Eawag – Swiss Federal Institute of Aquatic Science and Technology

Fish cell-based biosensor for evaluating water quality

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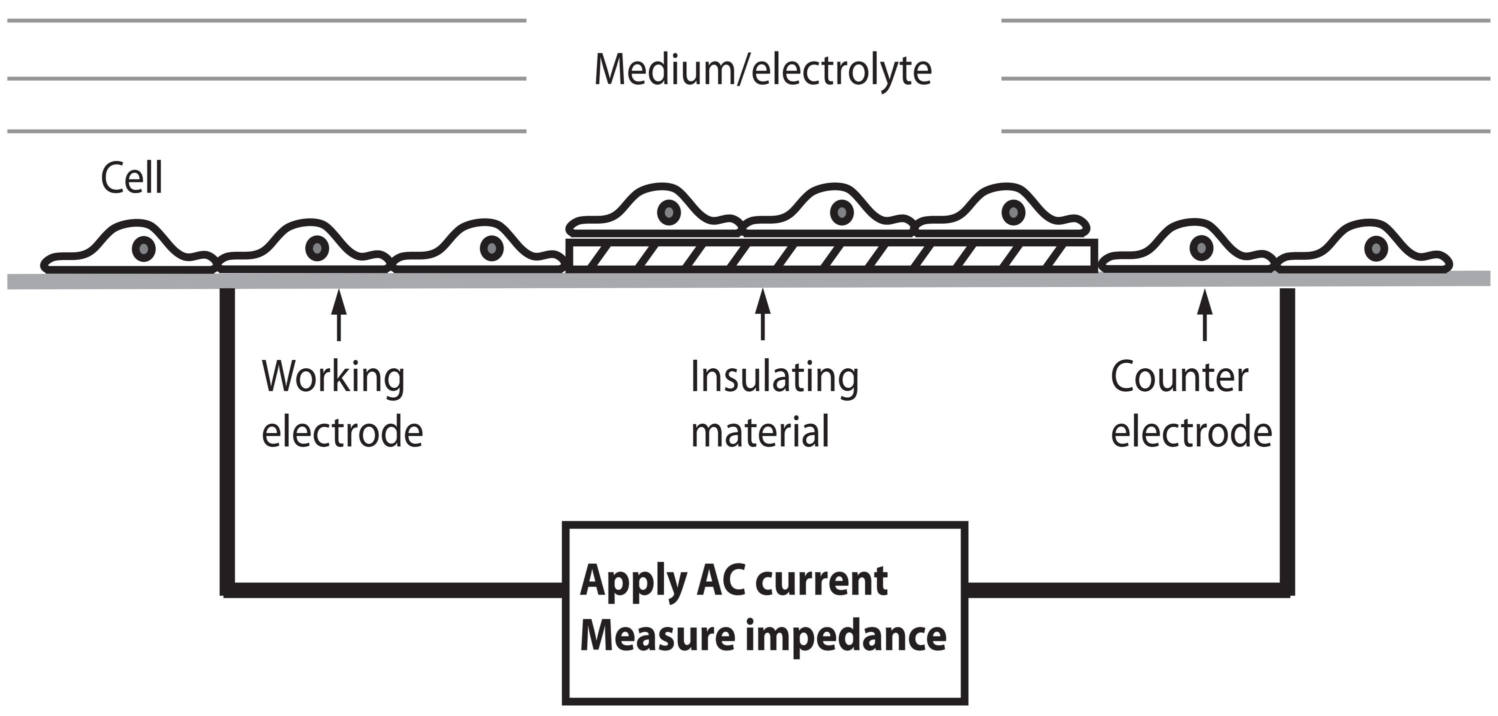
Introduction

- The development of effective, non-invasive methods for the detection of toxicants and risk assessment in the aquatic environment is a focal point in water research. The viability-based *in vitro* assays of rainbow trout (*Oncorhynchus mykiss*) gill cells showed very good agreement with *in vivo* fish acute toxicity tests (Tanneberger et al. *Environ. Sci. Technol.*, 2013, 47(2)). This indicative property complements the development of a cell-based biosensor. As part of the Envirobot project that aims to develop an automated robotic system using physical, chemical and biological sensors for assessing water quality in the field in real-time, we have been developing a fish cell-based impedance-mediated biosensor using the rainbow trout gut (RTgutGC) and gill (RTgill-W1) cells.
- The technology utilises cells cultured on electrode-embedded biochips as sentinels to detect toxic substances in water. The impedance measurement indicates cell status including cell growth, migration, morphology, cell-to-matrix and cell-to-cell interactions. The perturbation of the cells by chemical stimuli is indicated as changes in the impedance, reflecting the overall adverse effects of toxicants on the cells. Using this method, we systematically tested 31 organic pollutants and pesticides, as well as nine effluent samples. The impedance data (Z) were compared with conventional cytotoxicity assays (AB or alamar blue) and *in vivo* fish acute toxicity data.

Principle of cell impedance



Seed cells on a biochip, apply non-invasive AC current, measure impedance (Z) of cells on working electrode.

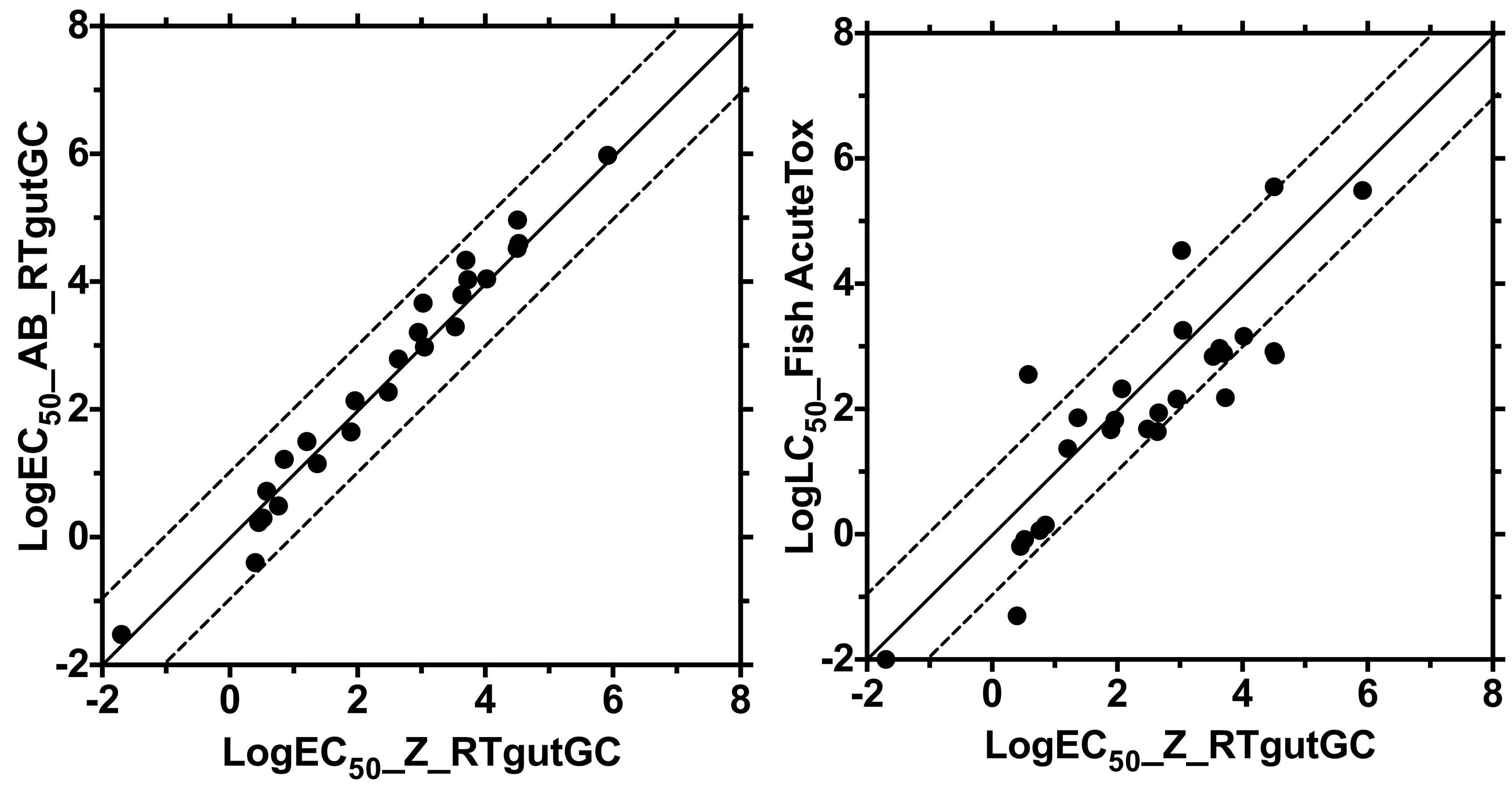
Summary and outlook

Summary: Cell impedance is effective in identifying toxic substances in benchmarking tests (31 chemicals), and could be applied to real-world applications (effluent tests). The impedance data indicate *in vitro* cytotoxicty and also reflect *in vivo* toxicity. The results provide the basis for the engineering and integration of a funcional fish cell-based biosensor unit for the Envirobot.

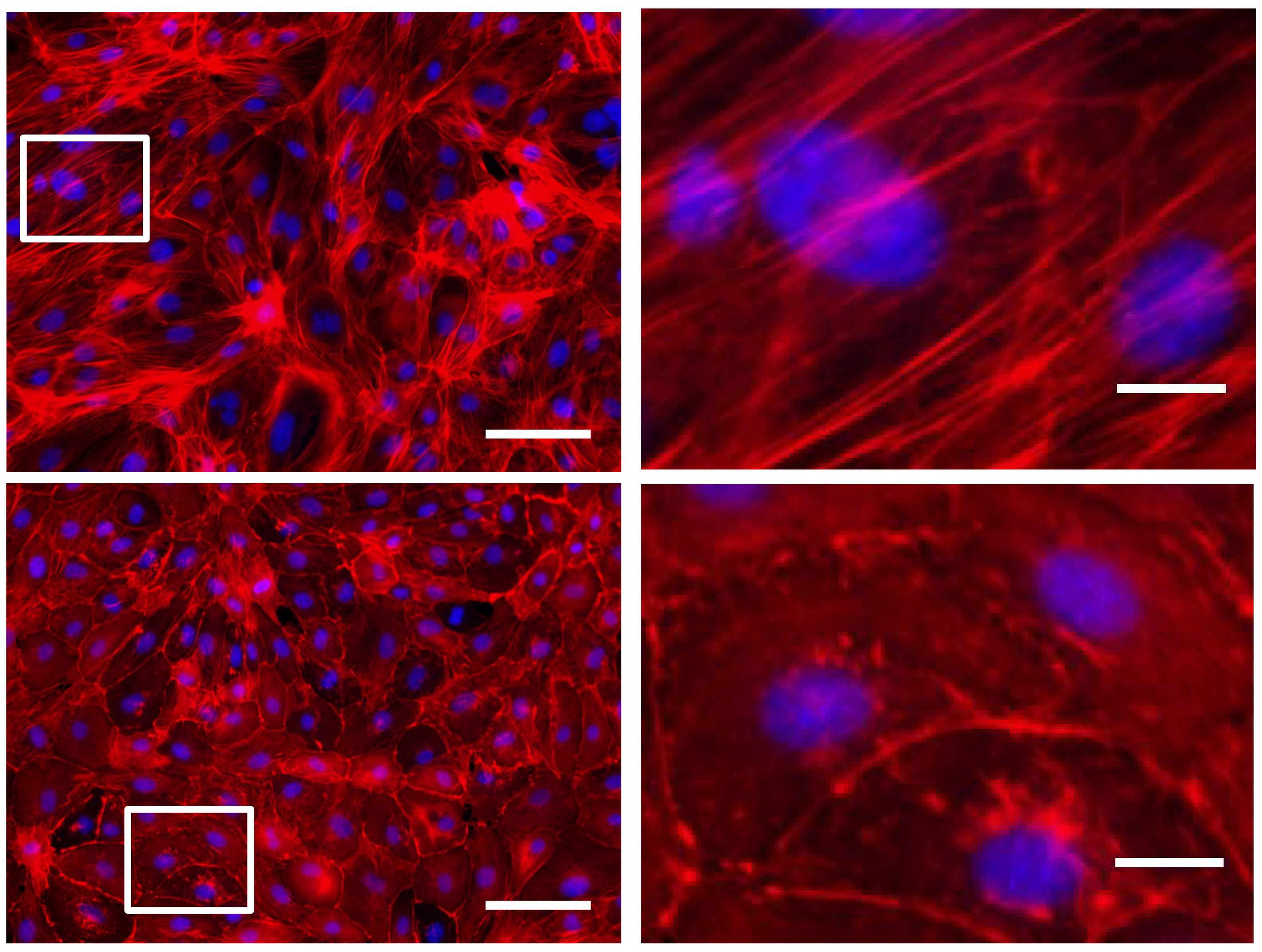
Outlook: the biosensor device has been designed and a prototype will be built. More on poster "Fish cell-based biosensor: the prototype".

Results

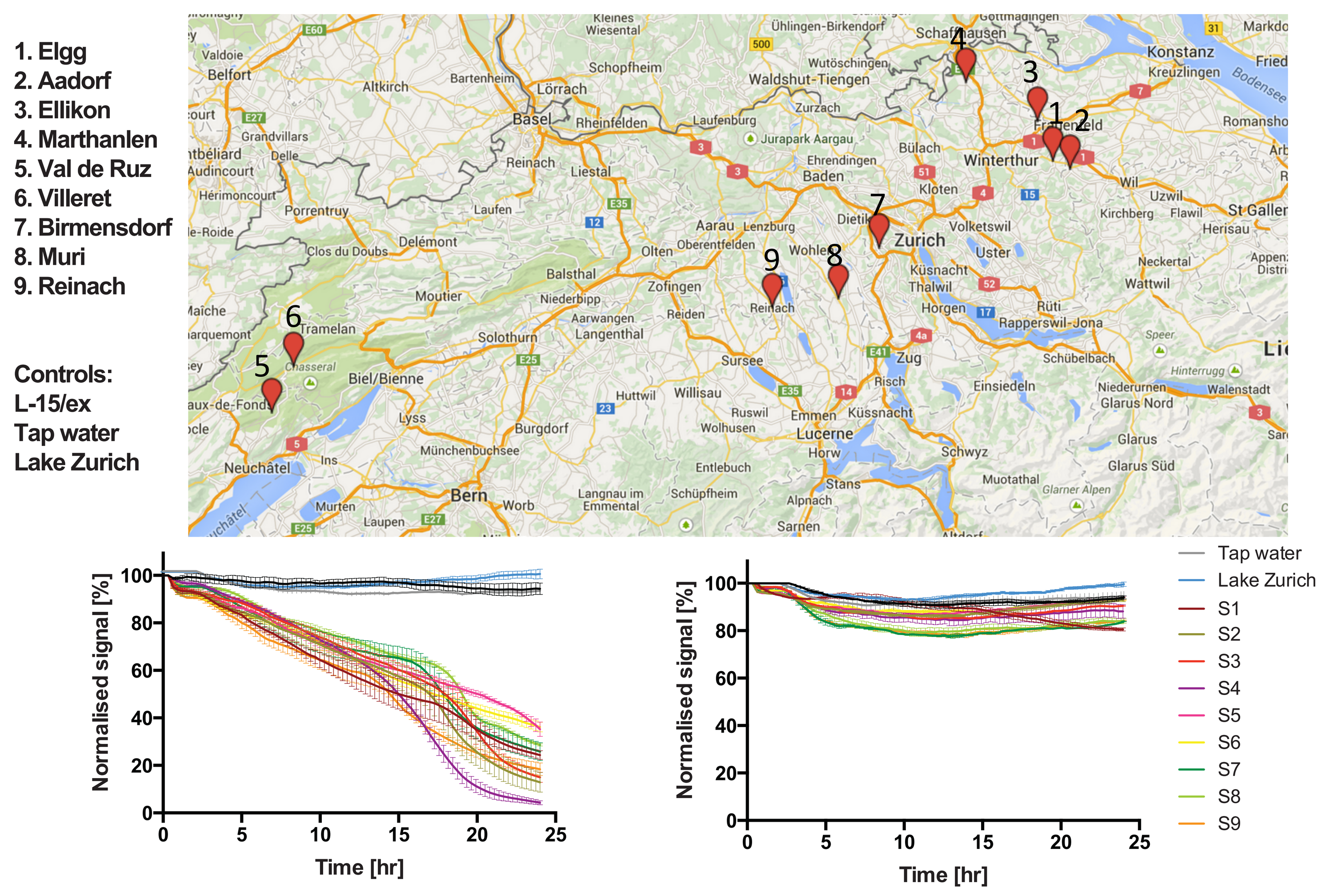
(shown are data from RTgutGC cells, RTgill-W1 similar)



$LogEC_{50}$ (μM) data of chemicals in benchmarking tests. Z vs. AB (left, r=0.9870, $p<0.0001$); Z vs. fish acute toxicity (right, r=0.8683, $p<0.0001$). Z correlates to toxicity on cellular and organismal levels.



Visualisation of typical damage of cells in actin staining. Top: untreated control cells, actin structure (red) normal. Bottom: cells treated with tetrachloroethylene, actin structure collapsed and impedance decreased. Scale bars: 50 μm and 10 μm (magnified, right)



Effluent water samples from nine sites across Switzerland were tested and compared with controls (Lake Zurich, tap water, L-15/ex). Unfiltered effluents were toxic to cells (left) mainly due to microbial activities, and filtered effluents were non-toxic (right).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