Fish cell-based biosensor: the prototype

Frederic Truffer[1*], Vivian Lu Tan[2*], Kristin Schirmer[2,3**], Serge Amoos[1], Gregory Emery[1], Martial Geiser[1**]

[1]HES-SO Valais, Rte du Rawyl 47, 1950 Sion, Switzerland, [2]Eawag, Swiss Federal Institute of Aquatic Science and Technology, 8600 Dübendorf, Switzerland, Empa, [3]École Polytechnique Fédérale de Lausanne (EPFL), 1015 Lausanne, Switzerland.
* Shared first-author contribution; ** Shared senior-author contribution. Contacts: frederic.truffer@hevs.ch; vivian.lutan@eawag.ch

Introduction

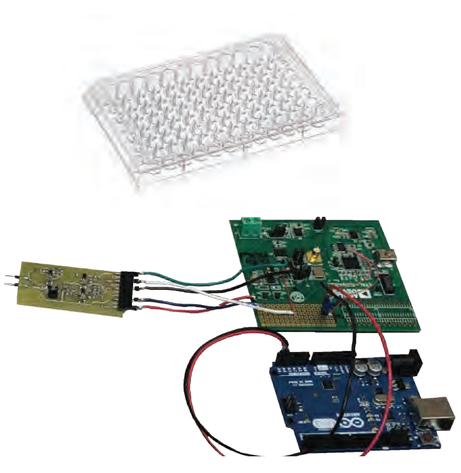
Eawag and HES-SO are collaborating in the prototype development of the fish cell-based biosensor. In previous investigations, Eawag has shown that the cell impedance of the rainbow trout gut (RTgutGC) and gill (RTgillW1) cells is indicative for both *in vitro* and *in vivo* toxicity of aquatic pollutants. For details please refer to the poster “Fish cell-based biosensor for evaluating water quality”. The results provide the basis for the engineering and integration of a funcional fish cell-based biosensor unit for the Envirobot project, a robotic system for automated monitoring of the aquatic environment.

In the prototype development, we have created a biochip (“Envirochip”) imprinted with electrodes and connected with cables to a portable impedance measurement unit. We have carried out the following:

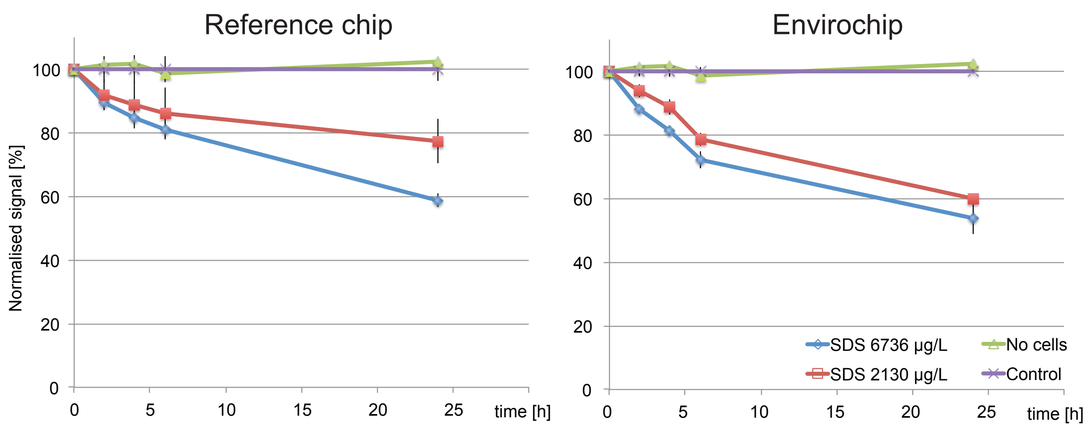
(i) Fish cell culture and exposure to toxicants, impedance measurement and comparison to a commercially available biochip (“Reference-chip”)

(ii) Integrated prototype design/blueprint

Envirochip vs. Reference-chip



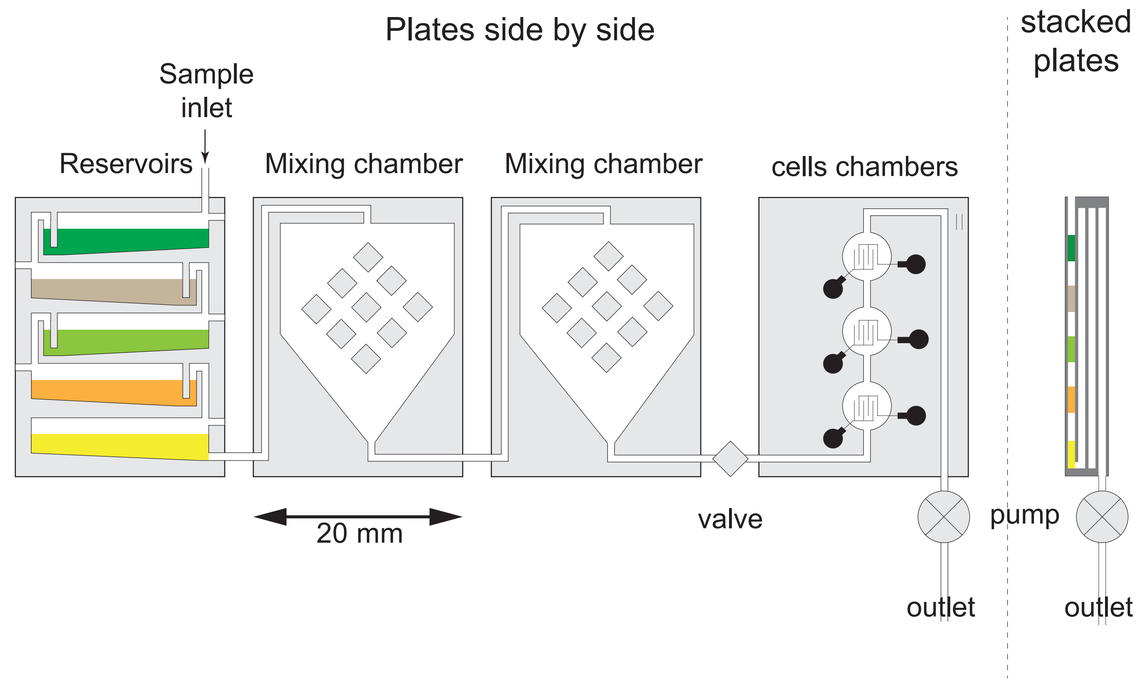
“Reference-chip” was a commercial 96-well plate with electrodes and external measurement unit supplied by the manufacturer. The device was not integrated or portable. “Envirochip” was a 96-well culture plate engineered by us, with embedded electrodes similar to the Reference-chip. Both chips were further manipulated: cables were directly attached to the wells, then connected with a portable external measurement unit. Image on top shows the look of both chips with no cable attachment. Image below shows the impedance measuring and processing units.



RTgutGC cells were seeded on Envirochip (right) and Reference-chip (left), and exposed to sodium dodecyl sulfate (SDS). Impedance was measured and normalised (y-axis) over time (x-axis). Toxicity and the dose-response patterns were consistent in both chips, indicating our engineered Envirochip was similar to the commercial Reference-chip and could be used in the biosensor.

Prototype design

A stack of 4 PMMA plates, one prefilled with several stock solutions and another prefilled with cells and nutrients and isolated with a valve is used as biosensor. To perform a measurement, the valve is open and the pump is turned on, pumping thus all liquid and the sampling first into the mixing chambers and then into the cells chambers.



Reservoir: Several concentrated stock solutions containing different kinds of salts, galactose and pyruvate for adjusting the osmolality of the water sample, are stored in separated chambers in order to avoid precipitation.

Mixing chambers: to ensure a good mixing of the stock solutions and the sampling, two mixing chambers are used before entering the cells chambers, which contains confluent cells in growth medium.

Summary and outlook

Summary: We developed the “Envirochip” which showed similar properties to the commercial chip for fish cell culturing and impedance measurement. This suggested that the engineering aspects including the surface coating, electrode embedding, cable connectivity, electronics as well as the measuring unit were fully functional and could be integrated into a portable biosensor. We designed the blueprint of the biosensor prototype. First test for filling the reservoir were successfully done as well as measurement with our electrodes on PET. The prototype consists of several stacked plates including the stock solution reservoir, mixing chambers and cell chambers. The osmolality of the water sample is conditioned before applying to the cell chambers that are connected with external impedance measuring and analytical units.

Outlook: The current prototype is more about design than function. As next we aim to test the design with cells, and fully integrate the cells into the biosensor for its application in the Envirobot.


Frederic Truffer, Senior Scientist
Systems Engineering, HES-SO
frederic.truffer@hevs.ch


Vivian Lu Tan, PostDoc Research Associate
Dept. Environmental Toxicology, Eawag.
vivian.lutan@eawag.ch


Martial Geiser, Group Leader
Systems Engineering, HES-SO
martial.geiser@hevs.ch


Kristin Schirmer, Group Leader and Head
of Dept. Environmental Toxicology, Eawag.
kristin.schirmer@eawag.ch


Serge Amoos, Senior Scientist
Systems Engineering, HES-SO
serge.amoos@hevs.ch


Gregory Emery, Assistant
Systems Engineering, HES-SO
gregory.emery@hevs.ch