

Soil improvers and growing media — Guidelines for the safety of users, the environment and plants

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the CR title page, pages 2 to 82 and a back cover.

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Contents

	Page
National foreword	Inside front cover
Text of CR 13455	5

English version

Soil improvers and growing media — Guidelines for the safety of users, the environment and plants

This CEN Report was approved by CEN on 17 March 1999. It has been drawn up by the Technical Committee CEN/TC 223.

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Contents

	Page	Page
Introduction	5	Annex D (informative) Proposal for the elaboration of precautionary soil values 70
1 Scope	5	Annex E (informative) Working priorities for WG 2 74
2 Terms and definitions	5	Appendix 62
2.1 soil improver	5	Bibliography 75
2.2 growing media	5	Figure 1 — Interaction between concentration of Cu in the soil and C-mineralisation after 32 days of Cu contamination 57
2.3 harm	5	Figure A.1 — Sir of the three trial soils during the entire test period in $\text{mg CO}_2 \text{ 100 g TS}^{-1} 24\text{h}^{-1}$ 68
2.4 hazard	5	Figure A.2 — Respiration of the three trial soils during the entire test period $\text{mg CO}_2 \text{ 100 g TS}^{-1} 24\text{h}^{-1}$ 68
2.5 risk	5	Figure A.3 — Arsuphate activity of the three trial soils during the entire test period in Nitrophenole g TS – 1 h – 1 69
2.6 contaminant	5	Figure A.4 — Dehydrogease activity of the three trial soils during the entire test period in $\mu\text{g TFP g TS}^{-1} 16\text{h}^{-1}$ 69
2.7 pollutant	5	Table 1 — USEPA Rule 503 sewage sludge distribution and marketing limit values 12
2.8 potentially toxic element	6	Table 2 — German RAL GZ 251 standard for composted material, PTE limits 13
2.9 user	6	Table 3 — Range of estimates of possible limit values for soil like materials (Annex B) 14
2.10 intended use	6	Table 4 — Austrian compromise proposal for general PTE limits in soil improvers 15
2.11 reasonably foreseeable misuse	6	Table 5 — Standards and guidelines for “total” potentially toxic elements (PTEs) in composted materials, sludge or soil (mg/kgDM) 17
2.12 safety	6	Table 6 — Controlled contaminants in drinking water Directive 80/778/EEC 21
3 Description of hazards and products	6	Table 7 — Examples of materials with potential for contamination with organic compounds and control approaches adopted or proposed 21
4 Product safety assessment	7	Table 8 — Lethal conditions for selected pathogens 29
4.1 Fire	7	Table 9 — Provisions for the exclusion of pathogens in Europe 30
4.2 Dust explosion	9	Table 10 — National limits on various impurities in composted materials, % dry weight 36
4.3 Potentially toxic elements	9	Table 11 — Hazards and corresponding recommended actions 39
4.4 Organic contaminants	16	Table 1 — Soil concentrations in the UK 42
4.5 Mineral constituents	22	Table 2 — Limit values for soil improvers for class II uses 42
4.6 Biological hazards, pathogens to humans and animals; microbial by-products and allergens	24	
4.7 Traumatic hazard	31	
4.8 Dust	32	
4.9 Radiation	32	
4.10 Physicochemical	33	
4.11 Seeds and propagules	34	
4.12 Plastic, glass, metal and other undesirable materials	35	
4.13 Eutrophication agents	35	
4.14 Gaseous emission	37	
4.15 Phytotoxic factors	37	
4.16 Plant pathogens	38	
5 Summary of hazards and corresponding recommended actions	39	
Annex A (informative) Background	40	
Annex B (informative) Metal limits in soil improvers and growing media note for discussion	41	
Annex C (informative) Heavy metal limits in soil improvers: discussion guidelines	48	

	Page		Page
Table 3 — Results of UK national food survey	46	Table 10 — Cd levels in green plants of spring wheat, spring barley and maize at 2 sites after a Cd input of 660 g/ha as Cd sulphate and 112 t/ha of sludge (after KÖCHL. 1984)	54
Table 4 — Calculation for average food limit value for cadmium	46	Table 11 — Heavy metal values in the soil and in the grain of oats after 4 years of garbage compost application (after WIMMER, 1984)	54
Table 5 — Calculation of the average uptake factor for cadmium	47	Table 12 — Cd, Ni and Zn levels in soil as well as in the grain and straw of winter barley after 18 years of sludge fertilisation (after V.BOGUSLAWSKI, 1987)	55
Table 6 — Limit values for soil improvers and growing media on the basis of food chain intake	47	Table 13 — Percentage of samples with Cd levels exceeding the food limit values (ZEBS) in relation to soil concentration (after SAUERBECK and LÜBBEN, 1991)	56
Table 7 — Limit values (in µg DM calculated for soil improvers and growing media	48	Table 14 — Orientation values for soil Cd concentrations (aqua regia extraction) above which food limit values in plants may be exceeded (after SAUERBECK and LÜBBEN, 1991)	56
Table 1 — Average airborne deposition of heavy metals/ha and year	49	Table 15 — Exceeding the Austrian soil limit values after only 100 years of compost application (10 t d.m./ha/a) based on the limits of WHEELER (1993; EC/U.L.)	58
Table 2 — Export and balance of heavy metals in g/ha/a (compost freight not considered)	49	Table 16 — Proposal for general PTE limits in soil improvers as a compromise on EU level (based on 30 % organic matter)	60
Table 3 — Heavy metal limits in soil improvers (compost) related to 30 % and 3,5 % organic matter	50	Table A.1a — PTE accumulation in 30 years; mg/kg d.m. Compost: 10 t d.m./ha/a; weight of 20 cm soil = 3 000 t/ha)	62
Table 4a — Balance 1 — with erosion: Percentage attainment of the Austrian soil limits according to ÖNORM L 1075 after 30, 50 und 100 years of continuous compost application of 10 t d.m./ha/a. All values > 70 % of the soil limits are included (in mg/kg d.m.)	51	Table A.1b — PTE accumulation in 50 years; mg/kg d.m. Compost: 10 t d.m./ha/a; weight of 20 cm soil = 3 000 t/ha)	62
Table 4b — Balance 2 — without erosion: Percentage attainment of the Austrian soil limits according to ÖNORM L 1075 after 30, 50 und 100 years of continuous compost application of 10 t d.m./ha/a. All values > 70 % of the soil limits are included (in mg/kg d.m.)	51	Table A.1c — PTE accumulation in 100 years; mg/kg d.m. Compost: 10 t d.m./ha/a; weight of 20 cm soil = 3 000 t/ha)	62
Table 5 — Attainment of the Austrian soil limits in years assuming the limits suggested for soil improvers CEN/Feb.93 and EC/U.L.	51	Table A.1d — Years until soil limit is reached when compost is applicated with 10 t/ha and year	63
Table 6 — Data and standards relative to heavy metal uptake by plants	52	Table A.1e — Years until soil limit is reached when compost is applicated with 10 t/ha and year	63
Table 7 — Transfer coefficient for Cd soil to plant > 1 (after LÜBBEN & SAUERBECK, 1992)	53	Table A.1f — Percentage of soil limit (Austria and EC directive/upper limit) reached after 30 years of compost application (10 t/ha/a)	63
Table 8 — Cd impact as a combined effect with the heavy metals Cu, Ni, Zn and V on the contents in the grain of wheat and on microbiological soil parameters (HORAK et al., 1994)	53	Table A.1g — Percentage of soil limit (Austria and EC directive/upper limit) reached after 50 years of compost application (10 t/ha/a)	64
Table 9 — Relationship between mobilised (NH ₄ -acetate) and total content (aqua regia) in test soils treated with heavy metal salts and in natural sites (after HORAK et al., 1994)	54		

Page

Table A.1h — Percentage of soil limit (Austria and EC directive/upper limit) reached after 100 years of compost application (10 t/ha/a)	64
Table A.2a — PTE accumulation in 30 years; mg/kg d.m. (Compost: 10 t d.m/ha/a; weight of 20 cm soil = 3 000 t/ha)	64
Table A.2b — PTE accumulation in 50 years; mg/kg d.m. (Compost: 10 t d.m/ha/a; weight of 20 cm soil = 3 000 t/ha)	65
Table A.2c — PTE accumulation in 100 years; mg/kg d.m. (Compost: 10 t d.m/ha/a; weight of 20 cm soil = 3 000 t/ha)	65
Table A.2d — Years until soil limit is reached when compost is applicated with 10 t/ha and year	65
Table A.2e — Years until soil limit is reached when compost is applicated with 10 t/ha and year	66
Table A.2f — Percentage of soil limit (Austria and EC directive/upper limit) reached after 30 years of compost application (10 t/ha/a)	66
Table A.2g — Percentage of soil limit (Austria and EC directive/upper limit) reached after 50 years of compost application (10 t/ha/a)	66
Table A.2h — Percentage of soil limit (Austria and EC directive/upper limit) reached after 100 years of compost application (10 t/ha/a)	67
Table 1a — Precautionary values for metals in soils, in mg/kg total content (aqua regia)	74
Table 1b — Precautionary values for PCB ₆ , benzo(a)pyrene and PAH ₍₁₆₎ in soils mg/kg total content	74

Introduction

This CEN report has been drawn up by CEN/TC 223, Soil improvers and growing media, Working Group 2, Safety. This report is primarily intended to inform the other Working Groups of CEN/TC 223 on significant health and safety issues related to soil improvers and growing media (SI/GM). It also classifies the hazards and risks from soil improvers and growing media so that technical information is available for manufacturers, users and regulators to refer to when evaluating the necessary risk minimization strategies to be adopted.

This comprehensive information is also intended as a resource to manufacturers, to assess their own products in relation to the markets that they sell in, to retailers and suppliers and to users of these products.

The objective of Working Group 2 of TC 223 was to examine aspects of soil improvers and growing media that are related to safety, and to propose to TC 223 the measures to ensure the protection of users and the environment from risks derived from the use of soil improvers and growing media.

WG 2 adopted the definition of safety of ISO/IEC Guide 51 (1990) *Guidelines for the inclusion of safety aspects in Standards*, as “freedom from unacceptable risk of harm”.

1 Scope

This document contains an assessment of the safety implications of soil improvers and growing media. This assessment provides a framework in which guidelines have been suggested to protect users (the exposed human population in general), the environment (flora, fauna, and ecosystems in a broad sense, including soil and water) and plants that are grown in the soil improver or growing medium.

Each hazard is discussed separately and includes:

- a description of the hazard;
- existing regulations that are relevant;
- a discussion of the applicability of the hazard to soil improvers and growing media; and
- recommended safety guidelines formulated by WG 2 of CEN/TC 223.

This is summarized with a list of the hazards and corresponding recommended actions. The annexes contain references and background information.

Not included in WG 2's investigations were those quality aspects that are:

- commonly referred to as “fitness for purpose”, i.e. the commercial quality, composition or formulation that makes a product suited to satisfy a specific market application;
- pertaining to consumer protection from commercial fraud including product conformity to a stated composition and tolerances of deviations from it.

2 Terms and definitions

For the purposes of this report, the following terms and definitions apply:

2.1

soil improver

material added to soil in situ primarily to maintain or improve its physical properties, and which may improve its chemical and/or biological properties or activity. [CR 13456:—]

2.2

growing media

material, other than soils in situ, in which plants are grown. [CR 13456:—]

2.3

harm

physical injury or damage to the health of people or damage to property or the environment. [ISO/IEC Guide 51]

2.4

hazard

potential source of harm. [ISO/IEC Guide 51]

2.5

risk

combination of the probability of occurrence of harm and the severity of that harm. [ISO/IEC Guide 51]

2.6

contaminant

a substance, material or agent that is unwanted in a soil improver or growing medium or their constituents

2.7

pollutant

a contaminant present in a soil improver or growing medium which due to its properties, amount or concentration causes harm

2.8**potentially toxic element**

chemical elements that have a potential to cause toxicity to humans, flora and fauna. Typically this term refers to “heavy metals” and others such as arsenic, selenium, boron, fluorine which exhibit a typical, dose related, sharp toxicity curve

2.9**user**

anybody exposed to the product, including professional and non-professional (amateur) users, and general public exposed not from an user standpoint

2.10**intended use**

the use of a product, process or service in accordance with information provided by the supplier.
[ISO/IEC Guide 51]

2.11**reasonably foreseeable misuse**

the use of a product, process or service in way not intended by the supplier, but which may result from readily predictable human behaviour

2.12**safety**

freedom from unacceptable risk
[ISO/IEC Guide 51]

3 Description of hazards and products

The hazard posed by a product and the risk of that hazard being expressed depend on the:

- product type;
- conditions of use of the product, (including both intended use and reasonably foreseeable misuse);
- user; and
- victim of harm.

The hazards from soil improvers and growing media considered in this report are the following categories:

- a) physical hazards (inhalation, ingestion, or contact with harmful physical agents);
 - traumatic (e.g. laceration, punctures, abrasion),
 - dust,
 - radiation (including ionizing),
- b) fire and explosion hazard (hazards immediately linked with fire or explosion, or incurred as their secondary consequences, including damage to property);
- c) physicochemical hazard (pH);

d) chemical hazards (inhalation, ingestion or contact with harmful chemical agents) of inorganic or organic nature;

- main chemical constituents,
- contaminants or additives,
- microbial by-products (e.g. mycotoxins),

e) biological hazards (inhalation, ingestion, or contact with harmful biological agents);

- pathogenic,
- allergenic.

The exposure scenarios considered are:

- hazards pertaining to safety for users (domestic and professional user, general public);
- hazards pertaining to the environment (fauna, flora, soil, water, air);
- hazards pertaining to the health and growth of the plant grown as crop.

However, since most constituents or contaminants of SI/GM can pose a hazard to more than one group of organisms, the hazards were then evaluated in a comprehensive manner in order to generate guidelines meant to protect at the same time the users, the general public, the environment and the plants grown in these products.

The risk of any particular hazard can be significantly different depending on conditions of use such as:

- type of user (professional or non professional);
- type of plant grown (food or non-food);
- place of use (indoor/outdoor, restricted or non-restricted access, in container or open soil);
- degree of misuse (typical misuses are over-application, bad storage, use for the wrong crop,
- ingestion, wrong or careless disposal, use without adequate protective clothing, mixing with incompatible materials).

For the purpose of evaluating hazards and their risks, soil improvers and growing media are classified in three distinct groups based on origin, natural or man-made, and main components, inorganic or organic.

Organic soil improvers and growing media are products made mainly of organic material of vegetable or/and animal origin. They include virgin materials such as peat, and recycled materials such as organic waste, composted or otherwise treated, and by-products from wood manufacturing, such as bark and wood fibres.

Inorganic soil improvers and growing media are products without any significant amount of organic matter. They are typically made of minerals. They can be unprocessed, such as sand, clay, gravel, and similar, or processed, such as thermally expanded clay like perlite, and mineral wool fibres.

Synthetic soil improvers and growing media are man-made products, usually resins or polymers, generated by organic synthesis and polymerization. They share a high uniformity, typical of industrially derived products, and the potential for presence of traces of chemical organic impurities (such as monomers of the polymerized product).

Each of these groups can carry hazards and associated risks which are distinctive of a specific, typical component. The classic example is the susceptibility to catch fire, and the likelihood of this event, which is definitely possible in organic and synthetic materials, but not in inorganic ones. Other examples are the presence of pathogenic micro-organisms and the risk of infection (high in organic materials of waste origin or other organic products which can support their life but low in inorganic and synthetic materials), and the presence of crystalline silica or asbestiform fibres, likely to be present in varying degrees in inorganic products but not in organic ones.

The CEN/TC223 Report "Soil improvers and Growing media — Labelling, specifications and product schedules" (CR 13456 WI 00223076) contains a schedule of products.

4 Product safety assessment

4.1 Fire

4.1.1 Description of hazard

Fire hazard is identified as the spontaneous or flame/spark activated ignition and combustion of a product. It can also be generated by exothermic reaction of two or more incompatible chemicals or materials. The hazard involves exposure risks to burns and inhalation of toxic/noxious or oxygen-displacing (suffocating) fumes. It also involves risk of property damage. Hazard to the environment means destruction or degradation of habitats and ecosystems, and the emission of combustion products into the atmosphere.

While several parameters quantify the flammability of a liquid/gas (flash point, flammable limit), the flammability of a solid material of the type used as soil improvers/growing media is more difficult to define. Calorific value (heat content) can be of help in the identification of the products and situations at risk, although no precise correlation is used for fire-prevention.

4.1.2 Existing regulations

The EEC Directive 91/325/EEC relates to Council Directive 67/548/EEC which aims at approximating the laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substances, an analogous rule for dangerous preparations is in EC Directive 88/379/EEC. These directives define and list dangerous substances and preparations, classify them according to the nature of the danger, and define the danger itself by setting criteria for the choice of phrases indicating risks and safety advice to address on the label/package. Flammability is one of many characteristics that can classify a substance or preparation as "dangerous".

Directive 91/325/EEC (Appendix VI, 2.2.4) defines as "highly flammable solid substances and preparations which can readily catch fire after brief contact with a source of ignition and which continues to burn or to be consumed after removal of the source of ignition". This definition relies on the testing of materials, and test methods are described in Appendix V of the same directive. No other definition concerning flammability of solid materials is given in this Directive.

A definition of "combustible" materials, more appropriate for products used as soil improvers/growing media, is not available in Dir. 91/325/EEC.

Directive 91/155/EEC (p. 35) states that "any person established within the Community who is responsible for placing a dangerous substance or preparation on the market, whether the manufacturer, importer or distributor, should supply the recipient who is an industrial user of the substance or preparation with a safety data sheet containing the information set out in Article 3. The safety data sheet need not be supplied where dangerous substances or preparations offered or sold to the general public are furnished with sufficient information to enable users to take the necessary measures as regards the protection of health and safety." (Art.1). Fire-fighting measures and stability and reactivity information are included in the obligatory information to be contained in the safety data sheet (Art. 3).

Flammability standards for soil improvers and growing media are not present in the UK. The closest reference is for toys (BS EN 71-2:1994), and for certain furniture (BS 5852:1990, BS 7175:1989 and BS 7177:1996). No closer reference was available from experts from other European countries.

4.1.3 Discussion of hazards

None of the materials listed as soil improvers and growing media by WG 2 is specifically mentioned in the list of dangerous substances or preparations for what concerns fire and reactivity danger, therefore the applicability of the rule relies on specific testing of material of concern according to the procedures described in Appendix V of Directive 91/325/EEC.

While inorganic soil improvers and growing media are non-flammable and non-combustible, a fire hazard is present for organic and synthetic SI and GM. In addition, synthetic materials can present incompatibility with certain specific chemicals which can be used in the same activities, thus creating a reactivity hazard. Such hazard, of interest mainly of the industrial/professional user, must be accurately addressed in the safety data sheet by the manufacturer.

Fire hazard is present in both domestic and professional uses of soil improvers and growing media. However, the associated risk in a domestic situation is estimated to be no greater than the one posed by potentially combustible household items such as paper, books, furniture, and similar. Therefore no specific requirement other than those normally applicable to such goods is needed.

Organic materials used as soil improvers or growing media can have calorific values of around 11–12 MJ/kg (peat). They are usually combustible and can ignite when exposed for example to the following conditions:

- when the product is dry;
- in case of excessive heat;
- in the presence of open flames, sparks, electrical arc, cigarette, welding operation, or hot piece of equipment.

Organic soil improvers and growing media are usually placed in the market in a moist state, therefore reducing the risk of ignition. Self-ignition (auto-combustion), however, can happen in certain storage conditions of moisture, and when large amounts of biologically unstable material are stored. For example, in professional use, risk can become higher if dry organic and or synthetic materials are stored in large amounts, or if biologically unstable bulk material should slowly ferment, generating flammable gas or reaching temperatures of spontaneous combustion. The risk of fire induced by chemical reaction of organic materials with oxidizers (which are unlikely to be present in significant amounts in typical domestic and professional situations), is less probable.

The combustion of organic soil improvers and growing media such as sphagnum peat usually generates products that are commonly generated by natural products (wood, vegetable matter), and fire fighting can involve any extinguishing media. Fire can persist inside bags or piles until they are separated or broken [1].

Synthetic materials are usually combustible and potentially reactive or unstable in the presence of certain other chemicals. Their combustion can (depending on the specific product) generate acrid and/or toxic fumes in addition to those generated by burning of natural products. For example, when heated to decomposition, polystyrene emits acrid smoke and fumes [2] and can not be steamed [3], polyurethanes emit acrid smoke and fumes of CN⁻ and NO_x [2], urea–formaldehyde heated to decomposition emits toxic fumes of NO_x [2]. If the products are free from fire retardants to reduce phytotoxicity, the risk of fire is higher.

4.1.4 Recommended safety guidelines

No specific standard requirement has been deemed necessary by WG 2, based on the consideration that:

- rules are already set;
- there is no practical way to reduce the combustible characteristics of the products other than keeping them moist; and
- typically the products of interest of WG 2 are sold in a moist form.

A generic phrase such as “be aware that organic matter burns” can be suggested on packages of materials where risk of fire is high but not immediately evident to the user (such as necessarily dry or synthetic materials).

Directly applicable requirements from Directive 91/325/EEC and subsequent amendments should be followed, also for what concerns chemical reactivity and therefore indications of compatibility (e.g. expanded polystyrene which should not be treated with chemical sterilizers, chloropichryin, methylbromide) for professional users.

4.2 Dust explosion

4.2.1 Description of hazard

The hazard is defined as explosion following ignition of flammable dust suspended in the air. The injury and damage are comparable with those attributed to fire, plus the ones induced by the air pressure increase generated by the explosion.

Dust explosion requires the following factors:

- combustible dust (at Lower Explosive Limit concentration) in fine fractions (risk increases with decreased particle size);
- oxygen (oxygen, air is sufficient);
- an ignition source (open flame, spark, electrical arc, cigarette, welding operation).

Also important in the hazard of dust explosion is the static electricity that can accumulate on dust particles and increase risk of sparks. The minimum concentration of dust able to give explosion vary between 10 and 600 g/m³. The cereal dust explosive limit concentration is around 25–50 g/m³, whilst those for synthetic materials is in the order of 25 g/m³ polyphenols, 15 g/m³ polystyrene, and 70 g/m³ formaldehyde resins.

The risk of dust explosion of soil improvers and growing media is mainly related to manufacturing phases when mixing of relatively large amounts of material can generate dust. The risk associated to professional uses is also only related to dust-creating phases of loose media mixing. The risk in domestic use is believed to be minimal.

4.2.2 Existing regulations

No direct regulation for soil improvers and growing media is available at this time. Since the risk of dust explosion is minimized by proper handling of materials and use of equipment, the closest regulatory instruments for the minimization of this risk pertain to the safety specifications of electrical and mechanical equipment, and to the control of dust (particulate matter) in the workplace. Directives 76/117/EEC, 79/196/EEC and their amendments regulate electrical equipment for use in potentially explosive atmospheres. Safety of machines is addressed in Directive 89/392/EEC (p.9) and is being standardized in CEN/TC 114. More information is reported under the chapter “Dust” in this report on the maximum admissible concentrations of dust in the workplace.

4.2.3 Discussion of hazards

Dust explosion is a typical concern in the wood (sawdust) and food (cereal dust and flour) industries. Any organic/synthetic soil improver or growing medium that is in a solid form and able to generate high amounts of dust when handled presents a certain, unquantified degree of risk.

4.2.4 Recommended safety guidelines

No specific safety criteria is deemed necessary by WG 2 to protect the user from this specific hazard, in consideration of the existing legislation and of the low risk associated with the use of the products. Since dust is also considered a health hazard, a warning phrase against the hazard of dust is however included in the recommendations against “Dust”, “Minerals”, and “Microbial by-products — allergens”. Other recommendations on storage such as “keep dust away from sources of ignition” and good housekeeping practices should be recommended in the label especially in the case of dust-forming, bulk delivered products.

4.3 Potentially Toxic Elements

4.3.1 Description of hazard

The hazards associated with Potentially Toxic Elements (PTEs) in soil improvers and growing media products are generally related to toxicity when the elements are in over supply and impaired growth when in under-supply. However these impacts on man, crops and the environment can be achieved by a number of pathways:

- direct toxicity/deficiency;
- indirect toxicity;
- environmental migration.

4.3.1.1 Direct toxicity/deficiency

Direct toxicity occurs when application of a product produces a toxic effect on the crop, or when the product is ingested (a reasonably foreseeable misuse for young children). This could lead to acute poisoning of the individual human, plant or animal.

Deficiency effects will generally be limited to growing media where the product is the only provider of trace elements or on sites where there are existing metal deficiencies. The two most important trace elements that can also cause toxicity effects in the products covered by this report are copper and zinc. As different plant species may have different nutritional requirements, deficiency is better considered as a “fitness for purpose” aspect of product quality, and therefore outside the scope of this document, it is only mentioned in this context briefly for completeness and perspective.

4.3.1.2 Indirect toxicity

Indirect toxicity is poisoning of organisms who use the plants grown in the product. This in general can be represented by health effects in humans via intake of PTEs through the food chain although other animals such as grazing animals or predatory birds could also be affected.

4.3.1.3 Environmental migration

Release of PTEs from anthropogenic sources will generally be dispersed into the environment. Many of the plants grown on soils treated with products containing PTEs and the animals that eat them will not be affected. However, the elements will find their way into the general environment in a dispersed form and will affect more remote, sensitive organisms as well as being concentrated in animals higher up the food chain due to the effects of bio-accumulation.

4.3.2 Factors affecting the hazard

The main factors influencing the hazard of the individual PTEs are:

- Concentration of element in the soil/growing medium
- Biological availability of element
- Sensitivity of organism to element (species specific)

4.3.2.1 Concentration

In general, and in respect to the other factors discussed later, as concentration increases, the risk from a PTE increases. However, the detailed chemistry is not fully understood for many elements and it is not known definitively whether there are threshold concentrations below which no effect occurs or whether any amount of the element has an effect and thus no level is wholly safe.

In some cases there are antagonistic relationships between the elements and increases in the concentration of one element can reduce the toxicity of another. The most common example of this in soil improvers and growing media is copper and zinc where a balance between the two elements should be maintained. The precise proportions of each element required is dependent on the availabilities of the metals. A similar situation exists between iron and many other metals and this relationship is particularly important for sewage sludge based materials where phosphate and ammonium also modulate bio-availability.

4.3.2.2 Biological availability

To become toxic, the PTEs have to enter the biological cycle and be absorbed into either a plant, animal or micro-organism. This usually happens once the PTE is in solution. The rate of absorption is controlled by the form of the PTE. The bio-availability generally follows the order: water soluble organic (the most bio-available); inorganic soluble salts; water insoluble organic; inorganic insoluble compounds, (the least bio-available).

For example, when ingested by humans, metallic mercury is only slowly absorbed through the gut wall and as such much of that ingested is directly excreted without any impact on the individual. In addition, the metallic mercury that is absorbed is not stored for long in the body and is also then excreted quickly, hence reducing the effect of the metal still further. Organically bound forms of mercury such as methyl mercury, however, are easily absorbed and so a large proportion of the ingested mercury in this form is taken up by the body. Methyl mercury is also more easily stored within the body so that it can remain in the body to affect the biological functions over longer time and therefore exacerbates the toxic effects.

Once in the biological cycle the PTEs are generally more easily absorbed, by chelation or conversion into organic forms and this can give rise to bio-accumulation where the tissues of species higher up the food chain accumulate the PTE contained in their food.

The composition and nature of the receiving soil will also have a major impact on the availability of the PTEs in soil improvers with the pH, mineralogical analysis, cation exchange capacity and content of organic matter having a major effect on the absorption of elements into the soil structure and therefore their biological availability.

Unfortunately chemical analysis techniques have not been particularly effective at modelling PTEs bio-availability. A wide variety of extraction systems based on water, solvents, chelating agents, electrolyte solutions, alkalis and acids have been tried but none of these to date has provided a reliable model to biological availability. This is in part due to the complex and species specific nature in which plants and animals take in material from their environment.

4.3.2.3 *Species differences*

Different types of organism have different requirements and therefore absorb PTE more or less effectively. For example, plants such as tobacco, lettuce and spinach absorb certain metals strongly whilst crops such as cereals, potatoes etc. only absorb small amounts of metals. This is represented by the soil/plant transfer rate. In addition to this, different parts of the plants accumulate elements in varying proportions with generally the roots accumulating the most, followed by the vegetative parts and least in the generative parts.

4.3.3 *Difficulties of evaluating the hazards*

The Scope of CEN/TC 223 covers a wide range of products that will be used in a multitude of applications. Many of these products have been used for many years without any concerns over their safety. However new products that continually being introduced to the markets and little may be known about their safety.

The differences in the composition of the many soil improvers and growing media, and in particular of their:

- proportion of organic matter;
- cation exchange capacity;
- concentration and form of the PTEs;
- form of organic matter;
- pH;

will change the biological availability of the PTEs present in these products. While the total PTE levels is the only measurement that is widely accepted, it has been proved very hard to unambiguously relate this measurement to the PTEs biological availability, which is the best indicator of the PTEs behaviour, and thus of the safety of the products. Measures of biological availability have not been developed that are reliable and broadly applicable and so analytical “available” measurements are impossible to relate to the response achieved by the full range of plants.

“Available” measurements also have the disadvantage that they do not take account of changes once the material is deposited. This is most uncertain as some PTEs will be in very stable forms and thus are unlikely ever to change and become available. On the other hand, other forms of the PTE could be more mutable and therefore alter their availability, becoming either more or less available with changing conditions. It is impossible to predict these changes which will be affected by factors such as climate, land use, soil type, other materials added to the soil. Nevertheless, risk assessment should encompass worst case situations and therefore total PTE loadings in relation to accumulation through repeated use is one of the factors that should be assessed.

4.3.4 *Methodologies of establishing limit values for acceptable risk*

The way in which limit concentrations in products for PTEs (that are considered to have acceptable risk) are determined, can vary according to the viewpoint adopted. Thus there is a number of different protocols that can be adopted to establish limit values with respect to the safety of the product. These can be simplified into the following:

- risk assessment based on no observable adverse effect levels (NOAEL);
- precautionary approach;
- no net accumulation (NNA);
- best available technology;
- hybrid systems that utilize toxicity assessments or embody soil protection without quantifying risk.

When considering the environmental safety provided by the limit values selected, many other factors should be taken into the equation. For example, many organic waste materials can be converted into soil improvers but if the limits set are impossible to meet for either economic or technical reasons then they will be disposed of via traditional disposal routes such as landfill or incineration. This could lead to an overall decrease in environmental quality. Too lax limits, conversely, could lead to eventual soil pollution and would not provide any incentive for improvement in organic waste treatment technology. Any limits have to also be considered in relation to the location as in areas where the soil quality is poor and few sources of organic matter, in this case overly stringent limits can result in organic wastes not being used and soil erosion occurring. This highlights the need for any limits to be considered in a wide context including other disposal options, soil quality and availability of other soil improvers.

4.3.4.1 Risk assessment — NOAEL — No Observable Adverse effect Level

This approach tries to determine the impact of adding potential pollutants to a soil by examining experimental results and utilizing the result to determine the risk levels to the relevant parts of the population considered. This is evaluated on the basis of determining the levels at which a defined adverse effect is observed, and as such is sensitive to the definition of “adverse effects” adopted. The normal approach is to select a number of scenarios or in the case of pollutants and pathways, and to calculate the risk to the most exposed individual under each pathway (scenario). Given this information the limits are set to achieve a given risk level. Typical risk levels selected are in the range 1×10^{-3} to 1×10^{-6} .

The most notable example of this is the US EPA sewage sludge regulations [4] (Rule 503), which adopted this type of approach. The investigation was based on a number of exposure pathways that could be used to model the impacts of substances on man and the environment. The study that supported the development of these regulations spanned 15 years and involved a great number of experts from around the world. However, it was limited to sewage sludge and the recommendations of the peer review group that assessed the work was that the results should not be used for other materials such as composted waste. This advice was given due to the specific nature of the chemical compound and the matrix in which it is contained.

The results of the study have provided a range of limit values that are high when compared with other limit values determined on other protocols. The limit values for uncontrolled use generated by the Rule 503 are given in Table 1. It should be pointed out that this is based on USA diet, soil type and agricultural practices, and can not reflect correctly an European scenario, but is useful as an example of the approach especially if the European characteristics are incorporated in to the models.

The study was still uncertain about some aspects as there are few data on soil biota and the only soil organisms considered were earthworms. Accepting these limitations it is still a very good example of the risk based approach to setting of limit values.

Table 1 — USEPA Rule 503 sewage sludge distribution and marketing limit values

PTE	limit concentration
	mg/kg dry matter
As Arsenic	41
Cd Cadmium	39
Cr Chromium	1 200
Cu Copper	1 500
Hg Mercury	17
Mo Molybdenum	18
Ni Nickel	420
Pb Lead	300
Se Selenium	36
Zn Zinc	2 800

This study only used results from unadulterated sludges as the availability of the compounds was found to be different in sludges that had been artificially contaminated for experimental purposes. Thus experiments using artificially contaminated sludges (even where ameliorated by long times or processing of the sludge) were shown to be not representative of sludge metal availability in the field. Similarly, pot trials were not considered appropriate as root exploitation is significantly different to that of field grown plants. Obviously this is possible with sewage sludge due to the availability of an extensive data set for this material, which may not exist for other materials.

4.3.4.2 Precautionary approach

The Precautionary approach takes the view that the risks from PTEs are not fully understood, and that limit-setting should be in accordance with sustainable behaviour or growth. The promotion of sustainable growth respecting the environment is one of the primary objectives of the Treaty of the European Union.

Precautionary limit values are to allow long term environmental protection against future adverse impacts. In this context, adverse impacts should be avoided or reduced where this is a reasonable requirement, also with respect to the use of the site. Long-term protection is aimed at preserving the possibility of different uses of soils. The derivation of soil precautionary values follows the notion that any soil will be protected against contaminants if ecotoxicological effect thresholds (balanced with data on background values) are not exceeded, and if at this concentration level no evidence arises of unwanted or hazardous effects on plants and groundwater, and if there is sufficient difference (safety factor) from the trigger values proposed for the pathway “soil to humans”.

From the viewpoint of soil protection, there are various possible technical options for limiting substance inputs. Brought to its extreme interpretation, the precautionary approach may be read as avoiding any increases of soil PTEs concentrations above current values. This means that additions of PTEs from soil improvers, fertilizers and the atmosphere should equal the losses via leaching, plant uptake and erosion. Although support exists for this approach [5], there are no regulations yet that follow this extreme interpretation, given the severe consequences it would have on agriculture and other sectors of the economy. An alternative to this extreme interpretation would be to set acceptable accumulation levels of accumulation in the soil, and then to define loading rates and/or concentrations in the materials that will satisfy this objective. Two examples of limit-setting that follow the precautionary approach are found in Annex C and Annex D.

4.3.4.3 Best available technology

An alternative to a fully fledged precautionary approach is a compromise where the lowest practical/achievable limits are selected. While the presumption that lower values are to be preferred is often used, allowance is made for the inadequacies of the processing technology or organic matter generation system. These limit levels are often between risk based and precautionary limits.

The most common approach is therefore to set the limits at the level that the technology/system can achieve, without any reference to the level of risk associated with those limits. This is obviously a political decision as all technological solutions have economic implications either on the soil improver/growing media industry or other more remote industries such as waste disposal, forestry or agriculture. One example of limits that have been set on this basis are those set by the German RAL standard [6] (Table 2).

Table 2 — German RAL GZ 251 standard for composted material, PTE limits

PTE	limit concentration ^a mg/kg dry matter
Cd Cadmium	1.5
Cr Chromium	100
Cu Copper	100
Hg Mercury	1.0
Ni Nickel	50
Pb Lead	150
Zn Zinc	400
^a Normalized to 30 % organic matter	

4.3.4.4 Hybrid approaches

In some cases none of these approaches is entirely appropriate in that factors other than those directly related to safety should be considered. For example, stringent adoption of the precautionary approach would limit a great deal of materials that could be applied to soil such as fertilizers, animal manures, sewage sludges, waste based materials such as composted products from separately collected organics, as the metal concentrations would add to the soil loading. This reduction in applied materials would lead to a greater use of other disposal methods such as landfill and incineration and potentially a reduction in soil fertility. These alternative disposal techniques also place burdens on the environment and thus there is a trade-off between the environmental burdens placed by the deposition of wastes as soil improvers and the disposal of those wastes when precluded by stringent environmental controls.

A compromise has to be achieved in the protocols of devising the limit values. Three different approaches (Annex B, Annex C, Annex D) are attached to this report as examples, none of which is preferred or commended by WG2. One such attempt was the CEN document *PTE limits in soil improvers and growing media, note for discussion* (Annex B) which calculated the limit values using a number of different approaches. These approaches were:

- acute human toxicity by the most toxic form assuming direct ingestion by a child;
- chronic toxicity assuming direct ingestion by a child;
- food intake, 100 % of food (excluding meat and milk) grown on soil treated with soil improver;
- application of soil improver equivalent to 50 % of the soil so as to reach EC sewage sludge directive soil quality limits.

In general these approaches showed that direct ingestion was less of a threat than environmental pollution through the food chain. However to provide a safety factor, this conclusion was based on the totally unrealistic set of assumptions, that all the most exposed individual's food is grown on treated soil and the toxicity indices were taken for the most toxic form of the PTE for which data was found. It would have been appropriate to use only a proportion of food to be grown, but there were insufficient data on this aspect to determine the appropriate proportions of home grown food.

The other most important deficiency of this work is that it only applied to "soil like materials" and thus products with high organic matter contents would be inappropriate to the calculations used. However, the calculations narrow the area of uncertainty and provide a range in which a realistic compromise can lie, but it should be emphasized that this only applies to a limited range of materials and alternative limit values would have to be developed for soil improvers and growing media containing composted materials, peat, bark, animal manures, vermiculite, perlite etc., as well as for mixtures of these materials. The details of this analysis are given in Annex B.

To show how greatly limits can vary depending on the criteria that are adopted for their formulation, the range of limit values suggested in this discussion document is given in Table 3.

Table 3 — Range of estimates of possible limit values for soil like materials (Annex B)

PTE	Class III Professional non-food use		Limit concentration dry matter mg/kgDM					
			Class II Professional		Class 1 Domestic			
	SI	GM	SI	GM	Acute toxicity	Chronic toxicity	Food intake basis	
							SI	GM
Cd Cadmium	c	c	1.1–5.5	1–3	10	100	1.5	1.2
Cr Chromium	c	c	162–262	100–150	220 (VI) 3 400 (III)	100–400	b	b
Cu Copper ^a	c	c	82–262	50–140	880–1 240	70 000	982	500
Hg Mercury	c	c	1.9–2.9	1–3	320	30–71	10.7	5.4
Ni Nickel	c	c	39–129	30–75	200	1 000	b	b
Pb Lead	c	c	52–552	50–300	60–4 000	300	210	129
Zn Zinc ^a	c	c	215–515	150–300	800	b	1 027	556

^a copper and zinc are significant essential micro nutrients.
^b Not determined due to lack of data.
^c Refer to national regulation.

An alternative approach (proposed by the Austrian experts and attached as Annex C), used the idea of balancing inputs and outputs to limit the accumulation in the soil and to calibrate this against soil limit values which can be found within a corresponding range in Austria, Germany and some other European countries. On a broad data basis derived from several investigations on availability and soil/plant transfer rates, this approach uses the assumption that the soil levels quoted are scientifically proven as “safe”.

This proposal states that the functionality of the agricultural soils has to be maintained in the long term. Thus, the input of PTEs stemming from organic fertilizer applications should be minimized. Exceeding toxicologically determined PTE limit concentrations within periods of 45–100 years by applying excessively contaminated soil improvers does not appear to be a reasonable strategy and thus it is suggested that the limits are reviewed after 10 years. A proposal from Austrian experts for PTE limits based on these principles is given in Table 4.

Table 4 — Austrian compromise proposal for general PTE limits in soil improvers (based on 30 % organic matter)

PTE	limit concentration (mg/kgDM)
Cd Cadmium	1.5
Cr Chromium	150
Cu Copper	200
Hg Mercury	1.0
Ni Nickel	75
Pb Lead	150
Zn Zinc	750

However, limiting PTE loads for composted products need to be combined with the evaluations of the soil concentration to provide a sustainable agro-ecological approach to soil protection.

This approach adopts the following assumptions and recommendations:

- a) knowledge of the background levels of PTEs in the soil;
- b) repeated application of soil improver at a rate of 10 t DM/ha/year:
 - meets the demand of a general agricultural management (humus balance),
 - proposed values guarantee (even if organic matter is mineralized) that the upper soil limit will not be attained for at least 150 years,

c) normalization of the organic matter to 30 % DM in order to provide comparable calculations;

d) restriction of validity of limits to 10 – 15 years due to potential for advances in technology and knowledge of risks.

Annex D provides an example of a precautionary approach-driven proposal for establishing PTE concentration limits in soils. These limits, which take into consideration soil texture as a discriminant actor in assessing ecotoxicological risk, would be used as a basis to draw maximum concentration values and/or application rates of soil improvers.

4.3.5 Problems of the regulatory approaches

As stated, all these approaches have deficiencies. None fully considers the impacts of the different materials themselves and the effect of the soil improver on the bio-availability of the PTE. In addition, this does not fully reflect the full range of factors that modulate the bio-availability of PTEs in soil improvers, such as antagonistic relationships, proportion of clay (mineralogical analysis), nature of the organic matter present, cation exchange capacity, pH, etc.

In addition the provision of limits on the product does not protect the soil from repeated applications or applications at higher rates as these situations lead to accumulation within the soil and hence higher concentrations. The Austrian proposal suggests an annual application rate of 10 tDM/ha whilst the other hybrid protocol assumes a total application of 50 % of the soil mass (top 150 mm).

Any set of limit values cannot be applied to the whole range of soil improver and growing media products covered by CEN/TC 223. This creates difficulties in that either limit values have to be developed for each product type, or any limit values that are applied are restricted to a subset of the full range of products covered. In the first case this would seem an impossible task as there is insufficient experimental evidence to develop rational limit concentrations for all products and mixtures of ingredients. Alternatively, some formula to adjust the limits to the different products may be established but the precise relationships between the factors and bio-availability are not known at present.

If, however, the limits are restricted to a group of products, this would be prejudicial to these products as they would have additional costs to the manufacturers for analysis and would restrict their use or sale. At the same time, products outside the specified group could have unsafe levels of PTEs whilst being unrestricted by the standard, hence being able to take advantage of a better marketing position.

Thus, under either situation the use of limit values would bias the market by either penalizing the products that are safe with higher concentrations, or limit those products which would be covered by the limit values. In both situations the safety of products could not be assured as under a limit value system applicable to all media some products could still be toxic whilst some safe products could be proscribed.

4.3.6 Existing regulations

The Directive 86/278/EEC defines sewage sludge quality for the protection of soil when sludge is applied to land, and several countries have adopted the Directive or have set analogous rules. Table 5 lists the legislative references found for sludge, soil and composted materials.

Composted materials and other waste related products are not, for the moment being, regulated by the EC, but most countries have adopted rules that set quality parameters and use criteria for the protection of the environment.

Few rules were found for other products. Norway regulates the cadmium content of inorganic fertilizers, setting the limit to 100 mg Cd/kg P [7].

Indirect references are EEC Directives concerning water quality (79/869/EEC and 80/778/EEC) and World Health Organization (WHO) recommendations for maximum concentration in food and drinking water [8].

Annex B includes very detailed and exhaustive references on inorganic contaminant toxicity levels. Acceptable daily intake (ADI) dose, levels in food and drink and plant uptake and food consumption statistics. The complexity of achieving meaningful concentrations of "safe" limits has been expressed by both the UK experts (19.12.93) and the Swedish experts (17.12.93) who also provided additional reference data on tolerable daily intake values for PTEs.

4.3.7 Recommended safety guidelines

Working group 2 was unable to reach agreement on any limit values or other mechanism that would adequately protect the safety of users as well as not discriminating against products that pose little or no risk to users or the environment. WG 2 therefore limited its scope to providing a discussion of the issues of PTE and the protocols for setting limits.

4.3.8 Products at risk

Potentially all materials are at risk contamination with PTEs. The potential for contamination is dependent on origin (e.g. production process, season, source of material, etc.). Risks should be assessed for each material on a case by case basis.

4.4 Organic contaminants

4.4.1 Description of hazard

The hazard is generated by the presence in soil improvers and growing media of man-made organic compounds that pose a hazard to humans, environment and plants due to their toxicity or other environmental adverse effect (e.g.: Volatile Organic Compounds, (VOCs) and their effect on ozone layer depletion). Organic compounds can constitute a hazard due to their volatility, mobility (also water-solubility), persistence (low biodegradability), and bio-availability.

Hazard to humans is related to the inhalation, ingestion, and/or contact of contaminated products during a) the manufacturing of synthetic growing media and composted materials from municipal solid waste (occupational hazard, probably the most serious exposure, is out of CEN/TC 223's scope of work, [9]), during b) the use of products that are contaminated (both a professional and domestic hazard) and c) during consumption of food products that have bio-accumulated or adsorbed significant amounts of the organic contaminant. The hazards to the environment relate both to the dispersion of volatile compounds into the atmosphere and to the bio-accumulation of persistent organic compounds up to doses of ecotoxicological significance. In addition, a number of organic compounds have shown to induce toxicity in plants.

Table 5 — Standards and guidelines for “total” potentially toxic elements (PTEs) in composted materials, sludge or soil (mg/kgDM)

Document	Zn	Cu	Ni	Cd	Pb	Hg	Cr ^{total}	Cr ^{VI}	Mo	Se	As	B	Co
Austria ON S2022 MSW compost 1986	1 000	400	100	4	500	4	150					100/25	
Austria ON s2200													
Bio-waste compost 1993													
(30 % organic matter basis) class I	210	70	42	0.7	70	0.7	70					<u>10</u>	
class ii	400	100	60	1	150	1	70					<u>10</u>	
Austria S2021 (Growing media) 1994	200	100	60	1	100	1	100		10		20		
Austria L1075 Orientation soil values ^a	300 ^b /150	100/50	60/40	1/0.5	100/50	1/0.2	100/50						
Austrian Fertilizer Ordinance LGB6160:1994	300 ^b	100 ^b	60	1	150	1	100	2					
Soil amendment (org. Matter > 20 % dm)													
Austria sewage sludge regulation 1994													
(lower Austria) sludge limit	2 000	500	100	8	400	8	500						100
sludge limit after 1/1/2005	1 500	300	25	2	100	2	50						10
soil limit	200	60	50	1.5/1 ^c	100	1	100						
Austria Compost Ordinance draft Oct 1998													
agriculture	500	150	60	1	150	0.7	100						
non food, land reclamation	1 200	400	100	3	250	3	250						
Belgium- compost, VLACO/Min of Agriculture	300	90	20	1.5	120	1	70						
EC ECO-label -Soil Improver (488/98/EEC)	300	100	50	1	100	1	100				10		
EC- Ecological agriculture “organic household waste” (2092/91/EEC)	200	70	25	0.7	45	0.4	70	0					
Germany								n/a					
Data Sheet M10/non-food	750	200	100	2.5	250	2	200						
RAL GZ251	400	100	50	1.5	150	1	100						
Blauer Engel	300	75	50	1	100	1	100						
bio-waste Ordinance (i)	300	70	35	1	100	0.7	70						
bio-waste Ordinance (ii)	400	100	50	1.5	150	1	100						
Bark soil standard RAL GZ250	300	50	30	2	80	0.5	50						
EC soil protection directive (86/278/EEC)													
soil limit pH 6–7	150–300	50–140	30–75	1–3	50–300	1–1.5							
soil limit pH > 7	225–450	75–210	45–112	1–3	50–300	1–1.5							
sewage sludge	2 500–4 000	1 000–1 750	300–400	20–40	750–1 200	16–25	100–200						

NOTES

“total” implies extraction with hot concentrated strong acid

underlined values are water extractable levels

^a 2nd values assumes a man caused enrichment of natural background levels

^b when exceeded should be declared on label.

^c Cd 1.0 when soil pH < 6.0

n/a not allowed in fertilizers

Table 5 — Standards and guidelines for “total” potentially toxic elements (PTEs) in composted materials, sludge or soil (mg/kgDM)

Document	Zn	Cu	Ni	Cd	Pb	Hg	Cr ^{total}	Cr ^{VI}	Mo	Se	As	B	Co
Italy L 99/92 sludge	2 500	1 000	300	20	750	10							
soil	300	100	75	1.5	100	1							
Italy L 748/84 and modif 27/3/98 (various soil improvers including compost)	500	150	50	1.5	140	1.5		< 0.5	20				60
Netherlands BOOM 1998													
compost	200	60	20	1	100	0.3	50				15		
very clean compost	75	25	10	0.7	65	0.2	50				5		
sewage sludge	300	75	30	1.25	100	0.75	75				15		
Norway Si, GM based on org. waste, sludge (Regulations concerning trade..1996)													
class I	400	150	30	0.8	60	0.6	60						
class II	800	650	50	2	80	3	100						
class III (non-food)	1 500	1 000	80	5	200	5	150						
Spain, compost (Min. Ord. 12731, 28/5/98)	1 100	450	120	10	300	7	400						
Spain, sludge	2 500–4 000	1 000–1 750	300–400	20–40	750–1 200	16–25	100–200						
Spain, soil pH 6–7	150–300	50–140	30–75	1–3	50–300	1–1.5							
pH > 7	225–450	75–210	45–112	1–3	50–300	1–1.5							
Sweden (SFS 1985:840)	800	600	50	2	100	2.5	100						
Switzerland Stoffverordnung, 1992													
compost	400	100	30	1	120	1	100						
sewage sludge	2 000	600	80	5	500	5	500						
<i>Canada mixed organics compost</i>	315	128	32	2.6	83	0.83	210						
<i>Canada BC Yardwaste compost</i>	315	100	50	2.6	150	0.8	210		5	2	13		26
<i>Canada BC Source separated mixed org</i>	315	100	50	2.6	150	0.83	210		5	2	13		26
<i>Canada Ontario yardwaste compost</i>	500	60–100	60	3–4	150–500	0.15–0.5	50		2–3	2	10–20		25
<i>Canada–Ontario– sludge</i>	4 200–840	1 700–380	420–80	34–4	1 100–220	11–1.4	2 800–500		94–1.2	34–6	170–35		340–77
USA- USEPA Part 503 — sludge	2 800	1 500	420	39	300	17	1 200		18	36	41		
<i>USA Florida 17–709</i>													
1	900	450	50	15	500								
2	1 800	900	100	30	1 000								
3	10 000	3 000	500	100	1 500								
4	> 10 000	> 3 000	> 500	> 100	> 1 500								
<i>USA Maine – mulch, topsoil</i>	2 000	1 000	200	10	700	10							
<i>USA New Hampshire not direct human food uses</i>	2 500	1 000	200	10	250	10							
<i>USA Minnesota 1991 compost</i>	1 000	500	100	10	500	5							
<i>USA New York 1991</i>	2 500	1 000	200	10	250	10	1 000						
NOTES “total” implies extraction with hot concentrated strong acid													
Italicized standards are those which the original standard documents are not available and reported values have been used.													
For a complete listing of current USA and Canadian standards on compost see Compost Standards. Composting Council Fact Sheet. Alexandria, VA, USA April 1996.													

4.4.2 Discussion of hazards

Organic contaminants are typically derived from human activity. Their presence in soil improvers and growing media can be ascribed to the following causes:

- voluntary addition as additives to improve specific qualities in the final product;
- trace impurities, as residues of production processes;
- generalized background presence from non-point source pollution of the environment;
- localized, point-source pollution of the site of extraction;
- present as contamination of the base ingredient of the soil improver or growing medium.

One problem that is very specific of this hazard is the difficulty of screening at a reasonable cost for such a broad spectrum of contaminants.

Composted materials and waste derived products can contain organic contaminants according to the origin of their base ingredients. Both volatile and persistent organic contaminants can be of concern in these products, whereas degradable organics can be subject to total or partial microbial decomposition during the composting process. It is to note in this respect that degradation metabolites in some cases are more toxic than the original product. VOCs are potentially present in discarded containers and other components of the waste stream, and can be volatilized during the waste sorting and composting phases [9].

Persistent organic contaminants that can be present in composted materials and waste-derived products include pesticides (including residues of banned products), polychlorinated biphenyls (PCBs), aryl-, and aryl/alkylphosphotryesters (used in hydraulic fluids, plasticizers, flame retardants etc.), and polychloro-dibenzodioxines and furans (PCDD/Fs). Fricke and Vogtmann [10] report ubiquitous presence of chlorinated pesticides in the environment, and that lindane is frequently found in biogenic composted material when woodchips are added. These lindane levels, however, are usually too low to influence composted material quality. Degradation studies reported by the same Authors have shown that composting can degrade HCH to a quite large extent (86 %), DDX at 64 %, and Polyaromatic hydrocarbons (PAHs) at 56 %. PCBs were however degraded at a 45 % rate, while PCDD/F degradation studies are still at an inconclusive stage.

A relatively larger literature is available on organic compounds found in sewage sludge. Studies funded or published by the EEC [11] list as possible contaminants of sewage sludge aliphatic and aromatic hydrocarbons, halogenated hydrocarbons, organo-chlorine pesticides, PCBs, PAHs, phthalates, and surfactants. A substantial analytical problem is identified in these studies in the large number and range in chemical form of compounds which can potentially justify examination. Also, as previously mentioned, the presence of degradation products should be considered.

Regarding PAHs, there is a general consensus that “airborne emissions are of greater importance for soil contamination than the input from sewage sludge, although a slight but permanent increase of soil concentrations of PAHs had been observed over the last decades” [11]. Webber and Goodin [12] studied VOCs in sludge, and Hembrock-Heger [13] evaluated transfer factors of persistent organic contaminants in soil, plants, and food. Welp and Brümmer [14] measured the toxicity of organic contaminants to soil micro-organisms, obtaining a wide variety of responses among which the most relevant was the one to pentachlorophenol.

The human exposure to PCDD/Fs via sewage sludge application to land has been evaluated by Wild et al. [15], who concluded that human exposure to those contaminants is elevated if sewage sludge contains typical concentrations of 33–37 I-TEQ (Toxicity Equivalence Factor, which expresses toxicity of a single PCDD relative to the most toxic 2, 3, 7, 8-T4CDD). The application of sludge to arable land appears to these authors, however, to have only a minor effect on human exposure. The most important transfer mechanism for PCDD/F and other lipophilic compounds (e.g. PAH, PCB, organochlorine pesticides, aliphatic and aromatic hydrocarbons, chlorinated hydrocarbons, phthalates, surfactants) has been identified in the livestock ingestion of sludge adhering to vegetation. The study concludes that the current WHO/EURO TDI guide-line value (REF) of 10 µg I-TEQ/kg per day is exceeded only when the sludge considered has a high concentration, and an individual consumes products exclusively obtained from sludge treated areas.

The United States Environmental Protection Agency (USEPA) has promulgated the sludge disposal rules [16], for the preparation of which a series of potential pollutants were investigated. Some of these (dimethyl nitrosamine and tetrachlorophenol) were found not to interfere with land application at the highest concentration found in sludges, and other organic contaminants have been deferred to a future investigation because of insufficient data. Among these are benzo(a)anthracene, bis(2-ethylhexyl phthalate), PCDDs and PCDFs, methylene bis(2-chloroaniline), methylene chloride, pentachlorophenol, and tricresyl phosphate. PCDD/Fs sampling in sludge and analysis for future rule making are ongoing at the present time.

Antibiotics and other medicaments can be found in products derived from animal and fish waste. The Norwegian delegation to WG 2 of TC 223 reported the presence of residues of oxolinic acid from medical treatment in fish waste.

Background concentrations of chlorinated pesticides (DDT, lindane) can be found in naturally derived products such as bark and wood fibres or, more significantly, from use as pest killer during timber cultivation outside of the EC. Lindane may be a less significant contaminant in countries where its use has been banned. German experts report that the limits of lindane, cypermethrin and DDT are often exceeded in bark and jute fibres, and that straw can be contaminated with fungicides. There was a consensus among WG 2's experts that most of the lindane-contaminated products (above generalized background concentrations) are found in bark products imported from the Eastern European Countries.

Herbicides have been found in peat as a residue of medium preparation for harvesting (Communication of French experts). While more precise data on this subject was available, their presence is reportedly expected to decrease in the future given the increasing adoption of modern peat extraction systems that do not rely on the use of herbicides.

Wood/fibres derived products can contain traces of persistent wood preservatives (pentachlorophenol, PCP) when treated wood is used. However, possible PCP concentration levels in such materials were not available to WG 2.

Inorganic, processed soil improvers and growing media such as slagwool and rockwool can contain phenol-formaldehyde resins as binders, mineral oil, and polypropyleneglycol as dedusting agents [17]. These compounds added during their manufacturing phases to promote certain characteristics such as water-repellency, durability, and handling. No data were however available on their levels in the final products, in order to evaluate the potential risks to the users, plant and environment.

Synthetic soil improvers and growing media can contain residuals of monomers, plasticizers and flame retardants that can be harmful (toxic) to users and plants. In particular, polyurethane foam can contain urethane and aromatic amines, ureaformaldehyde can contain free formaldehyde, polyphenol can contain free phenol and styrene monomer can be found in polystyrene. WG 2 agreed that data concerning such organic contaminants are extremely limited, sparse, as well as difficult to evaluate and compare.

4.4.3 Existing regulations

Existing regulations on composted products are summarized by Raninger [18]. Organic contaminants that are regulated in some, but not all, EU and EFTA countries are HCH (lindane), PAHs, PCBs, PCDD/Fs, and AOX (halogenated organic compounds). According to the same source there is no need to establish limits in soil improver and growing media, "given the data available and the assessment of the situation".

The German standard RAL GZ250 sets a voluntary limit for bark products of "residues of insecticides (lindane, cypermethrin)" at < 0.5 mg/l fresh substance.

An indirect reference on what contaminants are controlled in other fields, is found in Directive 80/778/EEC (water for human consumption), which identifies organic compounds that are unwanted in drinking water, and sets for those restrictive limits Maximum Admissible Concentration (MAC) or Guide Levels (GL) as summarized in Table 6.

4.4.4 Additional information

A number of specific contaminant limits and regulatory approaches have been proposed at different times by WG 2 documents, these are summarized in Table 7 [19,20,21,22,23].

Table 6 — Controlled contaminants in drinking water Directive 80/778/EEC

Compound	MAC or GL	Limit
Substances extractable in chloroform	GL	0.1 mg/l dry residue
dissolved or emulsified hydrocarbons; mineral oil	MAC)	10 µg/l
phenols, excluding natural phenols which do not react to chlorine	MAC	0.5 µg/l
surfactants (MBAS)	MAC	200 µg/l laurylsulphate
organochlorine compounds other than pesticides	GL	1 µg/l
pesticides and related products includes insecticides (persistent organochlorinated, organophosphorated, carbamates), herbicides, fungicides, PCBs and PCTs	total MAC	0.5 µg/l
	each group MAC	0.1 µg/l
PAHs	MAC	0.2 µg/l

Table 7 — Examples of materials with potential for contamination with organic compounds and control approaches adopted or proposed

Material	Contaminant	Notes
Bark	Pesticides, lindane, DDT, cypermethrin	Less or equal to 0.5 mg each of lindane and cypermethrin per litre of fresh matter (German proposal)
Straw	Pesticides, growth regulating substances	
Organic fibres	Wood preservatives	
Sawdust	Pentachlorophenol	
Jute fibres	Lindane, DDT, cypermethrin	
Synthetic products	Monomers, plasticizers	
Polyurethane		Dutch experts proposed a declaration on the label: “free of organic impurities”, and “free of additives that reduce burning”
Polyurethane	Aromatic amines, urethane	
Polyphenol:	Phenol	
Ureaformaldehyde	Free formaldehyde	
Polystyrene	Styrene monomer	
Polyacrylamide	Acrylamide monomer	
Aquaculture waste	Antibiotics (e.g. oxolinic acid)	Norway recommends the suspension of use of aquaculture waste that contains dead fish possibly containing traces of antibiotics as ingredient of SI/GM
Soil	PCB	France proposes max. input in soil of 1 mg/ha/year. (proposal EEC 91/C/299/05),
Sewage sludge	nonylphenol max 50 mg/kg DM Toluene max 5 mg/kg DM 3PAH max 3 mg/kg DM 3 PCB max 0.4 mg/kg DM	voluntary agreement in Sweden [19]

Other regulatory approaches proposed are setting loading rate target values for soil (calculated by the Belgian experts in an internal document), declaration of origin from uncontaminated source (proposed by the Dutch experts as a declaration of quality), the potential use of bioassays such as Microtox [25] [26] to screen at less cost for toxic compounds has also been proposed. After a review of the available documentation WG 2 experts were not satisfied that sufficient testing had been performed on the materials of interest, and therefore adoption for the purpose of screening organic contaminants' toxicity in soil improvers and growing media is premature at this stage.

4.4.5 Recommended safety guidelines

General agreement was reached that the available information is very limited (in fact no precise data were provided in support of the limits that were proposed) and does not represent a valid basis on which to create a safety standard. Special consideration was also given to the extreme variability of analytical conditions at which the available data were obtained, and to the extreme cost that a meaningful organic contaminants analytical screening would have compared to the envisaged benefits.

In conclusion, although generally organic contaminants are undesirable in soil improvers and growing media, no recommendation for limits can be proposed at this time due to the technical and commercial reasons explained above.

4.5 Mineral constituents

4.5.1 Description of hazard

All minerals in a crushed form have the potential to create dust, and the inhalation over long periods of substantial amounts of any inert (or so called nuisance dust), can overload the lung clearance mechanism, making the lungs more vulnerable to respiratory disease.

Toxic components in a mineral could increase the hazard from exposure to respirable dust.

Silica is a very abundant material in a variety of forms and accounts for approximately 20 % of the earth's crust with 95 % being quartz. It is present in nearly all mining operations, and as an extremely common mineral has been the subject of many detailed studies, summarized in the Crystalline Silica Primer published by the US. Bureau of Mines [27].

Trace amounts of free silica are found in some silicate minerals while materials such as sand and gravel consist mainly of free silica as quartz. It has been known for centuries that prolonged and excessive exposure to high concentrations of respirable free silica in dust can cause a related lung disease of occupational origin, silicosis [28]. This is a non-cancerous, but extremely serious, lung disease. Recent attention has focused on the possibility of a relationship between silica exposure and lung cancer. Confounding factors in human studies and flaws in animal studies leave the issue unresolved. In the USA minerals containing more than 0.1 % free silica are subject to Federal guidelines concerning hazard communication.

Asbestiform fibres are a known carcinogen and the use of asbestos in Europe is closely controlled by EC Directives. Among these are Directive 91/382/EEC which amended Directive 83/477/EEC on the protection of workers from risks related to exposure to asbestos. Also Directive 90/394/EEC, the carcinogens directive, regulates mineral constituents.

Man made mineral fibres are the object of a vast number of international studies and publications. Some authorities have considered these materials as possible carcinogens based on studies which have shown some association between man made mineral fibres and lung cancer but only after intraserosal injection. The international Agency for Research on Cancer (IARC) classified mineral fibres as possible carcinogens. In their 1988 report [29] IARC indicates sufficient evidence for carcinogenicity of glass wool in animals if injected, but inadequate evidence for carcinogenicity of glass wool in humans and limited evidence or inadequate evidence related to rock wool and slag wool. In 1997 the EC has classified mineral wool fibres as "possible carcinogenic (class3)" [30]. In some European countries occupational exposure regulations exist and limits are placed on the long term exposure to mineral fibres e.g. in the UK. 5 mg/m³ (8 hour TWA reference period) [31].

4.5.2 Products at risk

All soil improvers (SI) and growing media (GM) could be considered a hazard since under some conditions of use a dust can be created. However, the risk from this hazard is eliminated by simple measures.

Perlite and vermiculite are silicates and can contain trace amounts of free silica but the amount present even in high dust concentrations will be low and eliminated by normal dust control precautions.

Health studies that have been carried out on perlite workers going back over 40 years, and other scientific work concluded that perlite is not harmful to health. Some of the relevant published work relating to health risk associated with perlite is found in Weil (1990) [32], Cooper and Sargent (1986) [33], WIL Research Laboratories (1982) [34], Rosner-Hixson Laboratories (1977) [35], National Academy of Sciences (1981) [36], Association of American Feed Control Officials (1992) [37], and United States Department of Agriculture [38].

The presence of asbestiform filers in certain known deposits of raw vermiculite is well defined and understood by EC exfoliators of vermiculite. All major vermiculite suppliers ensure that studies have been made to verify that asbestiform fibres are absent or, if present, are at a level which does not constitute a known health hazard. From published studies and other information it can be concluded therefore that exfoliated vermiculite produced in Europe does not present any known health problem.

Relevant published data includes Hunter and Thomson (1973) [39], Parks (1974) [40], Goldstein and Rendall (1969) [41], Swenson (1975) [42].

For materials such as rock wool, glass wool etc., suitable dust control precautions are necessary to prevent inhalation of the dust fibres in line with all the mineral constituents. However in horticultural situations exposure levels are decreased since the mineral wool products are normally used in a wet state. Exposure is also decreased whenever they are used wrapped in a polyethylene growing bag. Nonetheless there are cases when the products are used unwrapped, and exposure may occur when the product is discarded and/or allowed to dry out.

A number of countries have occupational exposure limits for man made mineral fibres which relate to the use of dry unwrapped material. In general the man made mineral fibres industry consider that normal levels of exposure do not pose a carcinogenic risk of any practical consequence to health. This is supported by mortality and morbidity studies on workers in the production and user industries. The International Programme on Chemical Safety (IPCS) in 1988 [43] reviewed man made mineral fibres and concluded that the possible risk of lung cancer among the general public is very low if there is any at all, and should not be a cause for concern if the current low levels of exposure continue. The International Labour Office in 1989 [44] agreed with the IPCS.

Relevant published data includes Brown et al. (1991) [45], Chiazze et al. (1993) [46], Hughes et al. (1993) [47], Marsh et al. (1990) [48], Simonato et al. (1988) [49], Wong et al. (1991) [50], and the European Insulation Manufacturers Association (1994) [51].

4.5.3 Existing regulations

There are no existing regulations on mineral constituents in soil improvers and growing media.

With mineral products the total quantity of toxic component is of lesser importance than the amount inhaled and in particular the respirable fractions inhaled and many countries have occupational exposure limits for total inhalable and respirable dust fractions. These limits at present can vary slightly from country to country but have as their basis regulations to support various EC directives which include Directive 80/1107/EEC "Protection of workers from the risks related to exposure to chemical physical and biological agents at work", and Directive 91/659/EEC which adapted to technical progress Appendix 1

of Directive 76/769/EEC on the approximation of laws regulations and administrative provisions of Member States relating to restrictions on the marketing and use of certain dangerous substances and preparations.

Care needs to be taken in the interpretation of so called limits or detected concentrations of free silica and also asbestiform fibres in minerals and associated dust. Both are very difficult to detect at low levels and at present there are no internationally recognized standard test methods for them. Current techniques can detect free silica at around 1 % (although some methods claim lower levels), and asbestiform fibre at about 0.001 %, but methods are only partially validated.

4.5.4 Recommended safety guidelines

In commercial applications the use of basic dust control procedures when handling the dry SI or GM or wetting the material before use will eliminate risks associated with most of these materials.

Exposure levels are generally very much below national limits. Mandatory protection or control will be required if exposure approaches the national standards.

In domestic use the risks will be eliminated by using soil improvers and growing media in areas with good ventilation and by maintaining a reasonable standard of personal hygiene.

Manufacturers of soil improvers and growing media are required by existing legislation to supply safety data sheets and give adequate guidance to ensure the safe use of their products.