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Compost from organic solid waste: Quality assessment and European regulations for its sustainable use

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ABSTRACT

Composting represents the most common option to recover material from the organic fraction of municipal solid waste, due to the possibility to use compost as a fertilizer. To this end the assessment of compost quality needs to be adequately enforced in national regulations. This work aims at reviewing European regulations regarding compost quality, in order to identify the most common parameters used to define compost characteristics as fertilizer. It was found that the majority of European States requires the fulfilment of specific criteria, but a lack of uniformity in regulations and guidelines can be observed. In particular the approach to the evaluation of stability and maturity, which account for compost safe use on soils, shows great heterogeneity throughout Europe. As stability and maturity go hand in hand, the proper characterization of compost toxicity should rely on the determination of both parameters. The results of an annual monitoring of compost under the Italian regulation highlighted, indeed, that the evaluation of the germination index can provide only partial information on the product maturity but not reliable operating indication on compost inhibitory properties.

1. Introduction

Composting is the biological degradation process of organic matter under controlled aerobic conditions, with the production of a biologically stabilized material, which is not oxygen consuming nor able to generate phytotoxic metabolites. The microbial community in composting process converts degradable organic matter into more stable, humified forms as well as water, carbon dioxide and ammonia, releasing heat as a metabolic waste product (Ciavatta et al., 1993). The aerobic conversion process occurs through different steps: degradation extent depends on the input material as well as on the process operating conditions.

Compost originating from the organic fraction of municipal solid waste (OFMSW) is increasingly used in agriculture as a soil conditioner as well as a fertilizer, in order to meet both crop nitrogen and organic matter addition (Hargreaves et al., 2008; Iqbal et al., 2010). In Europe the use of compost is regarded as a way forward to address both security of nutrients and organic matter supply thus improving soil conditions (European Union, 2012). It has been estimated that 32% of the produced compost originates from biowaste and 9% from mixed waste, whereas the remaining part mainly comes from green waste and sewage sludge. Almost 50% of the whole amount of compost produced in Europe is used in agriculture (Sayen and Eder, 2014).

The application of OFMSW compost on soil may entail both health and environmental risks that are often neglected. Solid waste may contain a number of chemical or biological contaminants that may expose different populations to health hazards (Déportes et al., 1995). The removal of these pollutants from waste improves compost quality and, to this end, collection systems play a fundamental role.

Mechanical selection of residual waste and source sorting represent the two main pathways to obtain OFMSW. Cecchi et al. (2003) highlighted that OFMSW coming from mechanical sorting has a higher total solid (TS) content, due to the greater presence of materials, such as plastic and glass, which are not biodegradable and affect compost inert content. Gomez (1998) also proved that heavy metal concentration is significantly higher for compost originated from the treatment of MSW without separation than from source separated waste. Conversely, Zdanevitch and Bour (2011) highlighted that there are not significant differences, both in terms of organic and inorganic pollutants, between compost originated from mechanical sorted OFMSW and the one from source sorted organic waste. The same authors stated that compost is better stabilized when composting process follows an anaerobic stabilization phase,

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pointing out the importance of the biological process efficiency. A proper composting extent allows the degradation of some contaminants along with the substrate: differently from metals, organic contaminants may be metabolized by microorganisms during a composting process (Oleszczuk, 2007); only the very stable ones may persist in compost because their complex molecular structure is not easy to biodegrade during a conventional biostabilization process.

Scientific studies have been mainly focused on the detection of contaminants in compost, where harmful contents can be found due to the concentration effect originating from the curing phase (Paré et al., 1999). This approach takes into account that the concern related to the presence of persistent organic compound is mainly due to their resistance to degradation and tendency to bioaccumulation (Macgregor et al., 2010). If potentially toxic compounds that are ubiquitous in the environment can also be present in waste going to composting, it is necessary to quantify the potential for uptake of toxins and/or pathogens into the food chain, resulting from the use of waste produced composts within the supply chain (Hough et al., 2012).

Therefore compost characterization, both in terms of stability and maturity, represents the main requirement in order to safely use compost for agricultural purposes.

Compost stability is related to the level of activity of the microbial biomass. Several approaches have been proposed to assess biological stability of organic matter. Some of them consider both chemical methods (López et al., 2010), which are not expensive, and physical ones (Fernández et al., 2012), recognized as less time consuming. Biological tests have been largely investigated, whereas enzymatic methods have been proposed recently (Komilis et al., 2011).

Baffi et al. (2007) compared three techniques to assess the stability of 15 different composts and found that, differently from the biological one, chemical and thermo-analytical methods do not reflect directly the content of easily degradable organic material in composts and, as they are also affected by the composition of the input material, they do not substantially describe biological stability correctly. Biological tests are, therefore, suitable to realistically assess the achievement of the biological stability after a composting process. Such tests can be performed in either aerobic (Scaglia et al., 2007, 2011) or anaerobic (Barrena et al., 2009) environment as well as under static or dynamic conditions (Scaglia et al., 2000). Respiration techniques, in particular, have been reported to provide the more detailed compost stability characterization (Barrena et al., 2014).

On the other hand compost maturity refers to the degree of humification and implies the absence of both phytotoxic compounds and pathogens (Bernal et al., 1997). Maturity is partially affected by the relative stability of the material, since phytotoxic compounds are produced by the microorganisms in unstable composts (Bernal et al., 2009). Nevertheless Komilis and Tziouvaras (2009) demonstrated that stable compost, characterized by a low microbial activity, cannot be mature and, hence, phytotoxic. This outcome suggests that maturity also describes the impact of other compost chemical properties on plant development.

Even though different procedures are often used to describe compost maturity degree (Bernal et al., 2009), it is usually assessed by phytotoxicity tests.

Plant tests used in both research studies and quality standards can be divided into four broad categories: germination tests (including root assessments), growth tests (assessment of top-growth and sometimes root mass), combinations of germination and growth and other biological methods such as enzyme activities. Germination tests provide an instant picture of phytotoxicity, whereas growing tests will be affected by continuing changes in the stability or maturity of the compost tested: there may be damaging effects on growth in the earlier stages, but beneficial effects later on, with different conclusions depending on the time of assessment (Bernal et al., 2009). Komilis and Tziouvaras (2009) stated that germination indices are highly dependent on the types of seeds used.

Therefore the evaluation of compost maturity can properly rely on germination tests, which are not time-consuming, on condition that the seed to be used must be clearly identified in order to ensure result reproducibility.

Even though many attempts have been made in order to define the most suitable methods, further research is required for the definition of a reliable procedure to evaluate compost stability and maturity and to assess the effective risks associated with its agricultural use.

In Europe regulations dealing with compost quality assessment are differently established at national level.

This evidence states a risk for human health associated to both the use of toxic compost on soils and to the cross-border commerce of agricultural products. The lacks in quality assessment regulations imply the use of potentially harmful compost for agricultural purposes, including the cultivation of food products. This risk reasonably exists also in countries where strict limit values are established for compost quality evaluation, as any specific restriction is set for agricultural product market in Europe.

This work aims at reviewing European regulations dealing with compost quality, in order to identify the most common parameters used to define its characteristics as a fertilizer. In particular, stability and maturity tests adopted in different European States are discussed. Following the analysis of enforced legislation and guidelines, compost samples collected in a full-scale plant treating source sorted OFMSW were analyzed under the Italian regulation, in order to identify limits and capabilities of the proposed characterization procedure.

2. The assessment of compost quality in Europe

Across European Member States standards that compost must meet in order to be qualified as product differ considerably (Table 1). In some countries, including Austria, France, Germany, Italy, there are explicit and detailed rules set by legislation under waste law. In other countries, such as the United Kingdom, the classification of compost as waste is left to case by case decisions of the regulatory authorities. In the remaining Member States, there is an implicit assumption that compost ceases to be waste when registered as a product (Sayen and Eder, 2014). Similarly regulations and standards on compost quality are not equally established at European level, with the exception of the limits set by the Decision 2006/799/Ce as well as by the Animal By-Products Regulation. The former act specifies the criteria for a compost to be awarded of the community eco-label for soil improvers; the latter provides detailed hygienization rules for composting and biogas plants which treat animal by-products. A further reference is provided by the Regulation 834/2007/EC that lays down conditions for the use of compost in organic farming.

However within Member States, standards on the use and quality of compost differ substantially, partly due to differences in soil policies.

The lack of harmonisation creates legal uncertainty for waste management decisions and for the promotion of quality assurance. A high level of environmental protection can be achieved only if there is reliable and comparable information on the relevant product properties, whose variability should be within known limits.

While the agronomic value (C/N ratio, minimum carbon content, . . .) and contaminant presence in terms of heavy metals and inerts are usually well established in compost quality regulations, a lack