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# EFFECTS OF FUNCTIONALIZED MULTI-WALLED CARBON NANOTUBES ON THE AQUATIC ENVIRONMENT

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## *Introduction*

Due to their unique properties such as mechanical strength, very high electrical and thermal conductivity, chemical stability and high specific surface area, carbon nanotubes (CNTs) are being used as fillers in polymer composites for numerous applications (electrostatic discharge material, electromagnetic and thermal interface materials).

The increase of production of carbon nanotubes (CNTs), due to use in polymer nanocomposites has raised concerns as to their possible effects on the marine environment that could affect human populations. Their toxicity was tested on multiple organisms, and contradictory results on different plant species may indicate potential polluting effects and further testing is mandatory.

Thus, in this study, the possible effects of CNTs on aquatic organisms and their toxicity were evaluated. The pristine multi-walled carbon nanotubes (MWCNTs), as well as functionalized with carboxyl groups, were used.

## *Materials and methods*

*Materials:* Multi-walled carbon nanotubes (MWCNTs) was purchased from Sigma-Aldrich. MWCNTs were functionalized with carboxylic groups (MWCNT-COOH) through oxidation reactions and then reduced to produce hydroxyl groups (MWCNT-OH).

*Lemna minor* L., aquatic plant, very common in various areas and known as standard species for toxicity testing (potential bioremediator). *Lemna minor* L. (duckweed) individuals were collected from Suceava County, Romania.

The experiment was established using testing 3 concentrations of MWCNTs (10, 50, 200 mg/L) in the growth medium. At experiment initiation, duckweed individuals were placed in 300 mL test or control solutions. For each variant, 3 replications were set.

*Methods:*
Infrared spectra (FT-IR) were obtained by using a Nicolet 60 SX FT-IR under dry air, at room temperature, on KBr pellets, in the range of 4000–400 $cm^{-1}$.
The content of chlorophyll in fronds was determined in 80% aqueous acetone extracts. After filtration of extracts, their absorbances were read at 470, 648 and 664 nm wavelengths. Chlorophyll fluorescence was measured using a FMS2 portable fluorometer (HansaTech Ltd.). Total phenolic contents were determined in 70% ethanolic extracts prepared from *Lemna minor* fronds based on the Folin-Ciocalteu reagent assay.

***Results and conclusions***
The ΦPSII index had similar behavior in reference and 50 mg/L MWCNTs-OH concentration plants, after 1 and 3 weeks of cultivation (Figure 1). In the case of 10 mg/l MWCNTs-OH concentration plants, ΦPSII index increase after the first week, after that it decreases as in the case of the other samples.

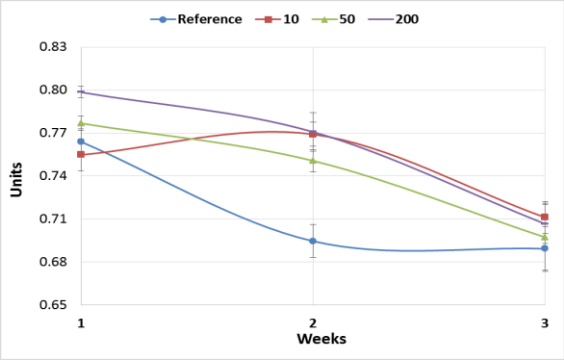


**Fig.1.** ΦPSII dynamics of *Lemna* plants

Regarding the photosynthetic apparatus, the MWCNTs in the medium lead to a decrease of chlorophyll a and b especially after 3 weeks of contact (Table 1).

**Table 1.** Chlorophyll in *Lemna minor* plants

| Samples mg/g | 1 week | | 2 week | | 3 week | |
|---|---|---|---|---|---|---|
| | Chl a | Chl b | Chl a | Chl b | Chl a | Chl b |
| Reference | 98.4661 | 40.713 | 100.0432 | 38.3266 | 42.2268 | 24.9838 |
| 10 | 88.8031 | 38.2387 | 117.7261 | 49.6097 | 36.6469 | 19.4514 |
| 50 | 84.0258 | 36.1579 | 124.0406 | 43.0720 | 49.2017 | 25.5721 |
| 200 | 94.7485 | 63.5939 | 100.2020 | 22.5461 | 53.5300 | 23.5211 |