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For Young Scientists

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STRUCTURAL ADAPTIBILITY OF HAEMATOCOCCUS PLUVIALIS GREEN PHASE CELLS EXPOSED TO MANGANESE EXCESS

Isidora Santrač[1*], Jelena Danilović Luković[1], Milena Dimitrijević[1], Marina Stanić[1], Marija Tanović[1], Valentina Ćurić[2], Snežana Kovačević[1], Bernd Zechmann[3], Milan Žižić[1,4], Ivan Spasojević[1]

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Haematococcus pluvialis is a unicellular green alga with a complex life cycle and a remarkable metabolic and structural adaptability that allows it to thrive in metal-infested environments. *H. pluvialis* could be potentially used in the remediation of waters polluted with metals, such as manganese (Mn). Mn is also an essential element involved in different metabolic processes, such as photosynthesis and antioxidantive defence. Herein, we examined morphological response of metabolically active green cell type of *H. pluvialis* (microzooids) to high Mn concentrations exceeding their physiological quota. When exposed to 1 mM Mn^{2+}, cell viability remained stable over a 3-day period. Inductively coupled plasma atomic emission spectroscopy showed the prompt uptake of Mn by the microzooid cells after 1 h of the treatment, with a modest increase of the concentration of Mn in the biomass at 24 h. Scanning electron microscopy revealed granular deposits on microzooid surfaces after 1 hour, likely Mn deposits, while transmission electron microscopy (TEM) micrographs showed that some cells had wall rupture and degraded intracellular content and damaged organelles. After 24 and 72 h, a different type of cell morphology emerged, characterized by thickened cell wall, preserved intracellular compartments, and reduced total area of lipid droplets. Both cell types exhibited vacuoles containing dark granules, possibly indicative of Mn accumulations. Quantitative TEM analysis demonstrated that an excess of Mn reduced cell cross-section and lipid droplet area while increasing vacuole cross-section and cell wall thickness. The intricate adaptive responses of *H. pluvialis* to elevated Mn concentrations exemplified by cell wall thickening, reduction in lipid droplets total area due to increased energy demand, and the accumulation of Mn in vacuoles, exhibits the impressive structural adaptability. Further investigation using analytical methods will provide a more profound understanding of the metabolic dimensions of adaptive response.

Keywords: microalgae; *Haematococcus pluvialis*; manganese; bioremediation; ICP; electron microscopy

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