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Towards a self-powered biosensors for environmental applications in remote, off-grid areas.

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Abstract

One important factor for developing biosensors is taking the source of electrical energy into account. The source of electricity is needed whenever we consider point-of-care diagnostics, in-vivo tests or in particular – environmental applications. The need of supplying energy to biosensor may be an important obstacle for its everyday use, particularly in developing countries. Here, we present the concept of biosensor able to generate power by bioelectrochemical oxidation of the analyte and thus – able to autonomously maintain its operation.

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Keywords: online monitoring; water quality; BOD; Biological Oxygen Demand; remote-sensing.

1. Main text

Environmental monitoring is indispensable in areas all over the world. In both cases the monitoring may be needed in remote, off-grid areas where the access to the electricity is limited. Constant monitoring of the quality of fresh-water resources is an important process that affects the quality of life but also aquatic ecosystems [1]. Biological Oxygen Demand (BOD) is a parameter describing the biodegradable organic content in the environment, thus – an indicator of pollution.

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The conventional method for measuring biochemical oxygen demand (BOD) has not changed for decades and typically it still takes 5 days to be completed. An alternative approach for BOD analysis is the use of Microbial Fuel Cell (MFC) based real-time biosensors [2]. However, the reading of MFC-biosensor measurements requires the use of peripheral apparatus, which is an important consideration when aiming to operate in remote locations.

MFC-based BOD biosensors have already proven their longevity [3]. Therefore, to ensure a long operation of the autonomous biosensor, we have designed an MFC system which allows the alkaline catholyte to accumulate in the cathode chamber [4]. This approach allows to prevent undesirable biofilm formation at the cathode [5].

In this work we focused on designing the autonomous biosensor that would be able to generate audio/visual cues in the presence of organic contaminants in fresh-water. In this system, water contaminants act not only as the target analyte, but also as the fuel for electricity. A combination of a living, respiring system with an electronic system creates a symbiotic connection between the two, as demonstrated previously for robotics [6]: the living system is used as a sensing element and provides the electricity to maintain the electronic system and the electronic system maintains the electroactive properties of the living system. The role of the electronic system is also to provide the energy needed to generate the alarm signal.

In such a configuration the MFC biosensor would be able to operate in remote, off-grid areas, where the environmental monitoring may help to improve the water-safety issues. We believe that his approach may open a new and exciting direction in the field of biosensors.

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