comparatively high Cd- concentrations.

Cd in soils: The origin of cadmium in soil is divided between the following sources: 20% Agricultural wastes, 38% Sludges, 2% Fertilizers, 40% Atmospheric fallouts.

Soil pH is the most important factor controlling the availability of cadmium; it affects the stability and solubility of cadmium complexes, as well as nearly all adsorption mechanisms. Some of the cadmium salts, such as the sulphide, carbonate or oxide, are practically insoluble in water, but these can be converted to water-soluble cadmium sulphate, cadmium nitrate, and cadmium halogenates under the influence of oxygen and acids. The more acid the soil is, the more mobile the cadmium becomes, whereby it can be taken up by plants or leach more readily. Compared to the other heavy metals, cadmium is relatively mobile in soil and more bioavailable. Cadmium uptake from agricultural soils by the crops is a major concern, but due to the relatively high mobility of cadmium the transport of cadmium from residues and landfills to the groundwater must be expected to be a faster process that for the other three heavy metals.

CHROMIUM (Cr)

Properties and sources: Large amounts of chromium are found in terrestrial crust. The most important part of the extracted chromium is used in alloys, for instance to produce stainless steel. It is also used for its heat resistance and wood protection properties, and, in chemical industry, as tanning agent, and pigment. Chromates are used for oxidation of organic compounds. Chromium may be found in several forms, mainly trivalent (referred to as CrIII), or hexavalent (referred to as CrVI). Chromium is extracted from chromite ore. World mine production of chromite has increased from 13.0 million tonnes ore in 1990 to 13.7 million tonnes in 2000. In terms of chromium, the mine production increased from 3.9 to about 4.1 million tonnes chromium.

Besides anthropogenic sources chrome can be naturally accumulated in minerals (basalt, 200-300 mg kg- 1 ; ultra-alkaline minerals, max. 3400 mg kg-1):

Chromium as impurity: With waste incineration: May get into air with pulverised fuel ashor as volatile chromium compound e.g. chromium chloride. Is partly oxidised to its hexavalent type and can be eliminated from the ashes easier than without incineration.

Cr in sludge: According to the level of industrialisation of the region, the origin of chromium found in sludge can be divided as follows:

- ✓ 35 to 50 % from industry (surface treatment, tannery, chemical oxidation),
- ✓ 9 to 50 % from runoff (dust, pesticide, fertilisers),
- ✓ 14 to 28 % from household effluent.

Cr in compost: Cr is not critical in composting. Potential sources like treated wood (paint and varnish); wastes of tannery are insignificant as feedstock for composting.

Cr in soils: Both Cr(III) and Cr(VI) can exist in soil, but in normal soils reduction of Cr(VI) to Cr(III) is favoured. The environmental chemistry of chromium in soil is very complex and it is difficult to extract some general patterns. The pH of the soil affects the speciation, solubility and bioavailability of the chromium forms. The effect of pH is, however, different for the different species; acidic conditions increase the adsorption of Cr(VI) to particles whereas in decrease the adsorption of Cr(III).

COPPER (Cu)

Properties and sources: Major sources of copper are from the industry (copper industry, non-ferrous metals industry, incineration). Cu is a micro element for plants and animals with a toxicity for micro organisms (bacteria etc.) and ruminants.

Yearly production: more than 7 million tons worldwide. (in 1900 only 0.5 million tons), a significant share thereof obtained by recycling. In addition to use in electrical industry required for water pipes, roofs, kitchenware, chemical and pharmaceutical appliances, in the fine arts als dye and as precipitant for selenium.

Copper suphate: as additive to green fodder in case of copper deficiency, as Algizid and Mollucozid in water, together with calcium as plant fungicide, as staining agent, for galvanising and als component of Fehling's solution for evidence of urine sugar.

Copperoxide:proposed as fungicide in viticulture and as additive to pig and poultry fodder as growth enhancer.

Cu in sludge: Copper in sludge and wastewater comes mainly from household effluents (domestic products, pipes corrosion…) but can also have an industrial origin (surface treatments, chemical and electronic industry).
Cu in compost: Drinking-water in areas with copper-plumbing may cause left-overs/ remnants with higher copper loads. The use of copper in feeding-additives for pig fattening causes higher copper loads in pig slurry, copper-fungicides in viniculture and horticulture cause plant waste with copper loads. Demolition wood may be contaminated with fungicide and bactericide timber preservatives with copper components. There is a relation between Copper-load and organic matter content.
Cu in soils: The origin of copper in soil is divided between the following sources: 55% Agricultural wastes, 28% Sludges, 1% Fertilizers, 16% Atmospheric fallouts.
Metals fix themselves preferentially to the soil organic matter, iron and manganese oxides and clays. The distribution of copper between these three fractions depends on the soil's pH level, the quantity and the composition of the organic matter. It tends to migrate very little.

MERCURY (Hg)

Properties and sources: Mercury exists under different chemical forms determining its toxicity and bioavailability. Under its inorganic form, mercury is present in the air as dust or in water. It has a natural presence in the environment, but also originates partly from industrial activity: mining (cinnabar HgS), founding, coal combustion, incineration. Other sources can be Fungicides (e.g. caustics for seed), and Mercury-batteries. Mercury can easily be found under its gaseous form. Under its organic form, mercury is mainly present in alimentation as it results from a biological process and therefore concentrates in the food chain. The global mercury demand decreased over the period 1990 to 1996 by 2,019 tonnes from 5,356 tonnes to 3,337 tonnes. Of the 3,337 tonnes, 1,344 tonnes was used in the chlor- alkali industry, 100 tonnes was used for gold extraction, 1,061 tonnes ended up in products and 832 tonnes was added to stocks. It should be noted that the uncertainty on the total consumption volumes is higher than indicated by the accuracy of these figures.
Evaporation and long range transport: Mercury is distributed via air over long distances and elevated levels of mercury can be found in remote areas far from the sources. To some extent it is also distributed via water. Contrary the other heavy metals, a significant part of the deposited mercury may re-enter the atmosphere by evaporation. Hg(0) can be formed in soil, landfills and sewage stacks by reduction of Hg(II) compounds/complexes mediated by among others humic substances and light. This Hg will diffuse through the medium and re-enter the atmosphere.

Hg in sludge: Mercury comes from pharmaceutical products, broken thermometers, runoff water, to what industrial discharge may be added.

Hg in soils: Its complexing behaviour greatly limits the mobility of mercury in soil. Much of the mercury in soil is bound to bulk organic matter and is susceptible to elution in runoff only by being attached to suspended soil or humus. Regarding contamination of the environment mainly the use in fungicides is critical.

NICKEL (Ni)

Properties and sources: Nickel is used for the production of stainless steel and in alloys for coins and different instruments production. It is also used for metal surface treatment and battery production. Nickel is also used for hardening of cooking oil, crude oil refining and production of organic chemicals. The anthropogenic source of nickel are basically the metal industry (metallurgy) and NiCd- accumulators, which should not be relevant in composting. Besides these potential anthropogenic sources nickel can be naturally accumulated in minerals (basalt, 140 mg kg-1 ; ultra-alkaline rocks, max. 2000 mg kg-1).

Ni in sludge: Nickel in sludge originates from household effluents (cosmetic products and pigments) but also from industrial effluents from the activities mentioned above.

Ni in compost: In addition to geologically and/or anthropologically caused loading of the raw material a contamination by nickel and chromium can also be caused by rub-off from the shredding and chopping machinery. Samples processed contain the same potential source of contamination. Chromium and Nickel concentrations found in BWC are very significantly correlated (r = 0.49). As Nickel is an essential compound of the urease of numerous plants the nickel load of plant waste is corresponding to the nickel background concentration of soils.

Ni in soils: The high mobility and bioavailability of nickel of exogenous origin (sludge, salt) in comparison with other metals has frequently been observed. On the other hand, there is insufficient information regarding the potential mobility of the nickel pre-existing in soil.

LEAD (Pb)

Properties and sources: The global consumption of lead has during the period 1970 to 2000 increased from 4.5 million tonnes to 6.5 million tonnes. Significant changes in the overall use pattern include increased consumption for batteries and decrease in the areas of e.g. cable sheeting and petrol additives. Lead has been used for many years and a very significant amount is today accumulated in the technosphere. Even when applications are phased out, waste of lead products may be generated for many years to come from this pool. As lead used and emitted to the environment since centuries, it is difficult to establish the "natural" content in rocks, soils and waters as well as in the atmosphere. Evaporation and long range transport: Most lead emissions to the air are deposited near the source, although some particulate matter (< 2 µm in diameter) may be transported over long distances and results in the contamination of remote areas.

Pb in sludges: There are two main origins for lead in sludge: water from road runoff and alteration of old pipes. Industrial effluents may also contain lead. Their contribution to the sludge content is of about 20 %.

Pb in composts: Increased lead contamination of compost can be observed in areas where the soil shows an increased Pb-concentration, due either to pedological factors or to anthropogenic activity. The Pb contamination of composts is declining and is significantly correlated with traffic density and date of introduction of unleaded fuel.

Pb in soils: The origin of lead in soil is divided between the following sources: 12% Agricultural wastes, 19% Sludges, 1% Fertilizers, 68% Atmospheric fallouts.

It appears that most of the lead found in soil originates from atmospheric deposition.

Lead is in general not very mobile in soil. Soil pH, content of humic acids, and amount of organic matter influence the content and mobility of lead in soils. Only a very small portion of the lead in soil is present in the soil solution, which is the immediate source for lead for plant roots, but soil acidification will lead to increased mobility and bioavailability of lead. More acid conditions (lower pH) not only increase the solubility of lead, but also other heavy metals.

Lead mainly emitted via automobile exhausts and spread via air, is prone to be strongly accumulated in garden soils, because dust which is attached to the leaf surface is concentrated by composting and subsequently added to the soil.

ZINC (Zn)

Properties and sources: Zinc can be seen as indicator for a common anthropogenic background load. galvanised iron and steel products. Zinc is used in surface treatment and is mostly used in alloys. It is also found in battery, as protective layer in the building industry, in textile, pharmaceutical and insecticide industry and residues of paint (white zinc). An Agricultural sources is Zinc-Bacitracin in pig- and poultry-fattening.

Zinc from galvanised iron and steel products is mainly released via water, what is intensified by acid rain.

Zn in sludges: Zinc originates mostly from pipe alteration, and in a secondary extent, from industrial effluents.

Zn in soils: The origin of zinc in soil is divided between the following sources: 61% Agricultural wastes, 20% Sludges, 1% Fertilizers, 18% Atmospheric fallouts

It appears that most of the zinc found in soil originates from agricultural wastes spread on land. The most common and mobile form of Zn is Zn^{2+} although other ionic forms may exist in soil. Clays, Fe and Al hydroxides as well as organic matter may strongly bind this metal. Zn is considered as more soluable than other trace metals in soil. It becomes highly available and Very mobile in acidic soils.

ANNEX 2 : Organic Polutants present in compost and soil

With increasing awareness of the environment, organic pollutants have become a matter of concern. Organic pollutants are produced by human activities: industry, transportation or human attempts to control the environment such as by the use of pesticides. Some leave residues that may persist in the environment, either intact or as breakdown by-products that may be more toxic than the original product. Some are emitted accidentally and others are -or were in the past- -released into the environment delibeately. Many on the list of potential problem chemicals are better known by their abbreviations: PCBs, PAHs, PCDD/F and DDT for example. They are widespread and some are inevitably present in raw materials for composting. Very few of the standards examined set limits for organic pollutants. As with pathogens there are a great many different chemicals that would need selective testing for, which is difficult and expensive. Some countries regulate levels of certain chemicals in sewage sludge, eg. Denmark (Nonlyphenols, PAH, DEHP and LAS), Sweden (Nonlyphenols, PAH, PCB and Toluene) and Germany (PCB, PCDD/F and AOX). A comparison of typical levels in compost and sewage sludge, as given in the AFR report, show that contamination in compost is generally much lower than that in sewage sludge. The German RAL GZ-251 standard set a voluntary limit for pesticide content at <0.5 mg L-1 of fresh mass and discussions are being carried out of limits for other pollutants such as PCBs and Dioxins. Through careful selection of feedstock it should be possible to reduce some of the potential contamination. This implies knowledge of sources of contamination, such as road sweepings, and the origins of feedstock. Especially in countries where it is not regulated, ie outside the EC, lindane is sometimes found in bark and timber. Residues from medical treatments such as antibiotics may find their way into compost. CEN/TC 223 WG2 reported that residues from the treatment of fish have been found in Norway, where fish waste is included in compost feedstock. This should be easy to separate out at source if it is considered a problem. Little information is available, however, on the behaviour of animal veterinary medicines when introduced to the environment. Clearly more research is needed in this area before meaningful recommendations can be made. From the large number of potentially dangerous and damaging compounds the chlorinated pesticides, the polychlorinated biphenyls (PCB), the polycyclic aromatic hydrocarbons (PAH) as well as the polychlorinated dibenzodioxins (PCDD) and the dibenzofurans (PCDF) are considered to be ecologically high relevant due to their high stability and toxicity. Set free into the environment through direct application or indirectly through transport with waste water, solid waste and air, those chemicals contaminate soils plants and thus also the raw materials for composting. Denmark sets quality criteria for soil that includes some organic pollutants. After application of compost at a rate of 10 t dry matter ha-1, all criteria were found to be met with huge margins. The Netherlands decided against setting limits as levels are considered too low to cause concern. Little information is available on the levels at which organic pollutants become hazardous. Opinions differ and research is lacking. It has also been noted that results of analyses vary widely even when performed on material from the same heap. CEN/TC 223 WG2 concluded that information was too unreliable to base limits on and therefore was unable to recommend any. To be certain to reduce contamination the best course of action would seem to be to select feedstock carefully with a view to excluding potentially problematic chemicals, and manage the process to maintain aerobic conditions throughout composting. Tests can be used as a fail-safe mechanism if contamination is suspected, and at intervals to increase confidence in the end product, if deemed appropriate. The options then could be summarised as:

- ✓ Segregate at source and refuse raw material as necessary
- ✓ Operate an aerobic composting process
- ✓ Test for suspected contaminants only as a last resort

POLYCHLORINATED BIPHENYLS (PCB)

Properties and sources: PCB is a group of substances obtained by chlorination of biphenyls. PCB is an extremely stable mass chemical which can be found in all environmental sample notwithstanding the production stoped in 1984. As a rule the data in literature refer to the sum of 6 of the total of 209 congeners, differentiated by their level of chlorination, with the numbers 28, 52, 101, 138, 153 and 180, which sum up approximately 30 % of the expected total PCBs. 130 can be found in commercial mixtures about 100 in environmental matrices. These PCB, attached to particles and carried by air are precipitated as wet or dry deposition on the surfaces of possible input materials. In the Composting Ordinance of the province of Baden-Wórttemberg a guide value for green compost and biowaste compost of 0.033 mg kg-1 d.m. per congener or a total of 0.2 mg kg-1 d.m. was fixed. PCB’s primary transport route is atmospheric transport

PCB in sludges: PCBs come from the industry and from oils. They also come from everyday products such as paper and alimentation. PCB content in sludge varies between 0 and 250 mg/kg d.m. in Member States

PCB in composts: The entry of PCBs into plant and other biogenic wastes mainly occurs through dust deposition. PCBs sometimes persist in paper and cardboard and are therefore more of a potential problem where household waste is to be included in the feedstock.

PCB in soils: These compounds are stable physically, chemically and biologically. They are lipophilic and have a tendency to concentrate in sludge and therefore in the organic material in the soil. They will be therefore slower degraded in soil rich in organic matter. Despite the biodegradation that can be observed in the soil and the partial volatilisation, these compounds are among the environmentally persistent compounds found nowadays forming a diffuse background in the environment

POLYCHLORINATED DIBENZODIOXINS AND DIBENZOFURANS (PCDD/F)

Properties and sources: According to toxicological assessment dioxins and furans are classified amongst the most problematic harmful substances. PCDD/F are ubiquitous in the environment at extremely low levels and can be lead back on anthropogenetic activities such as combustion/thermal processes and as trace pollution from various production-processes in chemical industries (chlorinated compound production processes; manufacture of insecticides, herbicides, antiseptics, disinfectants and wood preservatives). These groups consist of a total of 210 different congeneres. The whole spectrum of PCDD/F can be found in flue ash and flue gas of all types of waste incineration. On the one hand PCDD/F are a result of impurities in the incinerated waste, on the other hand they are synthesised during combustion (de novo-Synthese). Also other types of combustion processes, like domestic fuel (coal, wood, oil), traffic, processes in cable industry and different metallurgical processes can contribute to the general background load. PCDD/F are sometimes used in timber treatments.

PCDD/F in sludges: PCDD/F can be found in sewage sludges, whereby concentrations of PCDD were higher than at PCDF. PCDD/F arrive in sewage sludges as unwanted by-products from production processes, as impurities of products and as residue of burn processes. Following three origins can be identified:

- ✓ As by-products of the industry, they can appear in industrial effluents,
- ✓ They are present in the environment under a diffuse form for instance after deposition on soil and plants. They can enter the sewage system after running off from street and roofs,
- ✓ PCDD/Fs are present in the commercial preparations of insecticide products.

PCDD/Fs can concentrate in sludge. Sludge loss may happen through biological degradation or volatilisation, but that dioxins could also be generated during the wastewater treatment process because of biological activity.

PCDD/F in composts: PCDD/F contents of composts depend upon the processed raw material. In bio-waste and green waste composting lower values are in particular attainable by well directed collection and assortment of the material. Dioxins such as PCDD/F do not easily degrade and, in fact, tend to become more concentrated as composting proceeds due to the breakdown of organic matter. Inputs to compost can be reduced by refusing to accept PCDD/F treated timber. Many of the potentially problematic chemicals degrade during the composting process. However a general increase of PCDD/PCDF during the composting of yard and biowaste can be observed. Most examinations conducted during the composting process of biowaste showed an increase of hepta- and octa- PCDD. On the other hand the content of low chlorinated PCDD/PCDF decreased during the composting process and generally Furans are diminished. There are clear indications which show that the formation of dioxins originating from pentachlorphenol precursors is only possible above a temperature level of roughly 70 °C. Just as in other media dioxins and furans as anthropogenic compounds are also detectable in organic waste. A maximum value of 86.8 ng I-TEQ/kg in one compost sample and a sample median of 6.43 ng I-TEQ/kg dry matter were detected. In a decree in Baden-Wórttemburg (1994) a guide value for composts of 17 ng I-TEQ/kg dry matter (+30 %) was given. This is derived from the limit value in the German Sewage Sludge Ordinance of 100 ng/kg dry matter under the assumption of an annual input of dry matter of 10 tonnes of compost per hectare. Therefore the final guide value is 22 ng I-TEQ/kg dry matter. If the Austrian sewage sludge conditions were also based on this a guide value of 25 ng I-TEQ/kg dry matter (+30 %) would be set. An investigation showed that it is not necessary to conduct inspections of compost for dioxins and furans. However an investigation for PCDD/F is recommended where treated wood, dust and input materials contaminated with precursors such as PCP and PCB are used.

<u>PCDD/F in soils</u>: The main entry path for dioxins in soils are depositions via air. PCDD/F are nearly exclusively attached to dust particles and can reach the soils and/or their surface over dry, damp and wet deposition into. Beside the airborne dioxins also the secondary sources are of importance for soils, e.g. entries over sewage sludge, dioxin-loaded sediments in flood areas as well as in locally limited cases also deposits of contaminated material. Like PCBs these compounds are physically, chemically and biologically stable and are lipophilic. They tend to concentrate in sludge and subsequently in the organic material of the soil, and a very strong adsorption by soil is to be expected. In general, dioxins and furans will be found in the topsoil, and penetration to the deeper soil layers will only be possible under exceptional conditions (high water flow, preferential flow channel). They constitute a diffuse background of pollution in the environment. Volatilisation is a potentially important loss mechanism for PCDD/Fs in soil. Photolysis could also happen, but there is no consensus on this phenomenon. Lastly, biodegradation was observed in laboratory conditions, but it is assumed that it would be much slower in field conditions, especially for high-chlorinated species. Hydrolysis and oxidation are also thought to be insignificant in soils. Lastly, the formation of irreversibly bound,

nonextractable residues in soil could be of importance, but has not been enough documented yet If contaminated composts are repeatedly applied it is likely that within the foreseeable future an increase in the soil concentration of dioxins and furans will occur. In the production of "clean" composts.

POLYCYCLIC AROMATIC HYDROCARBONS (PAHs)

Properties and sources: Among others, the following compounds may be mentioned: naphtalene, polyphenyls acenaphtene, phenanthrene, fluorene, fluoranthene, pyrene, benzo(a)pyrene. Naphtalene is used in the colouring industry, as a component in wood treatment products and in mothballs. The polyphenyls are used as refrigerating fluid or as fungicide in the paper industry. PAHs are also generated as by products of incomplete combustion in certain industries in which carbon and hydrogen are pyrolysed: iron and steel industry, rubber industry etc. They are produced under mixed form, and their relative proportion in the mixture could enable to trace their origin. Naphtalene is the most soluble compound in water, the most volatile and the most biodegradable of the PAH compounds. Other PAH compounds however are insoluble in water, little biodegradable and have a high affinity for sludge's organic matter. Their characteristics of little biodegradable and lipophilic compounds increase with molecular weight. PAH are one of the most widespread persistent environmental pollutants. Sources of PAH are mainly defective processes for the incineration of fossil and organic fuels which are responsible for the heavy loading in metropolitan areas.

PAHs in sludges: There are three sources of PAH in sludge:

- ✓ PAHs are contained in exhaust gas and in the runoff of raining water on roads,
- ✓ PAHs are generated in the fumes of industrial thermal units and may reach the soil through raining water,
- ✓ PAHs are also found in industrial effluents.

PAHs can concentrate strongly in sludge and are little degraded by biological processes of water treatments. Sludge can contain between 0.018 and 10 mg/kg d.m. of PAHs in EU Member States.

PAHs in composts: PAHs have been found to be within acceptable levels when they have been checked for. They are easily degraded in sunlight by aerobic bacteria and are unlikely to persist through any well-managed composting operation. They are higher in material contaminated with tar or asphalt. Exclusion of these materials should reduce any risk to acceptable levels. The low aggregated PAHs, such as Triphenylene can be found in concentrations from n.d. up to 63.2 µg/kg dry matter, highly aggregated PAHs, such as Benzo(e)pyrene, were measured with concentrations up to 1264.7 µg/kg dry matter. The presence of ash in some of the composts is suspected at a few of the plants because of the raised levels of PAHs.

PAHs in soils: If compost is applied to the soil in quantities greater than 100 tonnes per hectare or is used as either the main part of the growing media in residential areas or in food production, then the PAH concentration should not be neglected. Future norms for recultivation concerning the addition of compost, secondary raw material and the replacement of soil following extraction should include limits the concentration of PAHs and be tailored to the local situation. Most PAHs are very persistent in soils. Their half-life can reach until 10 years. They also are slowly biodegraded. PAHs are relatively insoluble in water and are therefore absorbed to the particulate phase, especially the organic matter. Loss from soil may be due to photodegradation, or volatilisation (mainly for 2 and 3 ringed PAHs)

CHLORINATED PESTICIDES:

Properties and sources: Chlorinated pesticides as Aldrin, Biphenyl, Chlordan, Dieldrin, Endrin, Heptachlor, DDT [1,1,1-trichlor-2,2-bis(p-chlorphenyl)ethan] and its metabolites as well as Lindane and HCH-isomers (Hexachlorcyclohexan), Hexachlorbenzene (HCB) Heptachlor originate from their application in agriculture. They remain ubiquitous and contaminate the environment even though most of these chemicals are not allowed to be applied in agriculture any longer.

Chlorinated Pesticides in composts: Lindane-concentrations found in compost are extremely low, proving negligible for negatively influencing compost quality. The addition of wood chips to biogenic waste may lead occasionally to increased gamma-HCH-values (Lindane) in compost, because it is still in use for the protection of lumber in the forest. The contents of all other xenobiotics in BWC and GC are extremely low and give no rise to any questions with regard to compost quality. Pesticides have been found to degrade best at temperatures of around 52 °C. Good management of the process should therefore reduce any contamination and associated problems. Results of a suite of analyses carried out on a range of pesticides in compost in the UK have indicated contents below the level of detection. This suite included lindane, chlorinated hydrocarbons such as DDT and organophosphates. As a fitness for use issue, pesticides are, arguably, the most important group of pollutants to consider in compost. The combined group of chlorinated hydrocarbons is composed of differing chemical compounds. The occurrence of pesticides in garden compost as well as a few representatives of this group were to be found in almost all samples. For instance Lindane, a chlorinated hydrocarbon which is found in plant protection products and is applied as an insecticide, was frequently detected. Samples of compost with concentrations below 3.8 μg/kg dry matter were only measured in a few samples of compost. At the present time a routine investigation of the whole range of chlorinated hydrocarbons is not judged to be necessary. Random sampling for PCP, AOX as well as g-HCH in bark compost may prove to be useful.

DDT and metabolits (DDX)

In past decades this pesticide was used frequently and for many purposes. The persistence of this compound came to light straight away, so that its global use was limited to a few cases of use and in Austria all uses were banned. However traces are still found in all parts of the environment and an accumulation in the biosphere is found. In 15 plants compost samples showed DDX values of up to 21.2 µg/kg dry matter. This demonstrates the potential occurrence of these compounds in the environment. In the soils of Upper Austria an average of 0.6 and 1.0 µg DDX/kg d.m. was found under grassland and arable land respectively. The DDX value in the humus layer of Austrian background forested locations had a median of 7.79 µg/kg d.m. The biological decomposition of DDX in soil takes place extremely slowly. The take up of DDX through the roots by plants is not known or not available. The contamination from the air is substantial. The 1994 Fertiliser Ordinance (BGBl. 1007/1994) provides for a "Total" limit value for all organochlorine pesticides of 1 mg/kg dry matter. This group contains the following compounds: aldrin, dieldrin, endrin, heptachlor, total HCH, DDT and DDE, chlordane and hexachlorobenzene. If the highest values produced by this study are added up taking no account of which plants they come from a total value of 71.06 µg/kg d.m. obtained of which DDX constitutes one third. From this it can be derived that the loading of compost with chlorine pesticides is within the limit values of the DMVo, a finding that has also resulted from other investigations. For this reason it is concluded that routine investigations of compost for these substances are not necessary.

Pyrethroide

In this investigation the concentrations of Pyrethroides found were not remarkable. Nevertheless noticeable contamination is to be expected where the compostable materials from use in allotments, kitchen waste and pest control enter into the compost. As Pyrethroide are persistent substances the investigation also considered substances which are not permitted in Austria. Following the results of this analysis analysis can justifiably be limited to the substances which are both permitted and often used. The maximum concentration of Cyfluthrine and Deltamethrine detected were 68 and 60 µg/kg dry matter respectively which lie significantly below the limit value of the 1994 Fertiliser Ordinance, meaning that only where contamination is suspected it should be investigated.

Thiabendazole

Thiabendazole is a systematic fungicide which is taken up through leaves and roots. It is used both on crops such as bananas, citrus fruits and mangoes and to control pests and fungi in storage, such as on potatoes against Fusaria infestations. In the environment its toxic effects on fish are the most important. The median of the measured Thiabendazol concentrations in composts lies between the detection and the determination limits. Higher concentrations (max. 32.7 μg/kg dry matter) were found in kitchen compost than in garden compost.

Linear alkylbenzene sulphonates (LAS)

Properties and sources: Tensid, which is used in detergents, rinsing and cleaning agents, contained in sewage sludges. Annual worldwide consumption of LAS is approximately 2.106 tons and EU consumption is assumed to be about 300 000 tons. Linear alkylbenzene sulphonate (LAS) is an anionic surfactant. It was introduced in 1964 as the readily biodegradable replacement for highly branched alkylbenzene sulphonates (ABS). LAS is a mixture of closely related isomers and homologues, each containing an aromatic ring sulphonated at the para position and attached to a linear alkyl chain. In raw sewage, the LAS concentration was in the range of 1-15 mg/l. When the sewage was properly treated in activated sludge sewage treatment plants (STP), LAS was removed by more than 99% decreasing its effluent concentration in the 0.009-0.14 mg/l range. Its concentration was further decreased by dilution in the receiving waters where it could be found in the <0.002-0.050 mg/l concentration range.

LAS in sludges: LAS degrades rapidly aerobically, whereas it does not degrade under anaerobic conditions, except in particular conditions. In sludge treatment plant sludge, LAS concentration was in the range of <1 to 10 g/kg. During sludge transportation to the farmland, sludge storage, and application on agricultural soil, aerobic conditions are restored and rapid degradation of LAS resumes.

LAS in composts: LAS have a high degree of breakdown in aerobic composting conditions.

LAS in soils: In sludge-amended soils, LAS had a half-life of about one week and levels were around 1 mg/kg at harvesting time. No accumulation in soil and no bioaccumulation in plants could be detected experimentally.

Nonylphenol (NPE)

Sources: NPE are surface-active agents used in detergents and washing powders. The toxic decomposition product Nonylphenol is formed in wastewater treatment plants when incoming nonylphenolethoxylates are converted during digestion of the sludge and is therefore contained in sewage sludges

Nonylphenol in sludges: The main origin of those compounds in sludge is the daily and industrial use of detergents. Their metabolites can appear in the sludge during its biological evolution. They concentrate in sludge but undergo rapid biodegradation under aerobic conditions.

Nonylphenol in composts: Nonylphenol has a high degree of breakdown in aerobic composting conditions.

Nonylphenol in soils: NP has a short half-life in soil, suggesting a reduced risk of accumulation. In laboratory studies and some field studies, it has been found that all, or a large fraction of the NPs applied through sludge application disappear from soil within 50-100 days. These studies also reported that such an important degradation only takes place under aerobic conditions and if microbial activity is not inhibited. Studies also observed that microbial metabolism would be the main route for degradation of nonylphenols in soil.

Di (2-ethylhexyl) phthalate (DEHP)

Properties and sources: DEHP belongs to the esters of phtalates, which are all esters of the phtalic acid. It accounts for over half of the total use of phtalates and is also the most well studied of these compounds. DEHP may be used as a plasticiser, with application in the construction and packaging industries (for instance in the production of PVC), as well as in the production of alkyd resins (lacquer bonding agents/binders), of coloring materials and of components of medical devices. The detection of DEHP may be disturbed when using plastic chemical devices, as they can be found in such products. This organic compound is little persistent and lipophilic. Di (2-ethylhexyl) phthalat is produced in large quantities, appears ubiquitously and accumulates in the sewage sludge.

Phthalates in sludges: DEHP-like compounds originate from effluents of the plastic industry and from compounds in plastic matter, which can be transferred in the wastewater. DEHP and phtalates accumulate in sludge with concentrations between 20 and 660 mg/kg d.m. in EU countries.

Phthalates in composts: DEHP from plastics such as foils and floor mats, lacquers etc. probably is released into the environment by abrasion, evaporation or extracting and also introduced into the bio ton over impurities. Correlations between the DEHP load and parameters like impurities in the inputs material, sorting effort and catchment area are not significant. Composts with increased DEHP content do not necessarily show increased contents of other pollutants. Phthalates have a high degree of breakdown in aerobic composting conditions.

Phthalates in soils: DEHP has a low water solubility and a high octanol-water partition coefficient. Therefore its absorption in soil is high. Under aerobic conditions, micro-organisms degrade DEHP relatively easily, explaining the relatively low soil concentration reported in the relevant literature. DEHP seems to accumulate in soil after sludge distribution, but only when very large amounts of sludge are applied. At normal doses, accumulation does not occur because of the very short half- life of the compound under aerobic conditions. Under anaerobic conditions, DEHP is very slowly or not at all degraded

Nonylphenol, phthalates, toluene and LAS all have a high degree of breakdown in aerobic composting conditions.

ANNEX 3 : California Integrated Waste Management Board (CIWMB) Compost Quality Standards for finished compost

Indicator	**Quality Standard for Finished Compost**	
Visual	All material is dark brown (black indicates possible burning). Parent material is no longer visible. Structure is mixture of fine and medium size particle and humus crumbs.	
Physical	Moisture: 30-40%, Fine Texture (all below 1/8" mesh)	
Odor	Smells like rich humus from the forest floor; no ammonia or anaerobic odor.	
Nutrient	Carbon:Nitrogen Ratio	<17:1
	Total Organic Matter	20-35%
	Total Nitrogen	1.0-2.0%
	Nitrate Nitrogen	250-350 PPM
	Nitrite Nitrogen	0 PPM
	Sulfide	0 PPM
	Ammonium	0 or trace
	pH	6.5-8.5
	Cation Exchange Capacity (CEC)	>60 meq/100g
	Humic Acid Content	5-15%
	ERGS Reading	5,000-15,000 mS/cm
Microbiological	Heterotrophic Plate Count	1×10^{8} - 1×10^{10} CFU/gdw
	Anaerobic Plate Count	Aerobes: Anaerobes at 10:1 or greater
	Yeasts and Molds	1×10^{3} - 1×10^{5} CFU/gdw
	Actinomycetes	1×10^{6} - 1×10^{8} CFU/gdw
	Pseudomonads	1×10^{3} - 1×10^{6} CFU/gdw
	Nitrogen-Fixing Bacteria	1×10^{3} - 1×10^{6} CFU/gdw
	Compost Maturity	>50% on Maturity Index at dilution rate appropriate for compost application.
	Compost Stability	<100 mg O^{2}/Kg compost dry solids-hour
	E. coli	< 3 E. coli/g
	Fecal Coliforms	<1000 MPN/g of dry solids
	Salmonella	< 3 MPN/4g total solids

ANNEX 4 : New Zealand Seed Germination Test to Determine Phytotoxicity in Compost

The test involves visually scoring the germination and early root growth of radish seeds in the test sample, using a known non-toxic sample (aged bark) as a control.

Aged bark shall be purchased from HortResearch, Ruakura Research Centre, Hamilton.

1. Sample must be moist before testing.
2. Take two petri dishes and write details of sample on lids.
3. Mix equal parts of the sample and pumice (grade 0–3 mm) thoroughly in a container. Shake well for 30 seconds.
4. Lightly press sample into base of dish.
5. With a nail, make 8 'holes' in the sample media.
6. Drop one radish seed (Yates 'Salad Crunch') into each hole.
7. Carefully brush back media to cover the seeds and replace lid.
8. A control sample of aged bark is prepared at the same time as per Steps 1 to 7 above.
9. Leave on bench and keep moist and out of direct sunlight and check daily.
10. After 3–4 days record number of seeds germinated and score root growth as follows:

Root Length	Score
0	0
1-20% of control	1
21-80%	2
81-100%	3

According to NGIA standards the score for root length must be ≥2 while seed germination must be ≥75% of the control sample.

ANNEX 5 : Soil Association (SA) standards for green waste compost

This fact sheet is aimed at anyone who wishes to compost green waste or to use green waste compost in organic production. It explains how to produce green waste compost and use it in a way that fits within the framework of the Soil Association Organic Standards.

Organic farms need to recycle nutrients to sustain and build soil fertility, and to achieve crop and livestock health. The responsible and effective use of manure and plant wastes is essential for the effective cycling of nutrients. Composting results in a stabilised product, free of pests, pathogens and weed seeds - an excellent material for building soil organic matter and supporting soil microbial communities.

Although the organic ideal is the cycling of nutrients within the farm system, the Soil Association recognises that municipal green wastes represent a good source of compost feedstock, providing an important means to divert these biodegradable wastes from landfill sites.

Green waste is a 'restricted' material under organic standards, which means that an organic producer needs to get approval from Soil Association Certification Ltd (SA Certification) before they can use green waste materials on organic land and crops. The Soil Association recognises that use of green waste is compatible with the basic principles of sustainability and can be used as part of the on farm fertility and soil health programme.

Requirements for Soil Association approval:

- Provide details of the source of origin for material used - green garden/amenity waste (no food waste, although SA Certification would consider raw waste trimmings/spoils from a packing plant if GM issues were satisfied)
- Keep records of intakes and quantities
- Provide SA Certification with details of the 'screening process' to use green waste from kerbside collection schemes
- Provide details of the process to separate the waste and ensure contaminants are removed
- Carry out tests of the finished compost for heavy metal, microbiological and seed germination
- Create and maintain a clearly defined site management plan that prevents cross contamination of feedstock
- Ensure that composting sites comply with all other legal requirement

Relevant Soil Association standards relating to composting of green waste

1. To optimise nutrient cycles and prevent nutrient loss, you must return manure and plant wastes to the soil. You should return enough to increase or at least maintain soil fertility and microbial activity. Together with a sound rotation, this should form the basis of soil fertility management.

2 You may use:

- organically produced straw, farmyard manure (FYM) and poultry manure, preferably after composting it properly
- organically produced slurry, urine and dirty water, preferably after aerating
- plant waste materials and by-products from organic food processing, preferably after treating, and
- sawdust, shavings and bark from untreated timber.

3 With our permission, you may use non-organic animal manure or plant waste. However, you must:

- give us details of the manure, including the animal species and the husbandry system it comes from
- send us a completed GMO Declaration for brought in FYM (available from us on request)
- tell us why you need to use it, and
- make sure the manure or plant waste has been stacked or composted for the required time (see standard 17).

Note – we may ask you for a soil or manure analysis before we give you permission. This is to check that the levels of heavy metals in the soil or manure are acceptable.

With our permission you may use:

- compost activators made from microbial and plant extracts, and
- biodynamic preparations.

4 You must only use non-organic manure and plant wastes to complement your soil fertility management. You must use them only occasionally and when other ways of maintaining soil health and fertility are insufficient.

5 With our permission, you may use non-organic animal manure or plant waste. However, you must:

- give us details of the manure, including the animal species and the husbandry system it comes from
- send us a completed GMO Declaration for brought in FYM (available from us on request)
- tell us why you need to use it, and
- make sure the manure or plant waste has been stacked or composted for the required time (see standard 17).

Note – we may ask you for a soil or manure analysis before we give you permission. This is to check that the levels of heavy metals in the soil or manure are acceptable.

6 The following non-organic manure, plant wastes and by-products are acceptable to use subject to standard 5:

- straw, FYM and stable manure
- poultry manure and deep litter from the following egg producing systems (defined by EEC Regulation No. 1274/91):
  - free range – maximum 1,000 birds/ha
  - semi-intensive – maximum 4,000 birds/ha
  - deep litter – maximum seven birds/m^2
  - deep litter pullet rearing systems – maximum housing density 17 kg birds/m^2
- poultry manure and deep litter from the following meat producing systems (defined by EEC Regulation No. 1538/91):
  - free range
  - traditional free range
  - extensive indoor barn reared (maximum housing density of 12 mature birds or 25 kg/m^2)
- manure from straw-based pig production systems
- by-products from food processing industries
- plant wastes and by-products, including green wastes
- mushroom composts, worm composts and animal slurry made from non-organic animal manure conforming to these standards
- dirty water from non-organic systems, but only to in-conversion land

- feather meal from the non-organic systems identified in this standard.

7 You may use compost from household waste if it meets all legal requirements.
Note – please see www.defra.gov.uk/environment/waste/topics/compost/index.htm for more information on the legal requirements.

8 If you wish to use a compost which we have not licensed or approved you will need to provide us with a heavy metal analysis of the material. Compost from household waste must contain concentrations no more than (in mg/kg of dry matter):

- Cadmium: 0.7
- Copper: 70
- Nickel: 25
- Lead: 45
- Zinc: 200
- Mercury: 0.4
- Chromium (VI): 0.

9 If you produce compost for sale to organic farmers your composting facilities and methods must meet the requirements of the Publicly Available Specification for Composted Materials (PAS100). You must meet the PAS100 in addition to the requirements of these standards.
Note – PAS100 specifies the minimum requirements for the process of composting, the selection of input materials and the quality of the composted materials, but does not include requirements for organic production. If you need a copy of the PAS100 please contact The Composting Association, WRAP or our food and farming department.

10 You must not use:

- sewage sludge, effluents and sludge-based composts
- animal residues and manure from livestock systems that do not meet these standards, including:
    - i. battery poultry systems
    - ii. broiler units with stocking rates over 25 kg/m^2
    - iii. indoor tethered sow breeding units

- iv. other systems where the animals are not freely allowed to turn through 360°, where they are permanently in the dark, or are permanently kept without bedding.

Note – please refer to standard 9 for processed animal products and fish products you can use in protected cropping, propagation composts and perennial crops.

Managing compost, manure and slurry

11 The quality and effectiveness of manure and slurry improves after treatments such as composting, anaerobic digestion, aeration of slurry and storage.

12 Well managed compost heaps and anaerobic digesters will reduce the number of pathogens, destroy most weed seeds, chemical residues and antibiotics that may be present in the animal or plant wastes. Composting will also stabilise nutrients, reduce nutrient losses in the soil and help to meet the needs of a crop through the growing season.

13 You should:

- store and compost manure and plant waste indoors, under plastic sheeting or on hard standing where you can collect run-off (to prevent losing nutrients during periods of heavy rainfall)
- monitor the temperature throughout the composting process
- build slurry tanks and slurry lagoons to British Standard 5502: 1989, and install aeration facilities
- analyse compost to make sure human pathogens have been removed
  – we suggest you:
  - i. use a HACCP based approach
  - ii. record three continuous days' temperatures at over 55°C for each batch
  - iii. sample the first three batches for Salmonella and E. coli, and
  - iv. make further analyses if you change the manure waste source
- apply only properly composted materials, and
- only apply composted manure, plant waste and aerated slurry in spring and summer, and onto grassland, cultivated land and land you plan to use for fertility building crops.

14 You should keep compost heaps made from organic manure or plant waste for at least three months and turn them frequently to achieve an even temperature of at least 55°C.

15 Treatments you should use for organic manure and plant waste:

- treatment for slurry: aerated
- treatment for manure and plant waste, including straw:
    - i. stacked for three months
    - ii. stacked for two months and turned at least twice, or
    - iii. properly composted.

Note – please refer to standard 17 for how you must treat non-organic manure and plant waste.

16 You should produce a farm waste management plan which details how you will manage manure and crop residues to:

- • recycle nutrients, and
- • minimise nutrient losses.

Note – you can get a guide that will help you produce a farm waste management plan from Defra (Farm Waste Management Plan – The Defra step by step guide for farmers).

17 You must treat your non-organic manure and plant waste as follows:

- treatment for slurry: aerated
- treatment for pig and poultry manure from systems described in standard 6:
    - i. stacked for 12 months
    - ii. stacked for six months and turned at least twice, or
    - iii. properly composted
- treatment for other livestock manure and plant waste, including straw and by-products from non-organic food processing:
    - i. stacked for six months
    - ii. stacked for three months and turned at least twice, or
    - iii. properly composted.

18 Manure treatments, storage systems and applications must conform to the Water Resources Act 1991 and the Defra Code of Good Agricultural Practice for the Protection of Water. You can get free copies of these from Defra Publications or the Environment Agency.

19 Your storage facilities must be:

- able to cope with the amount of manure and slurry that is produced on your holding
- large enough to stop pollution of watercourses and ground water through direct flow, or by run off and penetration of the soil, and
- large enough to store manure throughout the times of the year you are not able or allowed to apply it to the land. This might be when the weather or land is not suitable or if your production unit is in a nitrate vulnerable zone.

Note – we consider that to meet the above standards you should have at least four months storage capacity for livestock manure and slurry. This should be in place before your land becomes organic.

ANNEX 6 : Compost specifications for the Landscape Industry in UK

Compost specification for use in mulching

The specification below sets out further requirements for the use of compost in mulching applications. This compost specification is designed to be used in addition to the requirements of PAS 100:2005 for this application.

Horticultural parameters	**Reported as** (units of measure)	**Recommended range**
pH	pH units (1:5 water extract)	6.0 – 9.0
Electrical conductivity	µS/cm or mS/m (1:5 water extract)	3000 µS/cm or 300 mS/m max
Moisture content	% m/m of fresh weight	35 – 55
Organic matter content	% dry weight basis	>30
Particle sizing	% m/m of air-dried sample passing the selected mesh aperture size	99% pass through 75mm screen <25 pass through 10mm screen
Contaminant parameters	Various	Meet BSI PAS 100 Criteria (Table 19)

How to use: Uniformly apply compost mulch over the entire treatment area, or in a one metre circle around the plant. Apply the compost mulch at a 25 - 75 mm layer over the area to be treated (2.5 – 7.5 m3 per 100 m2), or in a one metre circle around a singular plant (20 – 60 litres per tree). Apply mulch as soon as possible after planting, applying it closely around plant stems but not against them. Water plant(s) in thoroughly prior to mulching, then again after mulching.

Sold by: Compost will be measured by the cubic metre or the tonne at the point of loading.

Cultural practices: Take note that the addition of a compost mulch will reduce the required frequency of watering. In many cases, applying a compost mulch may reduce post planting fertilization, as the compost mulch will supply some soluble nutrients (when a stable compost is applied at recommended rates).

Footnotes: The Landscape Architect/Designer shall specify the compost mulch application rate depending upon soil conditions and quality, plant tolerances, and manufacturer's recommendations. For most projects, uniformly apply a 25 - 75 mm layer of compost mulch over the area to be treated, (2.5 – 7.5 m3 per 100 m2). The application rates above are typical for many plant species and sites.

Compost specification for use in planting bed establishments

The specification below sets out further requirements for the use of compost in planting bed preparation. This compost specification is designed to be used in addition to the requirements of PAS 100:2005 for this application.

Horticultural Parameters	**Reported as** (units of measure)	**Recommended Range**
pH	pH units (1:5 water extract)/td>	7.0 – 8.7
Electrical Conductivity	µS/cm or mS/m (1:5 water extract)	2000 µS/cm or 200 mS/m max
Moisture Content	% m/m of fresh weight	35 – 55
Organic Matter Content	% dry weight basis	>25
Particle Sizing	% m/m of air-dried sample passing the selected mesh aperture size	99% pass through 25mm screen 90% pass through 10mm screen
Contaminant Parameters	Various	Meet BSI PAS 100 Criteria (Table 19)

How to use: Compost that meets the requirements of the BSI PAS 100 will gaurantee an appropriate and safe product. BSI PAS 100 covers the range of materials used to make the compost, their quality and traceability, the minimum requirements.

Sold by: Compost will be measured by the cubic metre or the tonne at the point of loading.

Soil analysis: Before any soil preparation procedures ensue, a soil analysis shall be completed by a reputable laboratory to determine any nutritional requirements, and any pH and organic matter adjustments necessary. Once determined, the soil shall be appropriately amended to a range suitable for the plant species to be established.

Cultural practices: Take note that the addition of compost may reduce the required frequency of watering. In almost all landscaping applications, the addition of pre-plant fertilizer can be eliminated when a stable compost is applied at recommended rates.

Footnotes: The Landscape Architect/Designer shall specify the compost inclusion rate depending upon soil conditions and quality, plant tolerances, and manufacturer’s recommendations. The application rates recommended above are suited for most external planting beds. However, recommendations may require modification for plant species requiring low nutrient levels, and those that are limehating, such as rhododendrons, camellias, etc. Typically, compost should not be used (and sometimes used at 1/2 the normal application rate) where lime-hating species are established. Lower compost application rates may be necessary for salt sensitive crops or where composts possessing higher salt levels are used. For most projects, uniformly apply a 25 - 50 mm layer of compost over the area to be treated, (2.5 – 5.0 m^3 per 100 m^2). However, soils rich in organic matter may not require any compost, while even higher compost application rates could be used on soils that are very low in organic matter, or droughty (primarily sand and gravel based). These recommendations are suited for most ornamental planting beds.

Compost specification for use in grass establishment

The specification below sets out further requirements for the use of compost in grass establishment. This compost specification is designed to be used in addition to the requirements of PAS 100:2005 for this application.

Horticultural Parameters	**Reported as** (units of measure)	**Recommended Range**
pH	pH units (1:5 water extract)	7.0 – 8.7
Electrical Conductivity	µS/cm or mS/m (1:5 water extract)	2000 µS/cm or 200 mS/m max
Moisture Content	% m/m of fresh weight	35 – 55
Organic Matter Content	% dry weight basis	>25
Particle Sizing	% m/m of air-dried sample passing the selected mesh aperture size	99% pass through 25mm screen 90% pass through 10mm screen
C:N Ratio		20:1 maximum
Contaminant Parameters	Various	Meet BSI PAS 100 Criteria (Table 19)

<u>How to use:</u> Uniformly apply compost over the entire treatment area at an average depth of 25 to 50 mm, then incorporate it to a minimum depth of 150 mm using a rotovator or other appropriate equipment. Fertilizer and pH adjusting agents (e.g., lime and sulphur) may also be applied before incorporation, if necessary. Rake soil surface smooth prior to seeding, hydraulic seeding or laying turf. The soil surface shall be free of large stones and clay balls larger than 50 mm in any dimension, roots, tufts of grass, rubbish and debris, and other material which will interfere with planting and subsequent site maintenance. Water thoroughly after seeding or laying turf.

<u>Sold by:</u> Compost will be measured by the cubic metre or the tonne at the point of loading.

Soil analysis: Before any soil preparation procedures ensue, a soil analysis shall be completed by a reputable laboratory to determine any nutritional requirements, and any pH and organic matter adjustments necessary. Once determined, the soil shall be appropriately amended to a range suitable for the turf species to be established.

Cultural practices: Take note that the addition of compost may reduce the required frequency of watering. In almost all grass establishment applications, the addition of pre-plant fertilizer can be reduced and sometimes eliminated when stable compost is applied at recommended rates.

Footnotes: The Landscape Architect/Designer shall specify the compost inclusion rate depending upon soil conditions and quality, plant tolerances, and manufacturer's recommendations. For most projects, uniformly apply a 25 - 50 mm layer of compost over the area to be treated, (2.5 – 5.0 m3 per 100 m^2). The application rates above are typical for many sites. However, soils rich in organic matter may not require any compost, while even higher compost application rates could be used on soils that are very low in organic matter, or droughty (primarily sand and gravel based). These recommendations are suited for most swards, established through seeding, turfing, or hydraulic seeding. However, recommendations may require modification for sand-based pitches and golf surfaces, and possibly sportsfields.

Composting specification for ex-situ use when manufacturing topsoil on site using

The specification below sets out further requirements for the ex-situ use of compost in topsoil manufacturing. This compost specification is designed to be used in addition to the requirements of PAS 100:2005 for this application.

Horticultural Parameters	**Reported as** (units of measure)	**Recommended Range**
pH	pH units (1:5 water extract)	6.5– 8.7
Electrical Conductivity	µS/cm or mS/m (1:5 water extract)	3000 µS/cm or 300 mS/m max
Moisture Content	% m/m of fresh weight	35 – 55
Organic Matter Content	% dry weight basis	>25
Particle Sizing	% m/m of air-dried sample passing the selected mesh aperture size	95% pass through 25mm screen 90% pass through 10mm screen
C:N Ratio		20:1 maximum
Contaminant	Various	Meet BSI PAS 100

Parameters		Criteria (Table 19)

How to use: Analyse existing soil characteristics to determine the appropriate ratio of existing soil and imported materials (e.g., compost, soil) necessary to manufacture an acceptable soil. Identify a site location to complete on-site stockpiling of materials and blending activities.

1. Begin the process by cultivating the soil using a one or three tine ripper, or equivalent, to a minimum depth of 300 mm (300 mm to 900 mm) in two directions obliquely, when ground conditions are reasonably dry. Strip this existing, loosened, soil to a depth adequate to obtain the appropriate volume and quality of subsoil needed for the project.
2. Stockpile stripped (and imported) soils, and compost, at the identified location on the site, preferably, at or near the location for blending. Using a 360 degree excavator, front-end loader or equivalent, or customised blending plant, uniformly blend existing soil with compost on a volume to volume basis [or equivalent weight basis].
3. All materials must be thoroughly blended, but not 'over mixed' (not blended to the extent that soil structure is destroyed). Compost inclusion rates will be based on current soil conditions, expected use of the treated site (e.g., vegetation/plants to be established, intensity of activity on site, and the basic BS 3882 topsoil standard you are trying to meet). Also, blend in any imported soils necessary to meet the required soil grade or the textural requirements of the 'finished' manufactured topsoil.
4. Subsoil by ripping the area, if required, and then spread the full quantity of manufactured topsoil and gently firm (do not compact manufactured topsoil with machinery). Manufactured topsoil should be applied to a minimum depth of 150 mm for areas to be seeded or turfed, and 300 mm for areas to be planted. Complete a minimum of two weeks prior to seeding, turfing or planting. Analyse manufactured soil.

Sold by: Compost will be measured by the cubic metre or the tonne at the point of loading.

Soil analysis: When considering topsoil manufacturing for a specific site, more thorough soil sampling and evaluation is suggested on both the topsoil and subsoil. This will allow for a more precise estimation of soil textures and volumes. When manufacturing topsoil on a brownfield site, perform a soil investigation to include all relevant horticultural soil parameters, including those referenced in BS 3882 and the SGV table. Refer to BS 10175:2001, Investigation of

Potentially Contaminated Sites Code of Practice and BS 5930:1999, Code of Practice for Site Investigations for additional information.

Cultural practices: Take note that the addition of compost may reduce the required frequency of watering. In almost all non-grassing landscape applications, the addition of pre-plant fertilizer can be eliminated when a stable compost is applied at recommended rates. When establishing grass some additional fertilization may be required.

Footnotes:

1. Areas which possess hardstanding are preferred for stockpiling and blending, however other compacted surfaces are acceptable.
2. The depth to which the soil should be stripped is based on the depth and quality of the existing soil materials, and the finished levels of the final proposals, as well as the quantity (depth) of manufactured topsoil specified. Excavate to a greater depth if necessary to win the most suitable subsoils and make up levels with less suitable soils.
3. The customised blending plant should use paddles, or other mechanisms, that do not grind the soil components.
4. The Landscape Architect/Designer shall specify the compost inclusion rate depending upon soil conditions and quality, plant tolerances, and manufacturer's recommendations. Goal: to create a soil medium possessing characteristics that more closely resembles a loam soil, and possessing a minimum of 5% organic matter (on a dry weight basis). [Rule of thumb: Where a typical compost with an organic matter content of 30% on a dry weight basis (other 70% is water and mineral particles) blended at 65-84 m^3 (33 - 42 tonnes of moist compost) with 100 m3 (100 - 133 tonnes dry weight) of soil would raise the organic matter of a soil with low organic matter content, e.g. 2%, up to 5%.] These recommendations are suited for most swards, established through seeding, turfing, or hydraulic seeding and planting areas, and for most external planting beds. However, recommendations may require modification for areas used to develop sportsfields, and for planting areas used to grow plant species requiring low nutrient levels, and those that are lime-hating, such as rhododendrons, camellias, etc.

Compost specification for in-situ use in topsoil manufacturing

The specification below sets out further requirements for the in-situ use of compost in topsoil manufacturing. This compost specification is designed to be used in addition to the requirements of PAS 100:2005 for this application.

Horticultural Parameters	**Reported as** (units of measure)	**Recommended Range**
pH	pH units (1:5 water extract)	6.5– 8.7
Electrical Conductivity	µS/cm or mS/m (1:5 water extract)	3000 µS/cm or 300 mS/m max
Moisture Content	% m/m of fresh weight	35 – 55
Organic Matter Content	% dry weight basis	>25
Particle Sizing	% m/m of air-dried sample passing the selected mesh aperture size	99% pass through 25mm screen 90% pass through 10mm screen
C:N Ratio		20:1 maximum
Contaminant Parameters	Various	Meet BSI PAS 100 Criteria (Table 19)

How to use: Analyse existing soil characteristics to determine necessary additions. Cultivate the soil using a one or three tine ripper, or equivalent, to a minimum depth of 300 mm (300 mm to 900 mm) in two directions obliquely, when ground conditions are reasonably dry. Using excess site soil, grade the soil to smooth flowing contours that are within 25 - 75mm from the specified finished soil level. Immediately before spreading compost (and other soil materials, if necessary) remove stones larger than 25 mm. Uniformly apply compost. Application rates will be based on current soil conditions, expected use of the treated site1 (e.g., vegetation/plants to be established, intensity of activity on site, and the basic BS 3882 topsoil standard). Follow by applying any imported soils necessary to meet the required soil grade or the textural requirements of the 'finished' manufactured topsoil. Uniformly incorporate compost to a minimum depth of 150 mm for areas to be seeded or turfed, and 300 mm for areas to be planted. Through cultivation, break up soil into particles of 10 mm, and under. Complete a minimum of two weeks prior to seeding, turfing or planting. Analyse manufactured soil.

Sold by: Compost will be measured by the cubic metre or the tonne at the point of loading.

Soil analysis: When considering topsoil manufacturing for a specific site, more thorough soil sampling and evaluation is suggested on both the topsoil and subsoil. This will allow for a more precise estimation of soil textures and volumes. When manufacturing topsoil on a brownfield site, perform a soil investigation to include all relevant horticultural soil parameters, including those referenced in BS 3882 and the SGV table. Refer to BS 10175:2001, Investigation of

Potentially Contaminated Sites Code of Practice and BS 5930:1999, Code of Practice for Site Investigations for additional information.

Cultural practices: Take note that the addition of compost may reduce the required frequency of watering. In almost all non-grassing landscape applications, the addition of pre-plant fertilizer can be eliminated when a stable compost is applied at recommended rates. When establishing grass some additional fertilization may be required.

Footnotes: The Landscape Architect/Designer shall specify the compost application rate depending upon soil conditions and quality, plant tolerances, and manufacturer's recommendations.

Goal: to create a soil medium possessing characteristics that more closely resembles a loam soil, and possessing a minimum of 5% organic matter (on a dry weight basis). [Rule of thumb: Where a typical compost possessing an organic matter content of 30% on a dry weight basis (other 70% is water and mineral particles) is applied at a 50 - 75 mm depth (2 - 3") and incorporated to a depth of 150 mm, the organic matter content of the soil will be increased by approximately 2% (use the higher rate for soils with a higher bulk density).

These recommendations are suited for most swards, established through seeding, turfing, or hydraulic seeding and planting areas, and for most external planting beds. However, recommendations may require modification for areas used to develop sportsfields, and for planting areas used to grow plant species requiring low nutrient levels, and those that are lime-hating, such as rhododendrons, camellias, etc.

Compost specification for use in planting pits backfills:

The specification below sets out further requirements for the use of compost in planting pit preparation. This compost specification is designed to be used in addition to the requirements of PAS 100:2005 for this application.

Horticultural Parameters	**Reported as** (units of measure)	**Recommended Range**
pH	pH units (1:5 water extract)	7.0 – 8.7
Electrical Conductivity	µS/cm or mS/m (1:5 water extract)	2000 µS/cm or 200 mS/m max
Moisture Content	% m/m of fresh weight	35 – 55
Organic Matter	% dry weight basis	>25

Content		
Particle Sizing	% m/m of air-dried sample passing the selected mesh aperture size	99% pass through 25mm screen 90% pass through 10mm screen
C:N Ratio		20:1 maximum
Contaminant Parameters	Various	Meet BSI PAS 100 Criteria (Table 29)

How to use: Excavate a planting hole equal in depth to the root mass, and 2 to 3 times its width. Place the root mass on firm soil so that the top of the root mass is level with the soil surface. For shrubs, bulbs and herbaceous plants: uniformly blend a 3:1 ratio1 (v/v) of soil and compost where soils are sandy in nature, or subsoils. Use a 4-5:11 (v/v) soil and compost ratio when planting species that require low nutrient levels, or on sites where soil quality is more favourable. For trees: use a 4:1 ratio1 (v/v) blend of excavated soil and compost. Place blended soil around the root mass, firming occasionally. Do not apply fertilization in the backfill material, or at time of planting. Water thoroughly after planting.

Sold by: Compost will be measured by the cubic metre or the tonne at the point of loading.

Soil analysis: Before any soil preparation procedures ensue, a soil analysis shall be completed by a reputable laboratory to determine any nutritional requirements, pH and organic matter adjustments necessary.

Cultural practices: Take note that the addition of compost may reduce the required frequency of watering. In almost all landscape applications, the addition of pre-plant fertilizer can be eliminated when a stable compost is applied at recommended rates.

Footnotes: The Landscape Architect/Designer shall specify the compost inclusion rate depending upon soil conditions and quality, plant tolerances, and manufacturer’s recommendations. These recommendations are suited for most external planting pits. However, recommendations may require modification for plant species requiring minimal fertilization, and those that are limehating, such as rhododendrons, camellias, etc. Typically, compost should not be used where limehating species are to be planted.

ANNEX 7 : UK Case studies of good compost applications in agriculture

1. Park Farm, Suffolk

Following repeated applications of compost over the seven year period, the following conclusions could be drawn:

- compost applied with reduced levels of Nitrogen was as effective as compost with standard levels of Nitrogen and both were more effective than NPK fertiliser alone;
- an average increase of 7% in crop yield was found – for example, the potato crop, typically growing at 50 t/ha, increased to 53.5t/ha over the period of the trial when compost was used; and
- farmers could increase profit margins – for example, comparing the costs and benefits of using standard NPK fertiliser to the costs and benefits of using compost with reduced Nitrogen over a five-year rotation, the average net saving was £116.00/ha every year.

Many of the benefits derive from the fact that compost adds organic matter to the soil which means that repeat applications can cause long-term improvements in soil structure, making it more workable, providing better seedbed conditions, and supporting the retention of both nutrients and moisture for longer periods.

2. Organic Resource Agency's Trials in East Anglia

Ten fields on four different farms were treated with different applications of compost to grow sugar beet, winter barley, potatoes, winter wheat, and beetroots. The farms were chosen because of their different soil types and all fields had three different compost treatments:

- 25t/ha;
- 50t/ha;
- 75t/ha; and
- one specified control plot to clearly compare the benefits of compost application.

Similar to the Park Farm trial run by Enviros, the levels of organic matter in the soil were tested annually and these trials also showed the levels of organic matter rose in seven out of the ten fields. This led to a noted increase in workability by farmers, particularly on heavy soils. The trials also tested the levels of vital macro nutrients such as Potassium, Phosphorus, Magnesium and Sulphur. There was a clear and steady increase in both Potassium and Phosphorus in the soils, relative to the controls, resulting from the compost application (Figure).

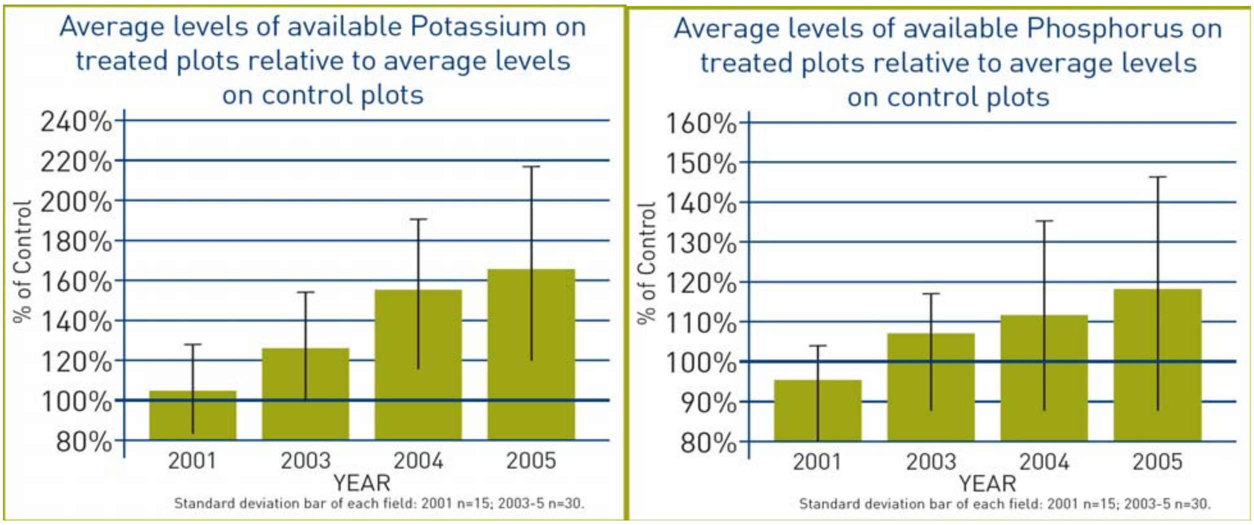

Figure: 5:Levels of available potassium and phosphorous on treated plots based on a case study in East Anglia -UK