Composition of seaweed from the shores of Mar Menor Lagoon with potential use in Agriculture

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The Mar Menor lagoon located in a semi-arid area (Murcian coast) is one of the largest hypersaline coastal lagoons of Spain. In the last years, the green alga ***Caulerpa prolifera*** has colonized the lagoon's muddy bottom spreading not only in the shallow water sandy areas with no other living organisms but also in other regions' habitats of marine plants such as *Cymodocea nodosa,* a phanerogam that grew in almost the whole Mar Menor basin and now is being displaced to only a few areas because of the wide explosion of the alga. The algae growth has increased reaching in August 2020 volumes approx. 60 tons of biomass (algae and phanerogam) that had to be removed and disposed of as waste with a significant economic cost and environmental impact.

In addition to the actions being taken to reduce pollution in the area, such as restricting the use of synthetic fertilizers and, in particular, nitrates, efforts are being made to explore potential uses for this waste in various sectors, including agriculture and energy production. The first step is the characterization of this material, which is fundamental to lead its subsequent application.

The objective of this work was to obtain a chemical characterization of the residue accumulated on the Mar Menor lagoon containing *C. prolifera* and certain sludge from the Mar Menor lagoon to orientate its potential use in Agriculture and energy production.

Material and Methods

The waste material was gathered from the Mar Menor shore, thoroughly rinsed with tap water, and preserved at -56ºC. Subsequently, it was freeze-dried, sifted to 4 mm to eliminate fine impurities, and finally, subjected to milling.

The percentage of humidity and total chlorophyll content were determined in the fresh waste. The rest of the determinations were done on the dried waste. They included pH, and electric conductivity (1:5 extract), CNHS elemental analysis, nitrates concentration (UNE-EN 10304-1), organic matter by calcination method, and ionomic analysis by Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES, iCAP-PRO XDuo Spectrometer, Thermo Scientific, UK). Other bioactive compound analyses were done including the concentration of hormones (Albacete *et al.* 2008), organic acids, and amino acids. The carbon of the seaweed waste was characterized by FT-IR and CP-MAS ^{13}C-NMR.

Results and Discussion

The humidity content of the waste was 77.8 ± 0.7 %, and the total concentration of chlorophyll was 2.33 ± 0.39 g/Kg (Chl_a 1.23 ± 0.30 g/Kg, Chl_b 1.11 ± 0.12 g/Kg). The elemental composition of the seaweed waste was 37% C, 4% N, and 1.6% S (Table 1). The spectroscopic characterization of the organic carbon by FT-IR showed a major faction related to carbohydrates and an appreciable amount of aliphatic and aromatic structures and possible N-H groups. The semi-quantitative analysis by CP-MAS ^{13}C-NMR showed 48% of O-alkyl groups, 12% of di-O-alkyl groups, 23% of aliphatic-C, 11% carboxyl-C, and 5% aromatic-C. These results indicate the high potential of this waste as a source of N and bioactive compounds such as carbohydrates. However, the low C/N ratio (9.35) and the high carbohydrate content alert us about the potential rapid decomposition of this waste, and the consequent necessity to design adequate management for this waste.

Table 1. Chemical properties and ionomic analysis of *C. prolifera* waste on lyophilized material.

Properties	Value	Properties	Value
%C	37.4	*Micronutrient concentration (mg/Kg)*	
%H	5.1	Fe	2330
%N	4.0	Mn	3010
%S	1.6	Zn	63.37
m.o. (%)	73.9	Cu	6.52
NO_3^- (mg N/Kg)	61	B	
pH (1:5)	6.51	Mo	1.04
Conductivity (mS/cm) (1:5)	21.0	Na	23553
Other Macronutrient concentracion (g/Kg)		Cl	5703
P	0.41	*Other elements concentration of interest (mg/Kg)*	
K	7.64	Al	3490
Mg	6.98	As	14.6
Ca	38.8	Br	374
		I	280
		Pb	82

Other chemical properties and the ionomic analysis of the waste are shown in Table 1. The electric conductivity of the waste was high, as well as the sodium concentration, which was not unexpected due to their nature. However, the value obtained was similar to those presented by biostimulant commercial products containing seaweed of other species (Valverde et al. 2022). The waste has a significant concentration of nitrate, which may be associated with the area where intensive agriculture has traditionally been done. However, this nutrient concentration could be of interest for applying the seaweed waste as a biostimulant or fertilizer. The concentration of P, in contrast, was very low. The notably high concentrations of iron and manganese can also contribute to the fertilizer properties of the waste material. The presence of other elements was analyzed, for instance, As and Pb that were under the limits indicated for biostimulants in the European Regulation (EU 1009/2019).

Because of the interest in studying the potential of the waste as fertilizer and biostimulant, an analysis of the hormones, organic acids, and aminoacids was done. A significantly high concentration of some hormones was obtained, indicating the high potential of the waste to be used as biostimulant. Similarly, the waste presented a notable concentration of succinic and citric acids and proline and glutamate aminoacids.

Table 2. Concentration of hormones, organic acids, and aminoacids in *C. prolifera* waste on lyophilized material.

Hormones		**Value (µg/Kg)**
Ethylene precursor		
	ACC	56.7
Cytokinins		
	tZ	1412
	ZR	0.888
	iP	16.9
Gibberellins		
	GA1	38.1
	GA3	107
	GA4	247
Auxins		
	IAA	14.5
	OxIAA	69.0
	PAA	374
	Mel	NF
Stress hormones		
	ABA	265
	SA	152
	JA	3669

Organic acids	**Value (mg/Kg)**
Malic	1.75
Succinic	29.4
Citric	9.95
Fumaric	0.982

Aminoacids	**Value (mg/Kg)**
Aspartate	0.320
Glutamine	0.481
L-Citrulline	0.360
Trans-4-Hydroxy-L-Proline	0.688
Proline	4.177
Glutamate	9.618
Valine	1.111
Phenylalanine	1.139
Tryptophan	0.256
Iso/Leucine	0.309

Hormone abbreviations: trans-Zeatin (tZ), zeatin riboside (ZR), Isopentenyladenine (iP), Gibberellin A1(GA1), Giberelic acid (GA3), Gibberellin A4 (GA4), Indole-3-acetic acid (IAA), 2-oxindole-3-acetic acid (OxIAA), Phenylacetic acid (PAA), Melatonine (Mel), Abscisic acid (ABA), Salicylic acid (SA), Jasmonic acid (JA).

Conclusions

The chemical composition of the waste of *C. prolifera* from the Mar Menor shores presents a broad array of active and nutritional compounds, including Fe, Ca, N, as well as certain hormones, amino acids, and organic acids, indicating that it may have potential use in agriculture, particularly as a fertilizer and biostimulant.

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References

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