Environmental screening and monitoring for emerging pollutants by immunoanalytical methods

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An increasing number of emerging pollutants has been detected in the environment over the last decades. Analytical methods suitable for trace analysis are needed that are desirably fast, inexpensive and, if possible, robust and portable. Immunoanalytical methods which are available in a broad range of formats, can be profitably used here to analyze for the presence and distribution of contaminants in the environment. Some of these methods are single-analyte but high-throughput methods. In order to use this approach wisely, priority chemicals, i.e. indicator substances, standing for a broad range of pollutants, have to be identified as screening targets. Other formats are field methods using portable instruments but also multi-analyte methods are feasible.

The microtiter-plate based ELISA (enzyme-linked immunosorbent assay) allows for the analysis of a large number of samples but only for one analyte at a time. Advances in using ELISA in screening and monitoring of anthropogenic markers such as the antiepileptic carbamazepine, the anti-histaminic cetirizine, the steroid hormone estrone, caffeine, and the bile acid isolithocholic acid have been made. An extremely sensitive ELISA able to detect 1 ng/L of caffeine in surface water samples without enrichment is presented (BAHLMANN ET AL. 2012).

ELISA cannot be reliably carried out in the field or on-site, e.g. in wastewater treatment plants. We have developed different on-site suited antibody-based methods, namely the homogeneous format fluorescence polarization immunoassay (FPIA), as well as electrochemical immunoassays. For carbamazepine an FPIA was achieved running on a portable polarimeter that allows for sensitive on-site measurement of influent and effluent concentrations (1 µg/L range) in wastewater treatment plants within a few minutes. Enzyme immunoassays making use of the oxidation of an electrochemically active substrate produce an amperometric signal on modified screen-printed electrodes and can be used on-site, power-supply provided. Continuous operation is achieved by immobilization of the antibodies on magnetic beads that allow for in and out of the immunoreagents in a microfluidic cell. This system is used to detect cocaine which is also considered a marker for anthropogenic impact upon surface waters.

The suitability of multi-analyte formats such as immunomicroarrays on glass slides depends on the choice of a signal producing system that provides small uncertainties of the measurements and the ability of performing adequate multivariate data analysis. Altogether these approaches show the great potential immunoanalytical methods provide to the screening and monitoring of emerging pollutants in the aquatic environment.

References

Bahlmann, A., J. J. Carvalho, M. G. Weller, U. Panne, R. J. Schneider, Chemosphere 2012, 89, 1278–1286.