Agricultural valorization of seaweed from the shores of Mar Menor Lagoon by composting

C. García-Delgado[1], V. Polo[1], B. Mayans[2], M.A. Jiménez-González[1], T. Fresno[2], E. Eymar[2], S. López-Rayo[2]

[1]Department of Geology and Geochemistry, Universidad Autónoma de Madrid, Madrid, Madrid, 28049, Spain
[2]Department of Agricultural Chemistry and Food Sciences, Universidad Autónoma de Madrid, Madrid, Madrid, 28049, Spain
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Presenting author email: carlos.garciadelgado@uam.es

Introduction

The Mar Menor Lagoon is a coastal saline lagoon located in the Region of Murcia, in southeastern Spain. It is the largest saline lagoon in Europe and is separated from the Mediterranean Sea by a strip of land known as La Manga. This lagoon has a semicircular shape and an area of around 170 km². Over the years, the Mar Menor Lagoon has faced various environmental problems, such as seaweed proliferation and eutrophication, due to intensive agricultural activity, urbanization, and lack of adequate water renewal.

The seaweed *Caulerpa prolifera* is a green alga characteristic of the Mediterranean Sea which entered the lagoon after the dredging and widening of the Estacion channel in the 70´s, causing an alteration in this ecosystem and, therefore, it is considered an invasive seaweed. The environmental disequilibria produced by decades of human activities in the lagoon produced a negative impact on the native seaweed species of the Mar Menor Lagoon which promoted the colonization of this lagoon by *C. prolifera*. Currently, recurrent episodes of bloom explosions of this seaweed are produced by the eutrophication of the lagoon and the favorable environmental conditions.

Among the different actions that are being carried out to regenerate the lagoon is the periodic removal of the seaweed that reaches the shore. There are estimates that the amount of seaweed removed from the shores of the Mar Menor reaches 7 tons per day which entails significant expense for the Regional Government and a growing problem of waste generation.

There are recurrent episodes of uncontrolled growth of seaweed around the world that cause serious concern and the most common waste management is the disposal in landfills (Gibilisco et al., 2020; Han et al., 2014). However, seaweed waste is useful for many applications in agriculture, biogas and biofuel, animal feeding, biotechnology, or the food industry, among other possibilities (Pradhan et al., 2022). The direct use of seaweed wastes is recurrent management in agricultural some coastal areas. However, this management may produce undesirable consequences such as fermentation, odors, production of toxic metabolites for plants, leaching of N changes in soil pH, salinity, and/or the accumulation of heavy metals in the soil (Madejón et al., 2022). Composting is a sustainable method to stabilize organic wastes, including seaweed. However, because of the low C/N ratio and high water content, this waste has to be mixed with other materials to facilitate the composting process and avoid undesirable rapid decomposition and N loss (Madejón et al., 2022). Differences in the proportion of taxa in the accumulated seaweed could influence the final concentration of nutrients, seaweed compounds, and the agronomic value of compost.(Gibilisco et al., 2020).

Therefore, the objective of this work was to evaluate the composting process of seaweed waste accumulated on the shore of the Mar Menor for its subsequent valorization as an agricultural amendment.

Materials and methods

Seaweed accumulated on the shores from the Mar Menor Lagoon (Murcia, Spain) was mechanically collected. A windrow pile of compost was formed by seaweed and urban pruning from the villages around the Mar Menor Lagoon at a rate of 1:2 to obtain a C/N ratio of around 30. The pile was formed in March 2023 in the Universidad Autónoma de Madrid (Spain) facilities. An initial weight of 87 kg of dry seaweed 170 kg or urban pruning was mixed to build a composting pile of 5 m length, 1.5 m width, and 0.7 m high. Aeration was achieved by mechanical turning and natural convection. The total C, N and C/N of seaweed and urban pruning is in table 1.

Table 1: Total Carbon, nitrogen, C/N ratio, pH, and electrical conductivity (EC) of seaweed and urban pruning.

	C (%)	N (%)	C/N	pH	EC (dS/m)
Seaweed	32.25 ± 0.01	3.18 ± 0.03	10.1 ± 0.1	6.73 ± 0.08	30.37 ± 0.93
Urban pruning	40.79 ± 0.57	1.02 ± 0.17	40.2 ± 0.8	6.93 ± 0.03	2.59 ± 0.15

The temperature of the pile was periodically measured by a temperature probe of 30 cm in length around the pile. Moisture was maintained at around 50% by periodic irrigation. Basic characteristics of the compost such as pH, electrical conductivity (EC), organic matter and carbon content, chloride, total-N (TN), nitrate and ammonium were periodically determined. The decomposition and quality of the organic matter was determined by FT-IR and CP-MAS ^{13}C-NMR analysis.

Results and discussion

The composting process was monitored for 167 days. The temperature profile of the pile is in Fig. 1. The temperature increased quickly from 18 ºC to 33 ºC on day 2. The maximum temperature of 49.6 ºC was achieved on day 18. The temperature above 30 ºC remained until day 113 denoting a long composting process. The total C content decrease during the composting process to reach a final value of 28.7 ± 0.7 %. Whereas no decrease of total N was observed during the composting process. The final value of total N was 2.1 ± 0.3 % denoting the high potential of the compost as N source. The matureness of the final compost was demonstrated by the low temperature of the pile at the end of the process and the C/N of 13.46 ± 0.83.
The pH of the compost increased from 6.86 ± 0.05 to 7.49 ± 0.04 whereas the EC decrease from 7.86 ± 0.34 dS/m to 1.67 ± 0.10 dS/m (extract 1:5; w:v). High values of EC and salinity reduce the temperature and delay of the composting process and is a critical point for further use in agriculture (Han et al., 2014). The chloride content of the compost decreased during the process from 4400 mg/L to 405 ± 19 mg/L (extract 1:5; w:v).

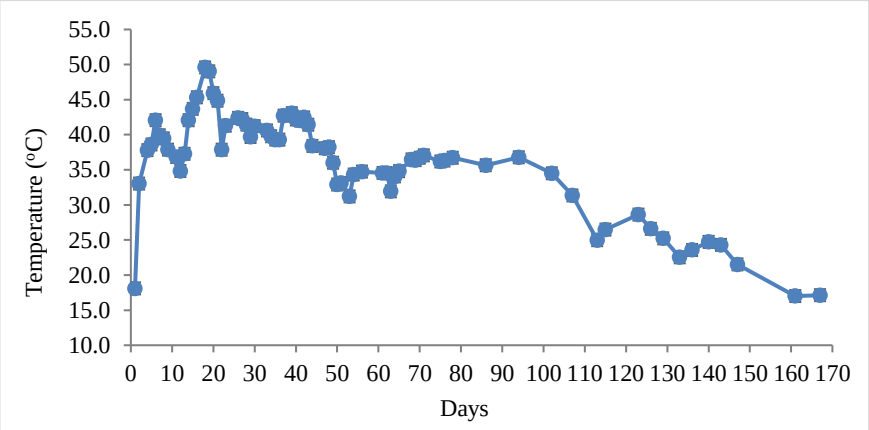

Fig 1: Profile of the mean values of temperature during the composting process of seaweed and urban pruning. Bars indicate standard deviations (n = 10).

The spectroscopic analysis showed the evolution of the organic matter during the composting process. The most important modification was taken out in the second month of composting when the O-alkyl groups, related to carbohydrates, decreased drastically and the aromaticity increased. From this time, the modification of the organic carbon was minor.

Conclusions

The composting of seaweed of the Mar Menor Lagoon with pruning waste is an effective procedure to recycle an organic waste that produce important economic and environmental problems. The final compost is a stable material with valuable nitrogen content and adequate basic characteristics to be used in agriculture.

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