Institute for Chemistry and Biology
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Mobile fluorescence sensing for citizen observatories

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Environmental crowdsourcing

The objective of environmental crowdsourcing is to include citizens in ecosystem monitoring, fostering their responsibility and increasing at the same time the amount of available data for scientists and policy makers. Among these approaches, the utilization of mobile devices is of increasing interest especially due to the fast evolving camera technology.

Fluorescence measurements allow the determination and quantification of basic biological and physical water quality parameters via their optical properties. Target constituents for fluorescence measurements are CDOM and phytoplankton, as well as hazardous substances that belong to the group of polycyclic aromatic hydrocarbons (PAH). The objectives of this work is focusing on fluorescence observations for marine environmental parameters using internal light sources from commercial smartphones as well as their inbuilt cameras.

Fig 1. Bio-optical measurements of water quality parameters, such as suspended particles, phytoplankton or coloured dissolved organic matter by citizens with mobile phones can enhance spatio-temporal coverage of environmental observations.

Fluorescence of water constituents

- CDOM and PAH fluorescence is excited in the ultra-violet spectral region, emission is in the blue (Coble et al 2007).
- Phytoplankton biomass is conveniently measured by the proxy chlorophyll *a*. Chl *a* fluorescence visible around 685 nm (Govindjee, 1995). Besides induced fluorescence (accessible with inbuilt white LED in mobile phones), also natural fluorescence by sun light is visible.
- Suspended particulate matter (SPM) is accessible via particulate scattering of light.

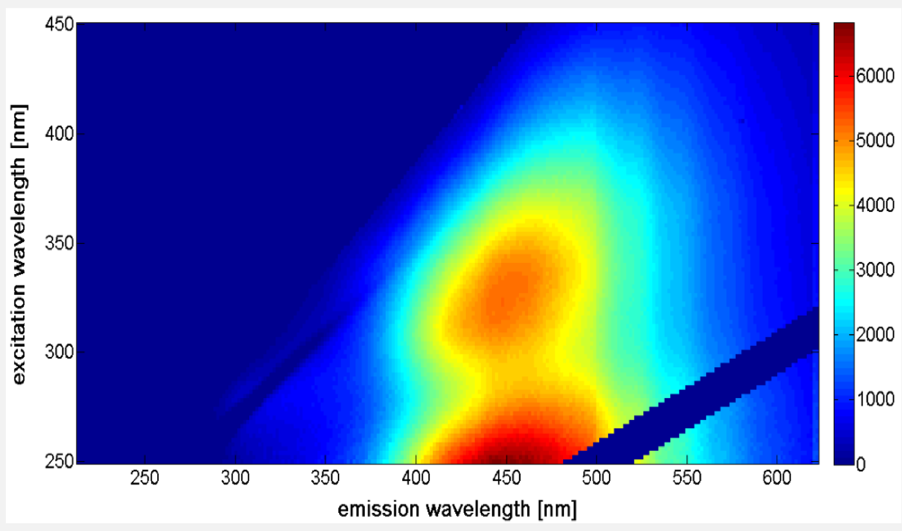

Fig 2. Exemplarily a typical excitation-emission-matrix (EEM) of CDOM. Fluorescence signals for different water components differ in the characteristic wavelengths for the excitation of molecules, as well as the spectral range in which the emission light is captured.

Use of inbuilt mobile phone light sources

Inbuilt mobile phone flashlights typically consist of white LEDs with a pronounced spectral contribution in the blue and a broader one in the green to red wavelength area. To ensure comparability of fluorescence measurements, LED flashlights of commercially available smartphones need to be tested for similarities.

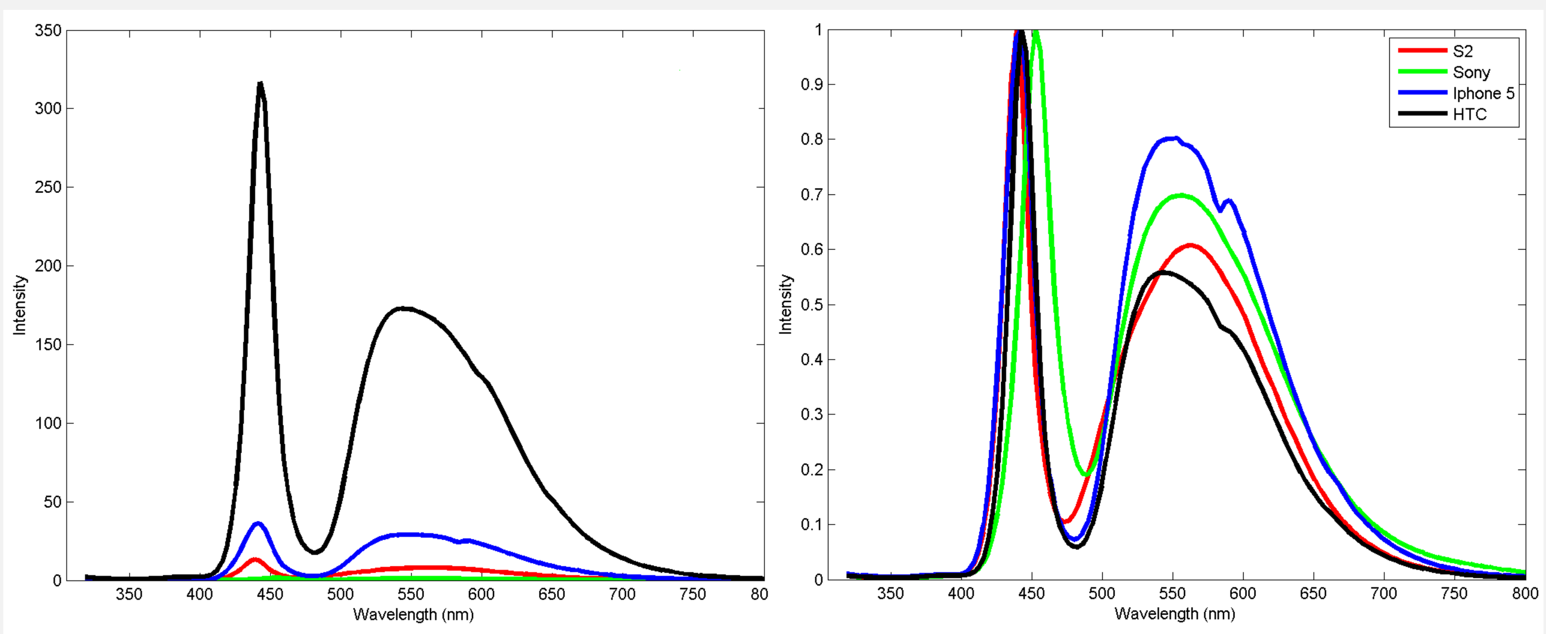

Fig 3. Similarity of spectral magnitude (A) and shape (B) for light sources of three different mobile devices in "*torch mode*".

Spectral shape of four tested internal light sources in "*torch mode*" is similar. Spectral intensity of four tested devices differed in magnitude.

- Need to adjust spectral intensity for all mobile phone types.
- Selection of excitation wavelengths by means of coloured filters (as in Figure 5).

Test environment for fluorescence measurements

Design of prototype of a cuvette holder for mobile phones (Fig 4).

Inclusion of coloured filters to limit the excitation and emission spectral range.

- Selection of filters for different parameters.
- Easy exchange to specific needs.

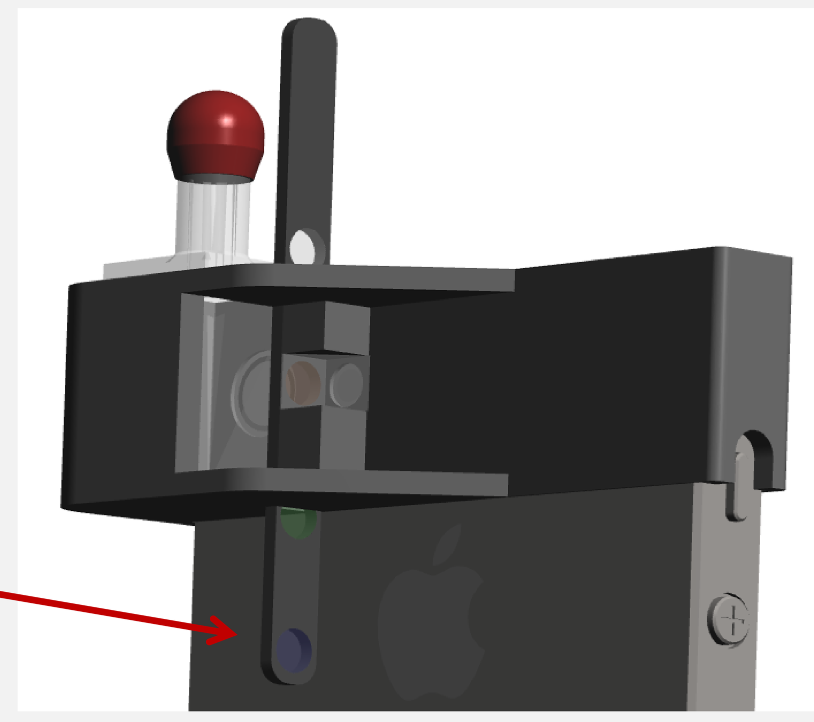

Fig 4. Design-prototype of a simple adapter utilizing the camera and the inbuilt flash of a mobile device for spectrometric measurements.

Fig 5. Schematic drawing for an App as test version for adjustments of fluorescence measurements.

Schematic App for the development of a first research application to test internal variables for fluorescence measurements in a cuvette with mobile phones.

Outlook

- Optimisation of the optical setup and laboratory evaluation of sensitivity.
- LED excitation in the ultraviolet to induce fluorescence in the blue-green spectral region. This approach was not followed in this work but is subject of future investigations.
- Add external illumination in the UV to broaden the range of applications to CDOM and PAH.
- Further development of first App for research application.
- Construction of adapter platform with selected optical elements (Fig 5).

Acknowledgements:
The authors would like to extend their gratitude to all supporting partners and persons. Furthermore we would like to thank Imke Mörking and Ursel Gerken for their assistance and support. The project is funded by the *European Commission* (Grant Agreement number 308469). More information: www.Citclops.eu

References:

Wernand, M.R., Ceccaroni, L., Piera, J., and Zielinski, O (2012)'Crowdsourcing technologies for the monitoring of the colour, transparency and fluorescence of the sea', Ocean Optics XXI, Glasgow, 2012, 00121127, 1-11.

Coble P G (2007) 'Marine Optical Biogeochemistry: The Chemistry of Ocean Color' Chemical Reviews 107(2), 402-418.

Govindjee (1995) 'Sixty-three years since Kautsky: Chlorophyll a fluorescence', Aust. J. Plant. Physiol. 22, 131-160.

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