

# The use of oxygen evolution to assess the short-term effects of toxicants on algal photosynthetic rates

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## Abstract

O<sub>2</sub>-production using either *Selenastrum capricornutum* or *Chlorella vulgaris* as indicator organisms to assess the presence or not of toxic compounds, was measured in a small volume oxygen chamber. These measurements were done at predetermined I<sub>0</sub> irradiances. At EC<sub>10</sub> and EC<sub>50</sub> levels, the response of *S. capricornutum* and *C. vulgaris* to atrazine toxicity was opposite to the response as determined at the EC<sub>10</sub> level. *Chlorella vulgaris* is more sensitive than *S. capricornutum* to high atrazine concentrations but *S. capricornutum* is more sensitive than *C. vulgaris* at the EC<sub>10</sub> level. It was shown that the heavy metals Hg, Cd and Cu and the herbicide, atrazine, influenced the photosynthetic rates but the organophosphate, gusathion, had no effect. The oxygen evolution assay may be useful as a rapid preliminary screening method for the presence or absence of toxic substances.

## Introduction

Concern over environmental perturbations has resulted in the search for methods of evaluating the effects of introducing substances to aquatic systems that may disrupt the equilibrium of those systems. The response of organisms to pollutants (excessive nutrients or toxic substances) is central to the disruption of equilibria and it is because of this that bioassays are used to evaluate the effects of pollutants.

In algal suspensions, changes in the dissolved oxygen concentration could be brought about either by photosynthetic evolution or respiratory depletion. From these changes two completely different metabolic pathways could be used in toxicity studies, i.e. photosynthesis or respiration. Hostetter (1976) developed a rapid bioassay sensitive to nutrients and the presence of toxic substances using a Clark-type oxygen electrode and a reaction chamber containing the water to be tested and the test organism. The rate of net photosynthesis as oxygen production was determined with this method. A prerequisite of such a method is that it is essential to reproduce the experimental conditions. Reproducing experimental conditions implies precise control of environmental conditions such as temperature and the light field, together with a rapid, reproducible, assessment of O<sub>2</sub>-evolution. Clark-type O<sub>2</sub>-electrodes offer advantages over other methods in that they allow for continuous measurements of oxygen production or consumption (Dubinsky et al, 1987). Net photosynthesis could be inhibited by toxic concentrations of substances.

In this study, results are presented where the oxygen chamber, as described by Dubinsky et al. (1987), was used to measure the possible effects of selected toxic substances namely; copper, cadmium, mercury, atrazine, gusathion and phenol (Table 1) on net photosynthetic rates as determined from oxygen liberation. The oxygen evolution assay may be useful as a rapid preliminary screening bioassay for determining which chemicals should undergo further testing.

| Compound  | Concentration<br>(mg.l <sup>-1</sup> )  |
|---|---|
| Cadmium   | 0.005, 0.01, 0.05, 0.1, 0.25 and 0.5    |
| Copper  | 0.01, 0.02, 0.2, 0.5, 1 and 2           |
| Mercury   | 0.005, 0.01, 0.02, 0.05, 0.1 and 0.2    |
| Atrazine<br>(an organochloride)                         | 0.005, 0.05, 0.5, 1, 5 and 10           |
| Gusathion or<br>Azinphos-methyl<br>(an organophosphate) | 0.00001, 0.0001, 0.001, 0.01, 0.1 and 1 |
| Phenol  | 0.01, 0.1, 1, 10, 100 and 200           |

## Material and methods

Unialgal cultures of *Selenastrum capricornutum* (CCAP 278/4) and *Chlorella vulgaris* (CCAP 211/12) were obtained from the Culture Collection of Algae and Protozoa (CCAP), Natural Environment Research Council, Cambridge, UK (now at the Institute of Freshwater Ecology, Far Sawrey, near Ambleside, UK). The reason for selecting these algae was that they maintain unicellularity throughout their life cycles which makes them suitable for cell counting using electronic particle counters. The algae were grown in synthetic algal nutrient medium (SANM), (Miller et al., 1978).

Semi-continuous cultures were maintained in a Conviron Model E7H (Controlled Environments, Winnipeg, Canada) growth cabinet at 23 ± 2°C. Continuous light was supplied at 300 μmol quanta-m<sup>-2</sup>-s<sup>-1</sup> by cool white fluorescent tubes and incandescent lamps arranged alongside and above cultures. Cells in the exponential growth phase (about 10<sup>8</sup> cells-m<sup>-1</sup>) were used in the experiments. The exponential growth phase i.e. three days after inoculation, was determined from a graphical plot of daily cell counts, measured with an electronic particle counter, Coulter Multisizer II (Coulter Electronics, England).

The experimental set-up was the same as described by

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