EXPERIMENTAL EXAMINATION

USING UV RADIATION TO DISINFECT WATER

1. Introduction

Using UV radiation to disinfect water is not new: UNICEF presented the idea in a 1984 booklet. Research has since investigated its potential to inactivate microorganisms in water. The principle is simple: pathogens are vulnerable to UV-A radiation (wavelengths 320–400 nm) and increased water temperature. Since sunlight has a strong UV-A component, it can improve water quality by eliminating pathogens. Water must be placed in a container and exposed to UV, which first passes through the walls, losing intensity through material absorption, then through the water, which also attenuates it. A longer path through the water gives greater attenuation.

Published scientific reports indicate that UV attenuation differs between plastics and water. We shall test this behaviour with the following aims:

1. Study UV absorption by different plastics.
2. Study UV attenuation in water.

2. Equipment

- UV source.
- Photodetector.
- Multimeter.
- Optical assembly.
- Glass cells of internal widths 2 cm, 3 cm, 4 cm, 5 cm and 6 cm.
- Noticeably turbid water.
- Blue, red, yellow, green and transparent plastic sheets (filters).
- Connecting wires.
- Graph paper.
- Card filter holder.
- Hollow white-card cylinder.

Important: The optical assembly's UV source is covered to prevent exposure during the experiment. Keep its movable cover closed as much as possible.

3. Procedure for parts A and B (*1 point*)

The photodetector produces potential difference U proportional to incident radiation intensity I: $U \alpha I$.

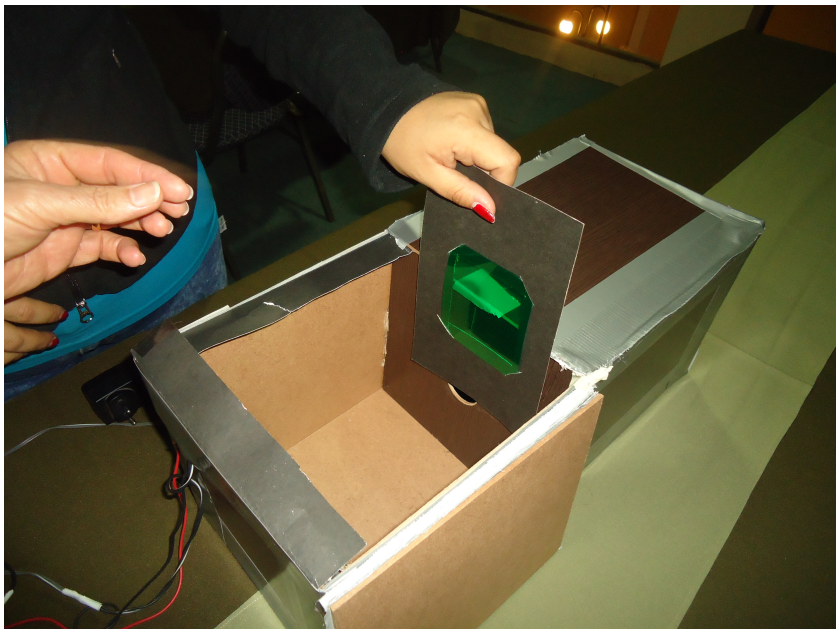
Tasks

1. Connect the UV detector and measure the baseline voltage with the UV lamp off: the response to radiation inside the box, or instrument zero error. (*1 point*)
2. Turn on the UV lamp and wait for the voltage to stabilise before measuring (about 10 minutes).
3. Keep the box closed for every measurement.

3.1. Part A (*8 points*)

UV absorption by plastics.

The photograph shows how to insert each filter.



A1. Measure the photodetector voltage without a filter. (*0,5 point*)
A2. Choose a plastic colour, insert one filter and measure U. Repeat with 2, 3, 4, 5 and 6 filters. (*0,5 point*)
A3. Repeat for the other colours and tabulate all measurements. (*1,5 points*)
A4. Plot effective voltage $U_{ef} = U - U_{base}$ versus filter count n from 0 to 6 for every colour on the same graph. (*2 points*)
A5. From your data, identify the colour with least absorption. (*0,5 point*)
A6. For that colour, determine transmission coefficient τ using model $U_{ef} = U_0\tau^n$, with constant U_0. Estimate its uncertainty. (*3 points*)

3.2. Part B (*11 points*)

UV attenuation by water

Determine the water's UV attenuation coefficient using glass cells of internal widths 2,0; 3,0; 4,0; 5,0 and 6,0 cm.

The cells only hold the water. Account for absorption by the glass so it does not affect the final result.

B1. Carefully insert the hollow white-card cylinder in the light-exit opening so the light goes directly to the detector. Measure the voltage without a cell. (*0,5 point*)

B2. Place the narrowest empty cell on the taped base mark, with its midpoint over the mark. Measure U_{vidrio}. (*0,5 point*)

B3. Repeat for all cells and tabulate the data. (*1 point*)

B4. Repeat with the cells filled with water; tabulate the measured voltage U_{total}. (*2 points*)

B5. Tabulate effective voltage U'_{ef} versus internal width x. It is the voltage that would result from attenuation by water alone. (*3 points*)

B6. Plot U'_{ef} versus x. (*1 point*)

B7. Determine the water attenuation coefficient α using exponential model $U'_{ef} = U_0 \exp^{-\alpha x}$, and estimate its uncertainty. (*3 points*)