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Simple and portable devices for measuring manganese in pore- and coastal water samples

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Manganese (Mn) plays a key role in biogeochemical cycles and can be found in the environment in the +2, +3 or +4 oxidation states. Therefore, quantifying this element is essential to understand its role in redox processes in the environment. However, the routinely used atomic spectroscopy methods are expensive, complex and non-portable.

Therefore, here we present simple and inexpensive colorimetric sensors developed for the reliable in situ quantification of Mn in aqueous samples. These sensors are based on a well-known reaction, the oxidation of leucomalachite green (LMG) to malachite green by periodate [1,2], which is catalysed by the analyte with limits of detection as low as 0.03 nM.

In this work we have made this method affordable and portable in the form of sensing strips on which the LMG has been immobilised. After incubation in the sample, a colour change from colourless to green-bluish takes place, which can be quantified either with a traditional spectrophotometer, by analysis of digital images, or with the aid of RGB colour sensors. For the last approach, an inexpensive device was constructed using the mentioned sensors, an Arduino® board and 3D printing.

Figures of merit of the sensors (sensitivity, limit of detection, linear range, etc.) were evaluated. The response was linear in the range of 0 to 40 µM $Mn^{2+}$and the limit of detection was 0.6 µM, which makes them suitable for analysis of porewaters. Furthermore, the effect of potential interferences (other metals, chloride and organic matter) was tested. The sensors were validated in porewaters from Spiekeroog Island (North Sea) and in water samples taken in the Amazon River during R/V Meteor cruise M147.

Our newly developed test strips are advantageous to current routine laboratory analyses due to their simplicity and cost efficiency, and superior to commercially available products since they allow for a real quantitative determination at low concentration ranges sufficient for the monitoring of many natural samples.

Bibliography

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