SOILS AND ORGANIC WASTES MANAGEMENT: NEW STRATEGIES TO INCREASE THEIR ECOLOGICAL CAPITAL

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Soil degradation by organic matter loss may have both, ecosystem and demographic consequences. Considering increasing populations and life expectancy, there will be vast amounts of waste that will need to be recycled. We can use ***organic materials (organic wastes) as an inexpensive and continuous source of external organic matter for the rehabilitation of degraded soils and desertified areas***.

To improve our scientific knowledge of organic wastes, and to offer the possibility of using them in new, effective, environmentally correct, economically viable, and socially acceptable ways, converting them whenever possible into "resources" as opposed to merely "waste" products is a necessary task. Alternatives will be put forward for obtaining **"à la carte organic materials"** by means of techniques that include the –omics and biotechnological methods, adapting the products to the specific needs stipulated. The ultimate aim of the proposal is to generate the needed scientific knowledge to improve the existing strategies, as well as to develop novel ones. This will allow that organic wastes can be used as high quality organic amendments in agriculture, as well as biopesticide products, and also as source of compounds with high added value. According to their "quality", organic wastes can be used for restoring degraded soils, improving soil quality and fertility as well as carbon sequestration in soils.

Soil degradation and Organic Carbon in arid and semiarid soils

Desertification is the main problem which arid and semiarid lands face. Within the context of Agenda 21, desertification is defined as "*land degradation in arid, semi-arid and dry sub-humid areas resulting from climatic variations and human activities*" (UNCED, 1992). The different forms of land degradation can include (UNCCD 2010): i) loss of nutritive matter due to agricultural over-exploitation; ii) loss of topsoil surface due to wind and water erosion, particularly due to the loss of vegetation; iii) landslides caused by the action of water and the effects of vegetation loss; iv) increased salinity and soil acidification due to inadequate irrigation, and; v) soil and water pollution due to excessive use of chemical fertilizers. Decline in agronomic productivity of soils in developing countries is partly attributed to human-induced soil degradation and the attendant decline in soil quality (Lal, 2006). This degradation is strongly linked to the loss of soil organic carbon (SOC).

Soil is the largest pool of organic C in the biosphere, storing more C than plants and the atmosphere combined, and also containing inorganic C forms such as calcite and dolomite. Lal (2004) indicated that the predicted amounts of carbon in drylands are 159-191 billion of tons and with a density of 35-42 (tons C ha^{-1}). If we compare with the values estimated for boreal (247-344 tons C ha^{-1}), tropical (121-113 t tons C ha^{-1}) and tundra (121-127 tons C ha^{-1}) ecosystems, it remains clear that soils in this climate are depleted on carbon, both for "natural" or "anthropogenic reasons". The hypothesis is that improvement in soil quality through increase in the SOC pool can achieve the desired rate of increase in crop yield and soil quality to ensure food security for the future (Lal, 2006).

SOC sequestration is a potential tool in climate change mitigation, but is finite in both time and duration (Lal, 2004). This soil function for carbon storage is different for each specific soil and depends on climate and land use (Lal, 2009). Arid and semiarid soils have been considered the lowest contributors to the global organic carbon stock (Janzen, 2004). However, the organic C sequestration potential for these ecosystems has been estimated as high, through OM increase (Lal, 2009). The OM in such systems will provide a dual solution to land degradation and desertification by: i) improving soil quality and ii) enhancing SOC sequestration.

Organic amendments (exogenous OM source) for soil restoration in arid and semiarid soils

The recent Thematic Strategy for Soil Protection, which is a preamble for a new European directive (http://ec.europa.eu/environment/soil/pdf/ com_2006_0231 in pdf), identifies *the loss of OM* as one of the principal causes of soil degradation. A report on OM and biodiversity within the European Thematic Strategy (Van Camp, 2004) mentions that exogenous OM, that is organic materials added to a degrade soil in order to improve harvests or restore a degraded soil for subsequent use, constitutes an invaluable source of OM and contributes to fixing C in the soil, thus partially diminishing the greenhouse effect derived from the release of CO_2 to the atmosphere. The maintenance of adequate organic matter levels in soils, which favours the establishment of a stable plant cover and the subsequent incorporation of organic elements, is considered one of the most effective methods in the fight against erosion an associated degradative processes.

Caravaca et al. (2004) found that the application of urban refuse increased the organic carbon (OC) content in fine particle-size fractions and both studies showed a higher OC content in silt in comparison with the clay particle-size fraction. In contrast, Steffens et al. (2009) studied the SOM distribution in a semiarid steppe and reported that higher OM input to a grazing land had not affected the OC concentration of the fine particle-size fraction after 25 years. Furthermore, Steffens et al. (2009) indicated a possible limitation to OC sequestration in small-size fractions in such ecosystems. Concerning this subject, Six et al. (2002) pointed out that the native soil OC may not reflect the ultimate carbon potential of a soil. Our own research (García et al., 2012) has evidenced that arid and semiarid soils have a great potential for C fixation. Nevertheless, despite the importance of soil OC, a lack of information on the capacity of semiarid soils to protect OC by association with soil particles after organic amendments still exists and the capacity of semiarid soils to distribute and protect OM in soil particle fractions after organic amendment remains unclear, as do the limitations.

Application of organic materials enhances the nutrient status of soil by serving as a source of macro- and micro-elements and improves its physical properties by increasing soil porosity and water retention as result of the presence of humic-like substances, known as a poly-condensed marcromolecular structure. In addition, one of beneficial effects about humic substance is that soil enzymes bound to humic fractions are protected for a long term against denaturalization by proteolysis attack in soil. In this context, the use of organic amendments to improve soil quality and restore degraded lands has been widespread (Garcia et al., 1992, Tejada et al., 2006, Bastida et al., 2013).

Organic amendments for a more sustainable agriculture

Common agricultural practices such as excessive use of agro-chemicals, intensive cultivation, deep tillage and excess of irrigation have degraded soils, increased gas emissions and polluted water resources. Among the practices recommended for the improvement of the soil quality and soil fertility in Mediterranean regions is the application of composted organic wastes, which slowly release significant amounts of nitrogen and phosphorus. As reported by Nyamangara et. al. (2003), management of soil organic matter by using composted organic wastes is the key for sustainable agriculture. Organic matter plays a key role in the development and functioning of terrestrial ecosystems, determining potential productivity of natural and agricultural systems. OM addition notoriously improves soil physical, chemical, and biological properties as well as soil water efficiency (Tejada et al., 2006). To improve soil quality and restore or increase its fertility and productivity it became necessary to provide to the soil the suitable level of OM to improve their physical properties and to reactivate nutrient biogeochemical cycles and microbial activity. Therefore, increasing soil organic matter content must be the first step in any farming practice in the Mediterranean region. Application of *high quality processed organic wastes* in crop cultivation may significantly contribute to increased yield efficiency improving soil quality, and presents a potential way to recover value and eliminate landfilling.

However, organic wastes may have beneficial or detrimental effects on soil, depending upon waste characteristics and management. Therefore, it is necessary to adopt waste management strategies, such as controlled biodegradation processes to both, stabilize waste organic matter and minimize their potentially negative environmental impact and improving their agronomic characteristics.

An important aspect on organic wastes is that they can “inoculate” the soil with vast numbers of beneficial microbes (bacteria, fungi, etc.) that promote biological activity of the soil (Pascual et al., 2000). These microbes are able to extract nutrients from the mineral part of the soil and eventually pass the nutrients on to plant. Furthermore, properly processed OW reduces soil borne diseases without the use of chemical control (Pascual et al, 2000).

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References

Bastida F., Hernández T., Albaladejo J., García, C., 2013. Soil Biology and Biochemistry, 65: 12-31.
Caravaca, F., Lax, A., and Albaladejo, J., 2004. Soil Tillage Research, 78:83-90.
García, C., Hernández, T., and Costa, F., 1992. Environmental Management, 16:763-768.
García E, Garcia, C. Hernandez T. 2012. European J of Soil Science, 63: 1-9.
Lal R (2004).Science, 304, 1623-1626.
Lal R (2006). Land Degradation and Development, 17, 197-209.
Lal, R., 2009. *Land Degradation and Develoment,* 20(4), 441-454.
Nyamangara, J., L.F. Bergstrom, M.I. Piha, and K.E. Giller. 2003. Soil.J. Eniviron. Qual. 32:599-606.
Pascual, J.A., Hernández, T., García, C.,De Leij, F.A.A.M. and Lynch, J. M. 2000. Biology and Fertility of Soil, 30: 478-484.
Six, J., and Jastrow, J. D., 2002. Marcel Dekker, New York, pp 936–942.
Steffens, M., Kölbl, A., Giese, M., Hoffmann, C., Totsche, K. U., Breuer, L., Kögel-Knabner, I., 2009. Journal of Plant Nutrition and Soil Science, 172(1):78-90.
Tejada, M. García, C., Gonzalez, J.L., Hernández, M.T. 2006. Soil Sci. Soc. Am. J., 70: 900-908.
UNCED. 1992. Conference on Environment and Development (UNCED), 1992
UNCCD 2010. Integration of UNCCD National Action Programmes (NAP) with UNFCCC National Adaptation Plans of Action (NAPAs), 2010.
Van-Camp, L., Bujarrabal, B., Gentile, A.R., Jonse, R.J.A., Montanarella, L., Olazabal, C., Selvaradjou, S.K., 2004. Organic matter, Vol. III. Reports of the Technical Working Groups established under the Thematic Strategy for Soil Protection. OOP EC, EUR 21319 EN/3, Luxembourg.