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Development of an in situ fibre optical sensor for low concentration measurement of Polycyclic Aromatic Hydrocarbons

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Marine environments are influenced by a wide diversity of anthropogenic and natural substances that may have adverse effects on human health and ecosystems. Among these, Polycyclic Aromatic Hydrocarbons (PAHs) are of high relevance and real-time measurements are required to adequately monitor these pollutants. PAHs derive from natural and anthropogenic inputs and show widespread occurrence in different water columns. They are also an important component of oil and its refined products. Since PAHs have toxic effects on humans as well on the ecosystem itself, it is necessary to detect even low concentrations in the order of ng/L preferentially in situ. In comparison to time-consuming and expensive laboratory measurements, in situ sensors have the advantage of real time measurements, supporting long-term applications with high resolution data sets. Most of the previously available in situ sensors do not possess the necessary sensitivity to measure normally occurring concentrations. This work is focused on the development of an in situ sensor that is applicable in coastal waters with sufficient sensitivity for typical concentrations of PAH's in natural waters. The measurement principle of the sensor system is based on a combination of absorption and fluorescence measurements. To obtain adequate results at high precision, despite low concentration ranges, it is necessary to improve the accuracy and sensitivity of spectrometric measurements. Improvements of photometric sampling can be reached by extending the optical path. However, conventional spectroscopy cuvettes are limited in their length by the resulting light scattering. A solution for this problem is the application of fibre optic capillary cuvettes. Within these cells the light path can be extended many times which allows absorption spectroscopy with highest accuracy. Simultaneous fluorescence measurements are performed by using bifurcated optical fibres and additional excitation light sources. Data of both measurements are compared, increasing the reliability of the sensor itself. Pre-treatment of the water sample is done by integrated solid phase extraction cartridges. Directing several liters of water through the cartridges concentrations of target substances were significantly amplified. PAHs are released from the cartridge using an organic eluent and then pumped through the fibre detection system. An additional advantage of the pre-treatment is the clean up of the interfering sample matrix. Using an organic eluent, deposits in the fibre optic capillary cuvette are prevented and the risk of losing sensitivity is avoided. The next steps will be the realization of an automated flow-through setup and an adaption of the sensor to high pressure subsurface environments.