Effects of cadmium on the physiology and chemical composition of the green algae *Ulva rigida* (C. Ag.)

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The green algae of the genus Ulva are among the species commonly found in polluted and eutrophicated coastal marine areas. In sea waters with high nutrient concentrations *Ulva* sp. have exhibited increased growth rates and elevated mineral nutrient content in their tissues[2]. It was also found during field and laboratory experiments that they demonstrate the ability to accumulate heavy metals, when exposed to high concentrations[3]. Therefore they can play a significant role in the food chain as well as in the biological and physicochemical transfer of metals from seawater to sediments[4].

The present study is part of an ongoing program with the principal aim to investigate the effects of different concentrations of heavy metals on the physiology and chemical composition of *Ulva rigida*, and understand the mechanism of uptake and release of metals.

Ulva rigida atoms were collected from a polluted bay near Athens (Gulf of Elefsis). The specimens were treated with increased concentration of cadmium (200 ppb) for 15 days[5]. The water was replenished every day with new quantities of cadmium enriched seawater from the same area. Individual algae were removed after 1,2,4,7 and 15 days and their cadmium content was determined by Atomic Absorption Spectrophotometry[6]. Portions of the samples removed, were kept for different periods of time in clean seawater (6 and 15 days), and at the end of these periods the remaining cadmium content was measured (see Table 1).

It was found that the metal uptake is faster during the first days of the exposure to high cadmium concentrations. Usual concentrations in algae ranged from 21.71 to 111.34 µg/g dry weight. When placed in clean seawater the alga releases most of the accumulated metal within the first 6 days. The remaining amount of metal depends on the originally accumulated quantity but never reaches the metal content of the untreated algae which is around 0.06 µg/g d.w.

It is known from the literature that *Ulva* sp. are rich sources of sterols and glycoproteins[7]. The production of chemicals during the metal treatment period, was used as an indicator of the algal physical condition. Unexposed algal samples as well as specimens treated with cadmium (200 ppb), were taken, air dried and extracted with organic solvents (chloroform/methanol). The extracts were concentrated under vacuum, and the residue was dissolved in ethyl acetate. Solutions of known concentration (10 mg/ml) were prepared and chromatographed by High Pressure Liquid Chromatography (Techsil 110sil column with a gradient hexane/ethyl acetate solvent system).

It was observed that the two chromatographs exhibited some marked differences. The organic extract of the treated algae showed the presense of some intense peaks (Techsil 110sil column with a gradient 70% hexane, 30% ethyl acetate --- 10% hexane, 90% ethyl acetate, 30 min. run, 2 ml/min, UV 254 nm detector) eg. peaks with retention time 6.93, 9.10, 9.40, 13.64 min. absent in the extract of the unexposed to cadmium samples. From the aforementioned results, we can assume that, under the intense stress conditions caused by the increased cadmium concentration, some metabolic processes in the algae were altered. This is the result of chemical adaptability observed also in other marine organisms when exposed to modified environmental conditions.

Table 1

Sampling days	Days in clean seawater	Metal content of the algal tissue (µg/g dw)
1	0	21.71
	6	5.23
	15	30.34
	0	24.72
2	6	6.85
	15	4.16
4	0	36.64
7	0	73.86
	6	11.43
	15	10.02
15	0	111.34

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