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Impurities and stone content

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SUMMARY

EU directives require a reduction in landfill and where possible recycling of waste in the form of composted materials. Methods of testing are required to indicate the amount of impurities.
In order to increase the use and repeated use of treated biowaste, customers must have confidence in the product. An adverse experience such as a cut hand on a glass shard will lead to customer rejection, adverse publicity and possibly financial liability.
No standard methods exist for the determination of impurities but several methods are used over the world.
The proposed draft standard is based on the German method for compost testing. After drying the material the fraction of coarse stones (>5 mm), plastic (>20 mm and >2 mm) and other impurities (>2 mm, stone, glass, metal) are determined. It is a simple and robust method with a lot of experience. Destruction and densitometric sorting can be added to the procedure but it makes the method complex. The accuracy will perhaps be better. An interlaboratory trial in which different methods (the proposed standard, the BNSCAO method and the PAS 100 method) are tested could prove which method is most suitable. The workability of the method in routine analyses should be concerned in the evaluation. Other remaining points to be resolved are:

- The method as proposed deals only with materials up to 40 mm. If a wider range of particles is wanted some research will have to be performed how to adapt the volumes in analyses. This will also have its influence on the method of sampling.
- Influence of temperature on physical characteristics of plastic impurities.
- The determination of light plastics should be evaluated e.g. by surface determination.
- The choice between different methods should be performed based on experimental work preferably by an interlaboratory trial.

1. INTRODUCTION

In order to increase the use and repeated use of treated biowaste, customers must have confidence in the product. An adverse experience such as a cut hand on a glass shard will lead to customer rejection, adverse publicity and possibly financial liability. The presence of such contaminants in material going to landfill is not a problem.

From the user's perspective, visual impurities in the compost and compost product are extremely off-putting, and have to be avoided as far as possible in order to guarantee a safe sale in the range of horticulture. (Brethouwer et al., 1995).

Impurities are all materials that are not wanted, for example Glass, Plastics, Metal, Rubber etc. Stones, Lava and Clay granulates may not be impurities but are recorded in the stone fraction.

Biological degradable Plastics are also impurities if they are visually recognisable.

2. EXISTING METHODOLOGY

Different methods are available for the determination of impurities in compost. Important for choosing a standard are if possible; good characterisation, reproducibility, simplicity, low cost and experience level. In table 1 a short characterisation of the existing methods can be found. In table 2 the score concerning suitability for a European standard can be found.

The BGK method originates from Germany and is used in The Netherlands as well (Kehres and Pohle, 1998). After drying compost the fractions of coarse stones (>5 mm) and other impurities (>2 mm) are determined. It is a simple and robust method with a lot of experience. The fraction of impurities is however not further differentiated.

The PAS 100 method originates from the United Kingdom; it is not a British Standard (PAS 100, 2002). It is a Publicly Available Specification published by British Standards and it was written in the main by The Composting Association. It is a combined method for the determination of the particle size distribution and physical contaminants in composted materials. After drying the sample, the different fractions of glass, metal, plastic, stones and other impurities are determined. The method gives a good differentiation of the impurities but is more complex, more expensive as the BGK method also there is less experience with this method.

France proposed the BNSCAO method (CEN/TC 223 N264, 2002). This method as proposed by France includes a bleach treatment to be able to easy distinct the inert materials. This is performed after drying the material. A disadvantage is the additional work of the destruction. After the destruction a densitometric sorting procedure is performed. With water and a calcium chloride concentrated solution the material is sorted into different levels of density. After this densitometric sorting the material is sieved and manually, with help of a magnet sorted. The French method has been developed with the idea to characterise products that may contain composted materials such as compost of green waste. It developed for horizontal usage. The method has been validated using a large set of products.

The French method with drying at 80 °C and destroying non-synthetic organic matter with bleach was made for 5 reasons:

1 After drying at 100 °C plastics are destroyed or deteriorated.
2 The mass of the sample is too low for the desired precision.
3 The sort is impossible with pellets (or small balls).
4 The sort is difficult because of the same colour between impurities and organic matter.
5 The operator is tired after 20 min of sorting the same sample.

For the AT-CompOrd method of the Austrian Compost Ordinance (AT-CompOrd : BMLFUW, 2001), which is based on the former ÖNORM S 2023 (1993) dried material is sieved using a 20 and a 2 mm sieve. The fractions of plastic, metal and glass are determined.

Table 1: Characterisation of the existing methods for the determination of impurities.

Method	Drying	Treatment	Sieving	Differentiation
BGK	105 °C	-	2, 5 mm	Stones >5mm, other impurities >2 mm
PAS 100	40 °C	-	31.5, 16, 8, 4, 2, 1 mm	Glass, metal, plastic, stones, other
BNSCAO	80 °C	Destruction with bleach and densitometric sorting	40, 25, 12.5, 5, 2 mm	Stones, Glass, Metals, Films and PSE, Other plastics
AT-CompOrd	105 °C	-	20, 2 mm	Plastic > 20 and 2 mm; glass, metal and total impurities > 2 mm

Table 2: Score concerning suitability for a European standard of the present methods for the determination of impurities.

Method	Good characterisation	Simplicity	Cost	Experience
BGK	+	++	++	++
PAS 100	++	+	+	-
BNSCAO	++	-	-	+
AT-CompOrd	++	++	+	+

2.1 Comparison of standards

A comparison of standards for compost throughout the world is made by WRAP (Hogg et al., 2002). It appears that specification of the different impurities is important. The different types have also a different 'value' concerning the quality observed through customer's eyes. The size of the different impurities is of lesser importance. Concerning this for plastic films it could be of importance not only to determine the weight but also the surface.

A Norwegian study on test methods for impurities in compost was performed for the BGK and the PAS 100 method (Aasen, 2001). The means were slightly higher for the PAS-method, but no statistically significant differences between the two methods were found (table 3).

Table 3: Determination of impurities (% dm) with the BGK-method and the PAS 100- method for composts from 6 different composting plants (A-F). The table shows means[1], standard error[2] and number of parallels (n). Shaded rows indicate that the compost is taken from batches that are not yet sieved after the composting process; un-shaded rows indicate that the compost is taken from sieved batches (Aasen, 2001)

	BGK			PAS 100		
Sample	mean	SE	n	mean	SE	n
A1	0.27	±0.05	5	0.3	±0.1	5
A2	1.2	±0.4	4	2.6	±0.4	5
B1	0.22	±0.04	4			
B2	3.6	±0.4	4			
C	3.6	±0.4	4			
D1	0.27	±0.02	3			
D2	3.6	±0.6	4			
E	1.6	±0.4	5			
F	0.11	±0.04	4			

[1] Mean: arithmetic mean. [2] Standard error (SE): SD/√n where SD is the standard deviation.

The Norwegian study concluded that the PAS 100 method was not suitable for composts with a sticky consistency, as they became lumpy during drying. The lumps did not crumble during sieving and impurities were "hidden" in the lumps, resulting in incorrect test results. The procedure seemed to lack a description of crushing the lumps.

In a study performed by France the BGK and BNSCAO methods are compared. It appeared that the BNSCAO has a higher accuracy. It is not clear if this is because of the higher amount of material taken into consideration and/or a better differentiation.

Table 4: Comparison of France between the BGK and BNSCAO methods (Results in % of dry matter).

		BGK	**BNSCAO**
Drying		100 °C	80 °C
Mass of the sample		100 ml, environ 50 g	500g
Criteria	**Average content % of dm**	**Content precision**	**Content precision**
Plastics films >5 mm	0.3	0.16	0.05
Autres plastiques > 5 mm	0.8	0.63	0.20
Glasses and metals > 2 mm	2	1.74	0.55
Stones > 5 mm	5	3.2	1.0

It seems that a simple method with three sieves and characterisation would therefore do. Destruction and densitometric sorting can be added to the procedure but it makes the method complex. The accuracy will perhaps be better. An interlaboratory trial in which the different methods are tested could prove which method is most suitable.

3. CONCLUSIONS

A method were the different impurities are sorted out in 3 fractions would do. The BGK method as used in Germany (Kehres and Pohle, 1998) would be an option. An adaptation should be made concerning the differentiation of the type of impurity. Destruction and densitometric sorting can be added to the procedure but it makes the method complex. The accuracy will perhaps be better. An interlaboratory trial in which different methods are tested could prove which method is most suitable.

4. THE METHOD IS EVALUATION OF DRAFTING A HORIZONTAL STANDARD

4.1 Sample size

The range of samples received into the laboratory will vary from finely ground material as will be found in sewage sludges to very coarse materials for example composted bark. Within the UK composters are preparing products with a sample size range from 6mm up to 65mm. For landfill the particle size could be even greater. It would be advantageous if the recommended method were to be able to cope with this wide range of particle size. If a wider range of particles is wanted, the relationship shown below is proposed. This will also have its influence on the method of sampling.

In 400-A, Concrete Test Procedures Manual the following table can be found concerning sample size to particle size. This is proposed to be the starting point for the volume to consider for the determination of impurities. The complete manual can directly be found: http://manuals.dot.state.tx.us/docs/colmates/forms/cnn.pdf . The table lists the nominal maximum size of aggregate and minimum mass size for testing. The derived graph makes it possible to extrapolate for samples with materials of over 40 mm. Thus a sample size of 7.5 l for the fraction 40-100 mm is proposed.

Table 5 Nominal Maximum Size of particles in relation to sample weight

Nominal Max. Size	Minimum Mass, g
37.50 mm (1-1/2 in.) or larger	5000
25.00 mm (1 in.) or larger	3500
19.00 mm (3/4 in.)	2500
9.5 mm (3/8 in.)	1000
4.75 mm (No. 4)	500
less than 4.75 mm (No. 4)	200

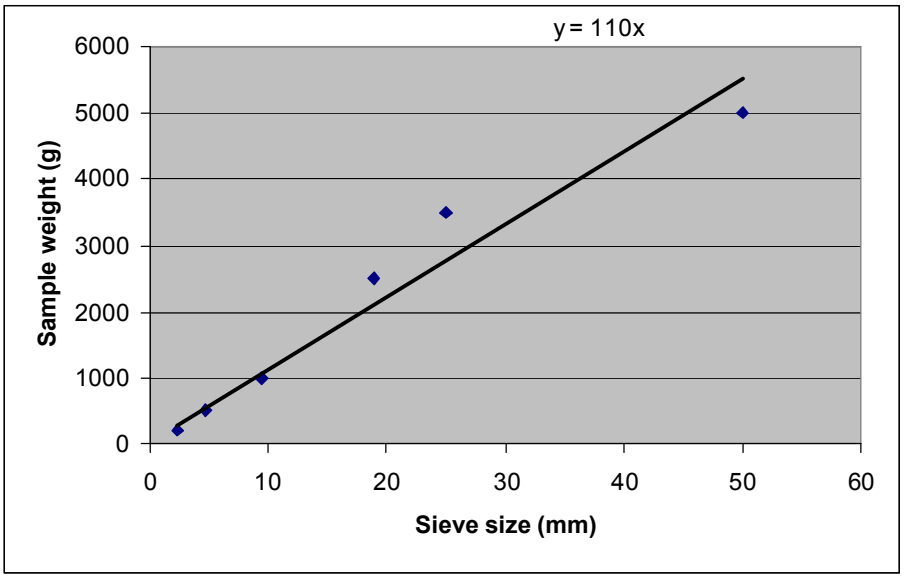

Figure 1 Graph derived from the data in Table 5, with formula for extrapolation

4.2 Sample preparation

The temperature of drying can influence the properties of certain plastic materials. Aasen (2001) tested the influence of drying temperature on plastic impurities in compost. It was concluded that drying at 105 °C resulted in a weight reduction of the plastic of 1.1-2% compared to drying at 40 °C. Continued drying at 105 °C had no significant influence on the mass of the plastic impurities.

Although the influence of the drying temperature on the weight is minor, the drying temperature is an area that needs research because the temperature will have influence on the shape and size of plastic films. Table 6 shows the properties of several common plastics. With some caution it may be concluded that deformation starts from temperatures as low as 48 degrees Celsius but a serious decrease in surface area is not expected for temperatures below 80 degrees Celsius.

Table 6 Some data physical properties of common plastic materials

		Density	crystalline melting point	Long term usage	max. for short term	Defor-mation
Material	Abbrev.	g/cm³	°C	°C	°C	°C
Polyvinylchloride Hard	PVC-U	1.45	130	-10 to +65	75	82
Polyvinylchloride Soft	PVC-P	1,2 to 1,3		0 to +55	65	
High Density Polyethylene	HD-PE	0.95	126 to 135	-30 to +90	100	48
Low Density Polyethylene	LD-PE	0.92	105 to 118	-40 to +80	100	
Polypropylene Homo polymer	PP-H	0.91	160 to 165	- 10 to 100	140	65
Polystyrene	PS	1.04	160	-5 to 60	90	
Polycarbonate	PC	1.2	230	-30 to +120	150	138
Polyester		1.8		-10 to +130	155	

Small pieces of compost will stick to the plastic materials. Aasen (2001) showed that washing reduced the mass of the plastic fraction by 27%. This result is based on washing and drying of plastic impurities from several composts. For the studied composts, typically 30-45% of the impurities were plastic. Given these conditions, the total mass reduction of impurities after washing of the plastic was approx. 10%. Washing of the plastic pieces is however a time-consuming activity, the study did not recommend washing in a standard method. However, the estimates should be taken into consideration when deciding a limit value for impurities.

4.3 Interpretation

Of the numerous papers published on the topic the WRAP (Waste and Resources Action Programme) in the UK made an overview (Hogg et al. 2002). In table 5 the requirements as being in operation can be found.
Many requirements are already regulated by law. A proposal for a European standard could be the proposal of Australia:

- Glass, metal and rigid plastics >2 mm ≤ 0.5%dm
- Plastics — light, flexible or film >5 mm, ≤ 0.05% dm

- Stones and lumps of clay ≤ 5% dm.

The quality standards and differentiation of particle size related to specific impurities may differ as far as different applications are concerned. A differentiation as related to the application of the compost could be concerned as well (table 6).

Table 7: Requirements concerning impurities throughout the world (Hogg et al., 2002).

Country	Requirement
Austria	Statutory, impurities >2mm, agric.: max. 0.5%; non food: max. 1.0%
Belgium	Statutory, stones >5 mm, max. 2%, impurities >2mm, max. 0.5%
Denmark	Statutory – plastic, metal, glass portion >2 mm may not exceed 0.5% weight in dm
Finland	Statutory max 0.5% fm
France	Yes
Germany	Statutory, 0.5% weight/dm plastic, glass, metal > 2mm; stones >5mm <5% weight – statutory
Greece	Plastic <0.3%dw; glass <0.5%dw
Ireland (licensing)	<1.5% of >25 mm in dry matter
Italy	Statutory, plastics (mesh size <10 mm): <0.5% weight/dm; Inert materials (mesh size <10 mm): <1% weight/dm Inert materials (mesh size >10 mm): absent
Luxembourg (licensing)	Statutory, plastic, glass, metal (>2mm) <0.5% weight/dm; stones (>5mm) <5% weight dm
Netherlands	Voluntary – glass (>2mm) <0.2% dm, stones (>5mm) <2% dm, glass (>16m) absent
Norway	Statutory, plastic, glass and metal (> 4mm) < 0,5 % dm
Portugal	No
Spain	Statutory, plastic particles and other inerts must not be over 10 mm
Sweden	Voluntary, plastics, glass and metals (>2mm) <0,5% dm
UK (Composting Association)	Voluntary, of total air-dried sample: ≤1% m/m glass, metal and plastic, of which plastic 0.5% m/m; and stones ≤5% m/m. (Impurity if >2 mm)
Canada	CCME (Statutory) and BNQ (Voluntary) – foreign matter defined as aany matter over 2 mm dimension that results from human intervention and having organic or inorganic constituents such as metal, glass and synthetic polymers (e.g. plastic 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
USA	No
Australia	Voluntary – Glass, metal and rigid plastics >2 mm ≤0.5%dm; Plastics — light, flexible or film >5 mm, ≤0.05% dm; Stones and lumps of clay ≤5% dm Suppliers and their customers are advised to agree upon an acceptable maximum level of visual contamination by light weight plastic
New Zealand	100% passes through 15mm x 15mm orifice

Table 8: Requirements concerning impurities based on the application (Austrian proposal).

Parameter	**Application/Area of application**	**Limit value (unit)**
∑ total impurities > 2 mm	Agriculture	< 0.5% DM
∑ total impurities > 2 mm	Landscaping and land reclamation, reclamation layer on landfill sites	< 1% DM
Plastics > 2 mm	Agriculture	< 0.2% DM
Plastics > 2 mm	Landscaping and land reclamation, reclamation layer on landfill sites	< 0.4% DM
Plastics > 20 mm	Grassland, horticulture, market gardening, allotments, ski slope maintenance	< 0.02% DM
Plastics > 20 mm	Landscaping and land reclamation, reclamation layer on landfill sites	< 0.04% DM
Metals	Agriculture	< 0.2% DM
Glass	Agriculture	< 0.2% DM

5. CRITICAL POINT AND RECOMMENDATIONS

5.1 Criteria for test methods

- The test methods should be simple to operate
- The test methods should be able to accommodate a wide range of sample types (The proposed method as written and tested is not applicable to samples > 40 mm but it could be adapted as indicated to take much larger sample volumes.)
- The cost of the method and apparatus used to be taken into account
- The method should give a good characterisation.
- The method should define particle size and impurity differentiation to be able to set specific product requirements related to the application.
- If possible there should be some experience

5.2 Method Recommendations

- After drying compost the fraction of coarse stones (>5 mm), plastics (>20 mm and > 2mm) and other impurities (>2 mm) are determined.
- Differentiation of the type of impurity.
- The method should be performed at least in duplicate because of the large differences between duplicates (see e.g. table 3)

5.3 Method Development

- The method as proposed is used only with materials until 40 mm. If a wider range of particles is wanted the sample size should increase, possibly as proposed in this paper.
- The determination of light plastics should be evaluated. The influence of temperature on physical characteristics of soft plastic impurities (film) should be known. Also surface determination of film should be considered. Drying or treatment temperature should not exceed 80 degrees Celsius unless sound test results prove otherwise.
- If the interlaboratory trial is performed a material should be made with a known impurity content. This will give a more clear indication of the detection limit and precision of the method. Also the workability of the method should be part of the interlaboratory trial.

DRAFT STANDARD

NOTE1 Where italics appear in the draft method indicates an area that requires additional work and confirmation.

NOTE 2 Whilst the title of the method and body of the text states 'composted organic materials' it does not mean that the method may not be suitable for other forms of waste.

A method to determine the visual recognisable impurities in composted organic materials

Contents Page

Safety warning

Care should be taken when handling samples that may contain sharp fragments, chemical contaminants or possible pathogenic organisms.

1. Scope and field of application

A method to determine the visual recognisable impurities in composted organic materials, soil improvers and growing media. The sample shall be obtained in accordance with SOIL IMPROVERS AND GROWING MEDIA - SAMPLING (EN 12579). The procedures described herein are only applicable to processed organic waste, sludge and soil.

2. Normative references

This method incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this method only when incorporated in it by amendment or revision. For undated references the latest edition of the publications referred to apply.

ISO 5725:1994	Precision of test methods - determination of repeatability and reproducibility for a standard test method by inter-laboratory tests.
EN 12579:2000	Soil improvers and growing media - Sampling
EN 13040:1999	Soil improvers and growing media - Sample preparation for chemical and physical test, determination of dry matter content, moisture content and laboratory compacted bulk density

3. Principle

After drying the test material the fraction of coarse stones (>5 mm), plastics (<20 mm and >2 mm) and other impurities (>2 mm) are determined. The fraction of impurities is further differentiated.

4. Definitions

For the purpose of this standard the definitions given in PD CR 13456, EN 12579, EN13040 and PAS 100 apply.

5. Reagents

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6 Apparatus

6.1 **Sieves,** diameter 200 mm or 300 mm 2, 5 and 20 mm apertures, ISO 3310-1:2000 or ISO 3310-2, 1999

6.2 **Analytical balance,** with an accuracy of 0.01 g

6.3 **Drying oven,** ventilated, fan assisted, capable of holding sample trays *105 ±3 °C.*

6.4 **Sample tray,** constructed of material thermally stable up to 150 °C, surface approximately 1250 cm^2

6.5 **Beaker,** 300 ml

6.6 **Tweezers**

7 Procedure

7.1 Sample preparation

7.1.1 Prepare the test sample in accordance with EN 13040:1999, clause 8.1, 8.2. Where 20% w/w or less of the laboratory sample has been retained the procedure can be continued. If not the method is not appropriate.

NOTE larger quantities may be required for very coarse samples.

7.1.2 Determine the test amount of test sample depending on the coarseness of the sample. For 0-100 mm 7.5 l is taken, for a sample with a fraction 0-40 mm 3 l is taken, for a sample with a fraction 0-25 mm 1.5 l is taken and for fine materials 0-12 mm 1 l is taken and put in the sample tray **(6.4)**.

NOTE the method is performed in duplicate.

7.1.3 Dry the materials for at least 16 hours until constant weight in the drying oven **(6.3)**.

7.1.4 Determine the dry weight with the balance **(6.2)**.

7.3 Sieving

Using the beaker **(6.5)** transfer approximately 100 ml of the dried sample (7.1.2) onto the 20 mm sieve **(6.1)**. Spread the >20 mm fractions one by one on a flat surface and gather the plastic particles > 20 mm with help of the tweezers **(6.6)**. Continue this procedure until the entire sample (7.1.2) has been sieved. Determine the total weight of the fraction rigid plastic and the fraction plastic light (flexible or film) individually using the balance **(6.2)**.

Transfer 100 ml on the 5 mm sieve **(6.1)**. Spread the >5 mm fractions one by one on a flat surface and gather the stones > 5 mm with help of the tweezers **(6.6)**. Determine the weight of stones using the balance **(6.2)**.

Join the fractions >5 mm and <5 mm without the stones (>5 mm) together. Sieve portions of 100 ml on the 2 mm sieve **(6.1)**. Spread the fractions >2 mm one by one on a flat surface and search out all visual recognisable impurities using the tweezers **(6.6)**. Sort out the following materials: stones, glass, rigid plastic, plastic light (flexible or film), metal. Determine the weight of the individual type of impurities using the balance **(6.2)**.

8 Calculations and expression of results

The mass of the impurities is expressed on the total dry weight (before sieving). The average results are calculated of the duplicates.

$$I_{P>20\ mm} = \frac{W_{p>20\ mm}}{T} \times 100\%$$

$$I_{R>20\ mm} = \frac{W_{R>20\ mm}}{T} \times 100\%$$

$$I_{S>5\ mm} = \frac{W_{S>5\ mm}}{T} \times 100\%$$

$$I_{G>2\ mm} = \frac{W_{G>2\ mm}}{T} \times 100\%$$

$$I_{P>2\ mm} = \frac{W_{P>2\ mm}}{T} \times 100\%$$

$$I_{R>2\ mm} = \frac{W_{R>2\ mm}}{T} \times 100\%$$

$$I_{M>2\ mm} = \frac{W_{M>2\ mm}}{T} \times 100\%$$

Where

I is the impurity part (%)
W is weight of impurity type
T is the total dry weight
S is stones
G is glass
P is rigid plastic
R is plastic light (flexible or film)
M is metal

9 Precision

No data

10 Test report

The test report shall include the following information:

a) a reference to this Standard;
b) a complete identification of the sample;
c) the results of the different fractions expressed as % on dry matter basis on 1 decimal place
d) any details not specified in the Standard, or which are optional, as well as any other factor, which may have affected the results.

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