CO-COMPOSTING: A BRIEF REVIEW

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ABSTRACT

A further and stronger effort has to be made in terms of allowing composting to reveal its benefits. Increasing technological experiments have been done with composting of biodegradable wastes and even some considered hazardous. Treated sewage sludge mixed with biodegradable wastes provides a rich source of bacteria and nutrients. But we have gone further and today co-composting is done with a diversity of wastes and not only. There is no turning back in our throwaway society and co-composting plays, thus, an increasingly serious role.

KEYWORDS

Waste, co-composting, biotechnology, biowaste.

RESUMO

É necessário um esforço superior para permitir que a compostagem possa revelar os seus benefícios. Têm sido efectuadas crescentes experiências tecnológicas com a compostagem de resíduos biodegradáveis e mesmo alguns considerados perigosos. A mistura de lamas tratadas com resíduos biodegradáveis constitui uma fonte rica em bactérias e nutrientes. Já avançamos e a co-compostagem é actualmente realizada com uma diversidade de resíduos e não só. Não existe forma de voltar atrás na nossa sociedade do desperdício e a co-compostagem desempenha, assim, um papel crescentemente importante.

PALAVRAS-CHAVE

Resíduos, co-compostagem, biotecnologia, bioresíduos.

1. INTRODUCTION

Wastes are generated by activities in all economic sectors involving loss of materials and energy, and imposes economic and environmental costs on society for its collection, treatment and disposal (Morselli, Vassura and Passarini; Raven and Berg). A sustainable waste strategy for the next decade and beyond must be of key importance, especially if biodegradable waste (also called biowaste) diversion from landfills is at stake (Sykes, Jones and Wildsmith).

References and mentions to compost occur in 10th- and 12th-century Arab writings, in medieval Church texts, and in Renaissance literature (Smith, Friend and Johnson). Composting is essentially an aerobic microbial process decomposition that requires optimal moisture and porosity (Haug). During composting, the biodegradable organic compounds are broken down, whereas part of the remaining organic material is converted into humic-like substances (Veeken et al.). According to Gajalakshmi and Abbasi, composting is one of the most versatile and remunerative techniques for handling biodegradable solid wastes, and it is, in fact, gaining growing popularity (Hargreaves, Adl and Warman; Otten). The process of composting is able to transform organic matter into a stable product consisting of a humus-like substance. Moreover, it also diverts the organic fraction of municipal solid waste, among other wastes, from landfills, and transforms these organic by-products into valuable agronomic resources (Kashmanian et al.). In this case, the end product will be available for agricultural use mainly (Déportes et al.). However, municipal organic waste has, usually, low organic matter and nutrient concentration than those of other feedstocks (Tognetti et al.), and thus, composting will then enhance organic matter and nutrient concentration. However, compost can also be used for landscaping in public parks and playgrounds or a part of soil cover at sanitary landfills. But many other uses (Raviv; Stofella and Kahn) are now implemented, being the most common soil amendment, organic fertilizer or raw material for other industries. Tourism in general and agro-tourism can also benefit from the use of compost in the improvement of forest and landscape (Manios). In fact, composted materials are remarkably regarded for their ability to improve soil health and plant growth, and suppress pathogens and plant diseases (Ahmad et al.; Hargreaves, Adl and Warman; Jakobsen; Ruggieri et al.). Indeed, it is clear that many authors consider composting an economically hygienic and ecologically sound system of waste management (Bernal et al.; De Bertoldi et al.; Fauci et al.; de Guardia, Tremier and Mallard; Mari et al.; Nahm; Paredes et al.; Williams; Zucconi and De Bertoldi). Thus, it can be said that composting is increasingly becoming a universal and popular option for an environmentally sustainable means of recycling agricultural and municipal by-products, particularly in an attempt to reduce the burden of household waste disposal.

It is important to make clear, however, that the microbiological quality of finished compost depends on the storage conditions, also. Thus, the storage stage should be viewed as part of the composting process (Déportes et al.). In fact, it is known that in order to guarantee the effectiveness of the composting process to produce a sanitised compost material, it is undoubtedly necessary to monitor the process and especially the cooling phase. It is during this phase that a microbial regrowth or reactivation can take place (Bustamante et al.). In fact, the emerging worldwide trend of environmentally safe technologies via composting (and co-composting, as presented below) processes is gaining importance in terms of examining the environmental health and safety of the products. This is why the current European Union (EU) legislation concerning composting technologies, requires the final product to be certified safe for its intended use and that fulfils statutory time/temperature combinations, for example (Anon). On the other hand, when considering costs and environmental impacts of waste management (Wei, Fan and Wang), moisture requirements and leachate generation are lower under dynamic conditions because the formation of agglomerates is avoided (Ruggieri et al.), and that must also be taken into account.

Composted raw matter is of various origins including yard waste, manure and sewage sludge (SS) (Déportes et al.). The composting process is also used to treat municipal solid waste (MSW).

Aiming to enhance the composting process, increasing the degradation rate and the quality of the compost, several modifications have been made, such as the addition of biodegradable wastes to reach the optimum C/N ratio of about 30 (Haug). This is called co-composting. The addition of chemicals to increase the reaction rates and the composition of the compost (Brown, Angle and Jacobs; Sánchez-Arias et al.), or the use of some of the mentioned below wastes together with the ones usually making part of the ordinary composting process, were also ways to enhance the process and/or, at the same time, to reduce the landfilling of other wastes. In fact, with co-composting not only the ordinary wastes that used to be treated with composting are used, it will be seen ahead in the text.

2. **EXAMPLES OF SOME CO-COMPOSTED WASTES**

Solid waste management is one of the important aspects of environmental biotechnology. Composting/co-composting are also methods for decontamination of polluted soils. Co-composting of organic compounds of wastes under controlled aerobic conditions is actually a biotechnological process of helping to solve this worldwide crisis we face in terms of waste management. It is possible to find in the scientific literature a huge number of works dealing with co-composting - **many times only entitled composting** - as a technology designed to achieve higher benefits in the deviation of some non-biodegradable wastes from landfilling. Some of those works are briefly referred across this text, aiming to illustrate the diversity of wastes that can be found it terms of co-composting, in a very brief way.

Tognetti, Mazzarino and Laos (Improving the Quality) and Tognetti, Mazzarino and Laos (Co-composting Biosolids) applied co-composting when mixing municipal organic waste with biosolids, and the results showed that this led to improved organic matter concentrations, therefore enhancing the compost quality and market value, while creating products that improve the nutritional capacity of soils. This is also an example of different waste streams being treated in an integrated way.

The composting of winery waste is an alternative to the traditional disposal of residues, always involving a commitment to the reduction of the production of waste products. Bertran et al. co-composted sludge and grape stalks (GS), and found out that the resulting compost had a high agronomic value and was particularly suitable for the soils of the vineyards which have very low organic matter content. The same authors highlighted the fact that the compost could then be reintroduced into the production system, thereby closing the residual material cycle. Fernández et al. have evaluated carbon degradation during co-composting of exhausted grape marc (EGM) with different biowastes: cow manure and straw (CMS), MSW and GS. They concluded that the co-composting of EGM with other biowastes not only enhanced the carbon degradation rate, but also reduced the carbon remanent fraction at the end of the composting process. GS seems the best waste to co-compost with EGM.

One of the by-products of instant coffee production is a solid waste with high organic content. Nogueira, Nogueira and Devens co-composted coffee waste and agricultural wastes and obtained satisfactory results, with the production of a high quality compost.

Fats and oils are among the main components of organic matter in wastewater (Saatci, Arslan and Konar) and solid wastes, especially those produced by the food industry (Galli et al.; Mari et al.). It is acknowledged that composting of fats is inherently difficult due to the nutrients deficiency, especially regarding low nitrogen and phosphorous content relative to high carbon content (Sasaki et al.). However, Gea et al. had already shown that animal fat could be successfully composted with sludge at high ratios to obtain a stable and sanitized product. A maximum content of 30% was recommended to obtain high fat degradation (85%) and to avoid excessively long composting periods. In a posterior work, Ruggieri et al. studied the biodegradation of animal fats present in a high proportion in a composting process with digested sewage sludge used as co-substrate. They concluded that sewage sludge acted as an adequate co-substrate in fats composting in terms of nitrogen source and providing additional biodegradable organic matter and active biomass. It is important to mention than composted products derived from animal sources, for example, are required by EU biohazard safety regulatory legislation to attain 70 ºC for over 1 h, via treatment, in terms of the upper limit for thermal lethality, for achieving biosecurity of the animal waste composted products. In fact, most vegetative bacterial pathogens are generally destroyed in temperatures in excess of 45-50 ºC within 6-8 weeks periods of composting (Jones and Martin). However, exceptions still subsist. The discussion of the legislation involving each situation would be extensive and cannot be done here. It is also not appropriated in this paper, to separate co-composting processes by co-compost used, since in same cases, it is used in different perspectives and aims. Fang et al. "Changes in Biological Parameters", for example, have evaluated the effects of coal ash residues, as a co-composting material for sewage sludge, on the thermophilic bacteria population and four enzyme activities during a bench composting trial. They concluded that the enzymatic activity demonstrated that the addition of coal fly ash would not impose a significant impact on the nutrient cycling of the composting product, except for sewage sludge containing a 25% ash amendment (addition of 25% fly ash), which might be due to the unavailability of phosphorus at a high pH condition. In a posterior work, it was recommended that 25% or less coal fly ash should be used to co-compost with sewage sludge (Fang et al. "Co-Composting of Sewage Sludge"). Also, Sánchez-Arias et al. have studied the effect of incorporating an acidic ferrous sulphate waste (SF), an industrial waste, over co-composting process of sewage sludge and olive mill solid wastes in a 1:2 v/v wet basis. According to them, all composts obtained fulfilled the limits determined by current European regulations and presented better characteristics for its use as soil amendment and organic fertilizer than the traditional composts without SF. This small list of experiments clearly illustrate that much is being done in investigating the synergies in mixing more than one type of wastes, in order to produce a valuable compost. It is also a way to treat different streams of waste at the same time, with obvious advantages.

But co-composting is going further. For example, co-composting of soil (not seen as a waste) is the process of simultaneously stabilising organic materials and degrading toxic compounds foreign to the environment. Again, it offers significant advantages as it is more controlled than landfill and less costly than incineration (Aguilera-Vázquez et al.).

Being known that compost cannot be considered potentially detrimental or dangerous, for the environment or for the human health, it is also accepted that the MSW from which it has usually been obtained can contain several pollutants that may represent environmental or health risks (Brändli et al.; Veeken and Hamelers). Critics are apprehensive with the consequences of mixtures within composting. Richard and Woodbury stated some years ago that sewage sludge, for example, should not be added to the compost at any point since it would raise the metal content of the compost. Those fears, while still present in innumerous articles focusing in human health, must today be clearly explored to the light of the present technologies. For instance, concerns relating with loading the soil with metals are today discarded by Eneji et al., Smith and van Herwijnen et al., who clearly make all part of the scientific literature where composting processes are believed to increase the complexation of heavy metals in organic waste residuals, thus limiting their solubility and potential bioavailability in soil and, consequently, diminishing hazardous risks to humans and fauna. Metal mobility and availability can be reduced, for example, by raising soil pH, since cationic ions are less available at high pH conditions (Brady).

When performing experiments relating the viability of using co-composting, the compost quality needs sometimes to be further evaluated in further experiments, in order to guarantee the feasibility of the process towards certain aspects of its possible use. In the most usual way of application, for example, it is acknowledged that the compost quality for agricultural use depends on its inorganic nitrogen content, since the fertilizer N needs to have immediate availability of to plants (Gajalakshmi and Abbasi). When Fang et al. ("Effect") evaluated the effects of coal ash residues, as a co-composting material for sewage sludge, they were careful enough to draw the attention to the fact that their only concern about co-composting sewage sludge with coal fly ash would be the quality of the final composting product for plant growth, which would demand further greenhouse experiments. Smidt et al. have designed an experiment with the only intention to co-compost lignin with biogenic wastes to build up humic substances, in order to improve compost quality. Humification was a target to be reached by composting due to the favourable properties for soils and plants. Results obtained have shown that the addition of lignin can induce a synergistic effect in composts with regard to humic acid formation, depending on the added lignin source. This is the example of an experiment conceived with the main goal focused in the compost quality. The experiment has also shown that, due to the fact that lignin presents a reduced availability of for composting micro-organisms, fungal pre-treatment does not have a positive effect on composting of wood, which is an important advantage in terms of economy. This last aspect, focusing on economy, is especially important relating the compost quality, since each economical aspect that can be saved means that the investment can be made in something else, in order to satisfy the client's demands.

Thus, this particular aspect of the composting process is a key issue in terms of the market. In fact, the economics of composting systems are greatly enhanced if the compost can be sold. To be marketable, the compost will have to obey to the specifications/conditions imposed by the buyer. Those specifications will comply items like odour, colour, particle size, pH, moisture, carbon, nitrogen, and C/N ratio, among several others, which may be dependent on the required uses. In terms of legislation, aspects to be taken into consideration clearly address the fact that composters must be able to check critical controls of thermal destruction of bacterial or fungal pathogens and other important vectors, which may be present in pre-composted ingredients, including wastes from animal origin, for example. It is not possible to clearly find specific EU legislation relating co-composting by itself. However, much has been done lately in terms of environmental EU legislation concerning many different aspects. The management of biowaste in the EU concerning the Green Paper on the management of biowaste in the EU can be consulted at http://www.cor.europa.eu/COR_cms/ui/ViewDocument.aspx?siteid=default&contentID=dc762731-7b80-4618-8668-c81f9cffcfdb and allows to understand how sustainable development, which is also the focus of all these emerging technologies, is an important goal in EU's strategy. According to this, composting of biowastes is, for example, also presented as an alternative to potential reducing emissions of greenhouse gases, a very important issue at the present. This is a clear sign of EU concern towards the management of wastes.

3. CONCLUSIONS

Co-composting, as ordinary composting, is an effective strategy for diverting several types of waste from landfills, while transforming them into valuable resources. This is an essential point in waste management, since it allows obtaining progress in completely different management areas. With co-composting, not only agricultural and municipal by-products are at stake, many industrial wastes can also be treated this way. Therefore, it is important to conceive strategies to improve and enhance the composting process. Biodegradable wastes can be successfully mixed with previously treated sewage sludge and many other non-biodegradable wastes, in order to create a high-grade compost. This may effectively replace alternative high-cost and sometimes unavailable bulking agents needed to treat these solids. Many of these developing recent waste management biotechnologies will need to be further investigated to accomplish a clear characterization of the quality of the compost obtained. However, there is no doubt that co-composting is readily becoming a fundamental tool in the hierarchy of integrated waste management programmes. Bearing in mind that organic wastes represent a major part of all generated wastes, it becomes clear that they can be extensively used to recover other wastes from being discarded through common forms of disposal. This allows to understand the importance that EU has been giving to biowastes, as referred in the text.

Some studies seem to need to invest in compost quality characteristics, thus allowing to draw further uses to the compost obtained. At this moment in time, every environmental investment in knowledge relating landfilling alternatives is automatically justified.

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