INTERNATIONAL CONFERENCE
ADVANCED TECHNOLOGIES FOR THE WATER AND WASTEWATER TREATMENT AND WATER REUSE
BUCHAREST 2009

Effective means to detect noxious compounds in water

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Overview

- Aim & How
- The Bioaffinity Platform
- The Cellular Platform
- Future development
- Conclusions

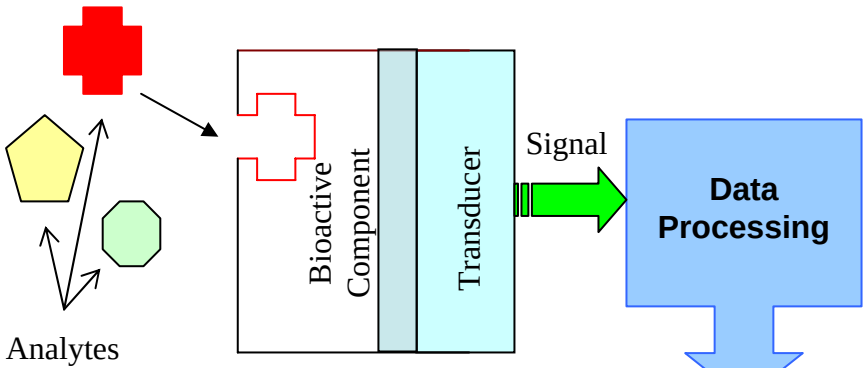
Aim

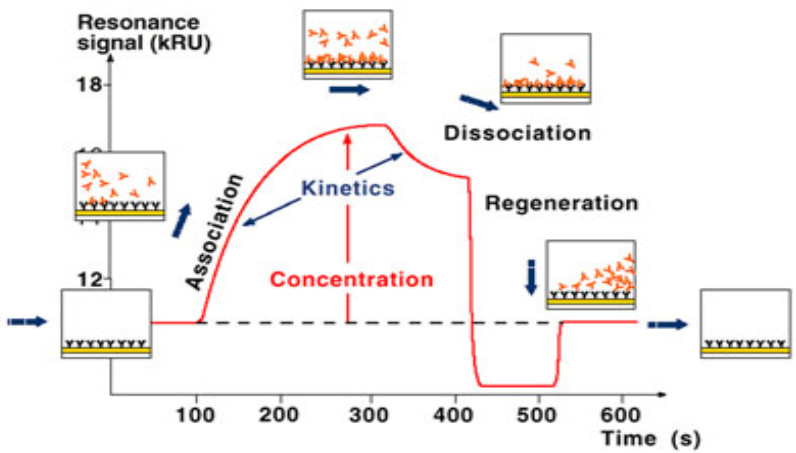
- Testing the capabilities of bio-affinity and cellular platforms analyzed by an electro-optical system to assess the presence of low weight compounds (e.g., antibiotics, detergents/toxins).

How

- Use of bio-affinity approach to detect the presence of one or more contaminants in the sample
- Evaluate the cytotoxic effect of the contaminants present in the water samples using cellular platforms are used as toxicity sensors, by monitoring changes in the behaviour of cell monolayers.

Bio-affinity platform concept

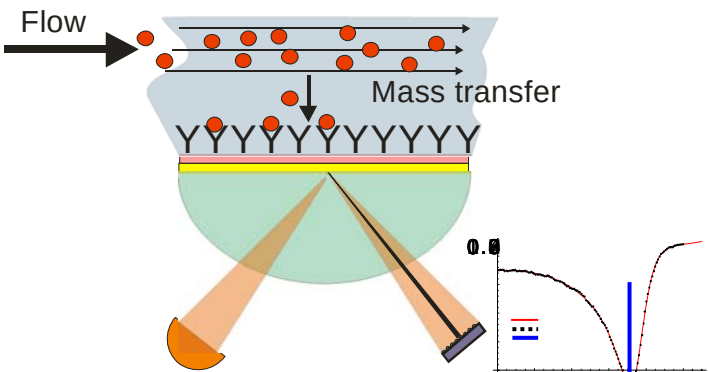


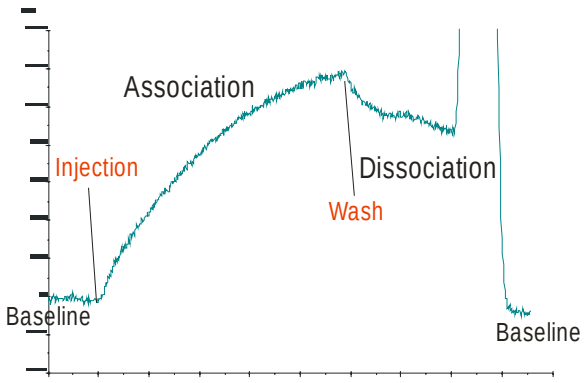


- The target compound (analyte) flows with the aqueous solution interacting with the bioactive component (ligand) from the surface of the sensor
- Properties of the bio-functionalized matrices on transducers are modified due to the specific binding of the target analytes.
- The related changes are assessed by the analytical methods providing a direct means for detection.

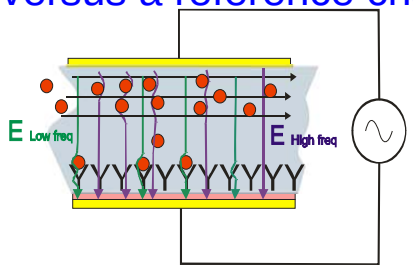
The Analytical Methods

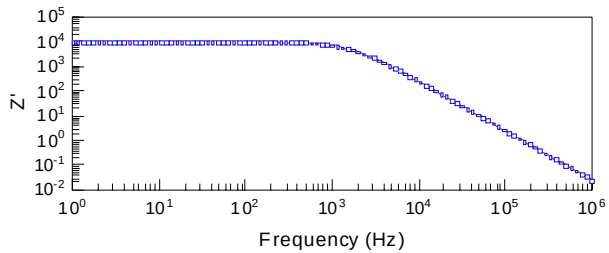
SPR Surface plasmon resonance is an optical technique that enables real-time monitoring of changes in the refractive index of a thin film close to a surface.

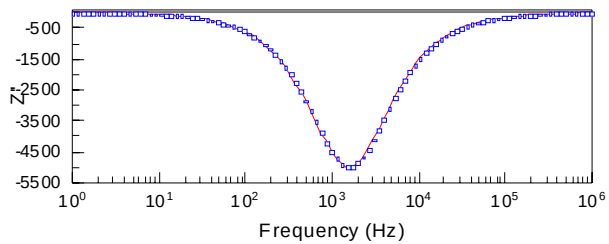




Differential Electrical Impedance Spectroscopy (DIS) is a method providing complex spectra of the impedance of a sample versus a reference channel.







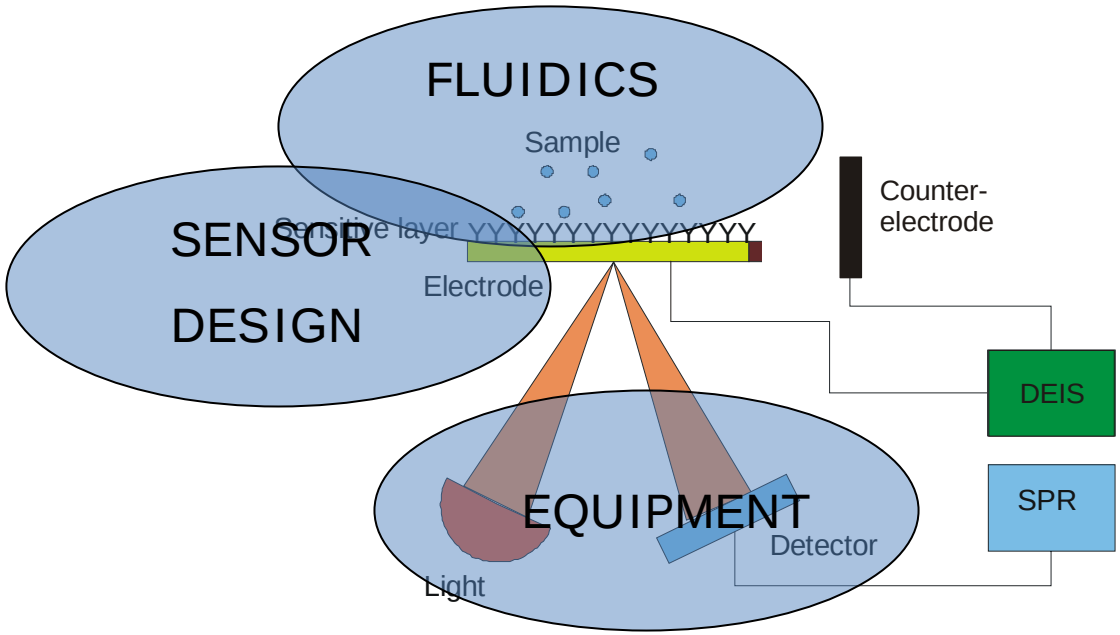
The Dual SPR-DIS System

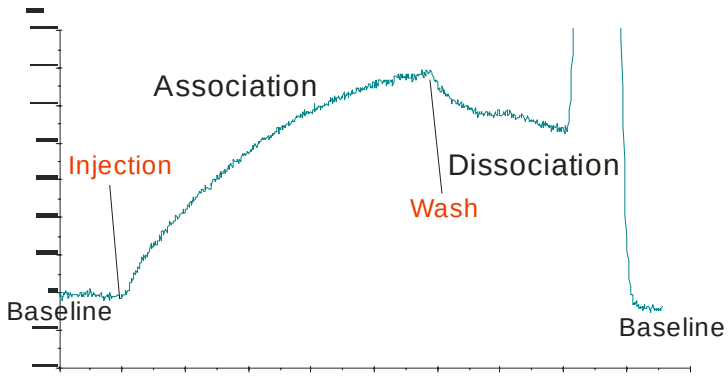
- Combining the **Differential electrical Impedance Spectroscopy (DIS)** with **Surface Plasmon Resonance (SPR)** provides inner validation and expands the analyte detection range while enabling sensor characterization during functionalization as well as effective analyses.

- Based on the Bioaffinity Platform concept, the dual **SPR-DIS** is used for direct detection of the presence of a contaminant or a mixture of contaminants in a sample

- The contaminant (analyte) can be **any type of compound** from low molecular weight chemicals to whole cells, for which an interaction partner (ligand) exists.

The SPR-DIS Concept

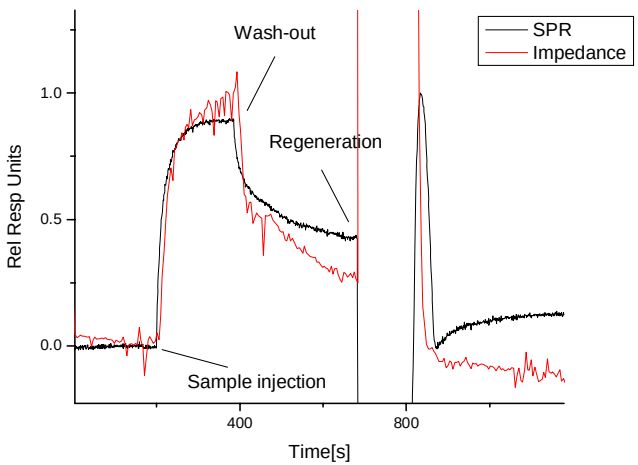




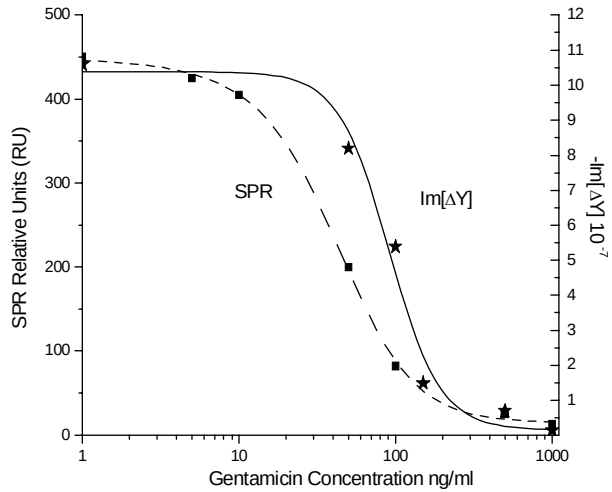
Dual SPR-DIS system - Results

The capabilities of the system to investigate interfacial changes were tested using the BSA nonspecific adsorption to gold

The applicability of both methods for detection of low molecular weight analytes was tested using a competitive approach (gentamicin detection)



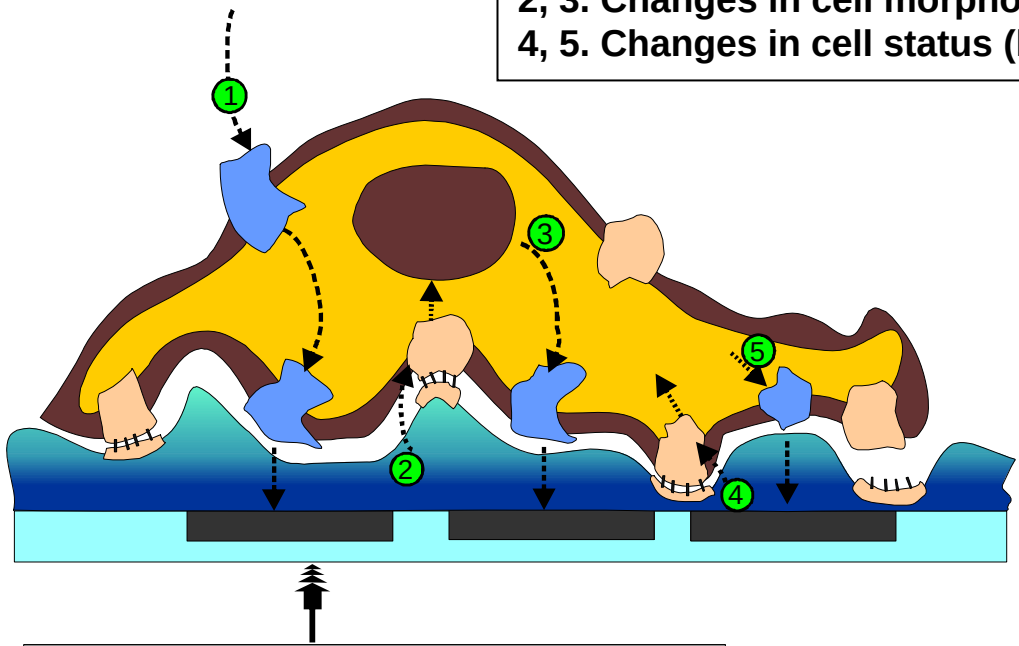
Dual signal for protein adsorption (BSA 1 mg/mg on gold)



SPR and DIS calibration curves for gentamicin detection in a competitive assay

The Cellular Platform

1. Sensing environmental influences on the cell;
2, 3. Changes in cell morphology;
4, 5. Changes in cell status (life cycle, health)

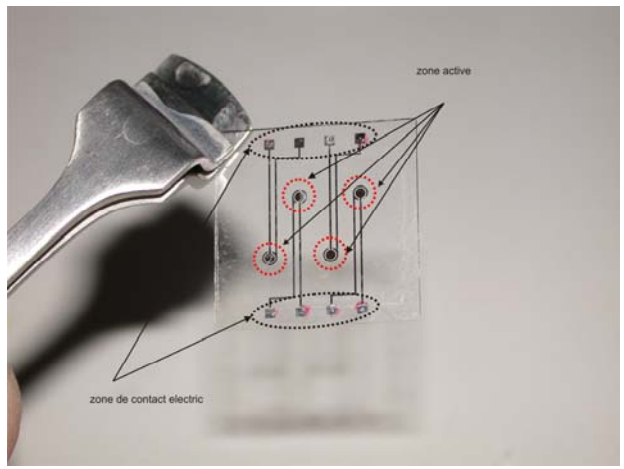


Electrochemical impedance Spectroscopy
Surface Plasmon Resonance

The Cellular Platform

Sensor-chip preparation

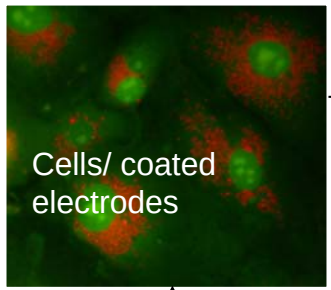
- **Glass (0.2 mm)**
- **Chromium electrodes**
  - **Siloxan based polymer coatings (spin-coated)**
    - **Siloxan methyl-metacrylate MMA**
    - **Siloxan-organic copolymers MC**

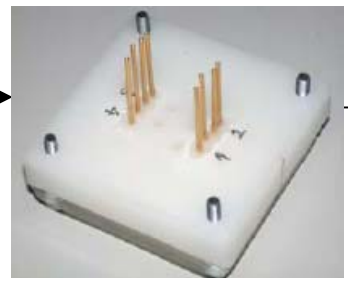


The Cellular Platform

Experimental setup

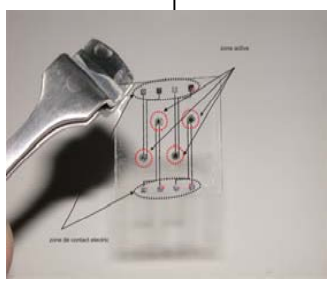
Measurement Cell





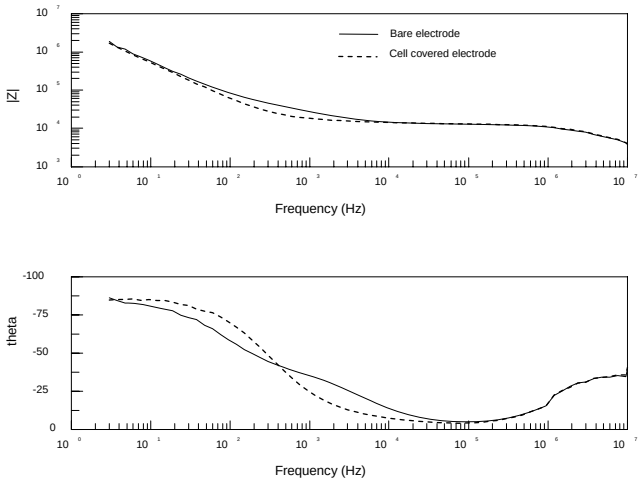
Multichannel
Frontend

Solartron SI 1260

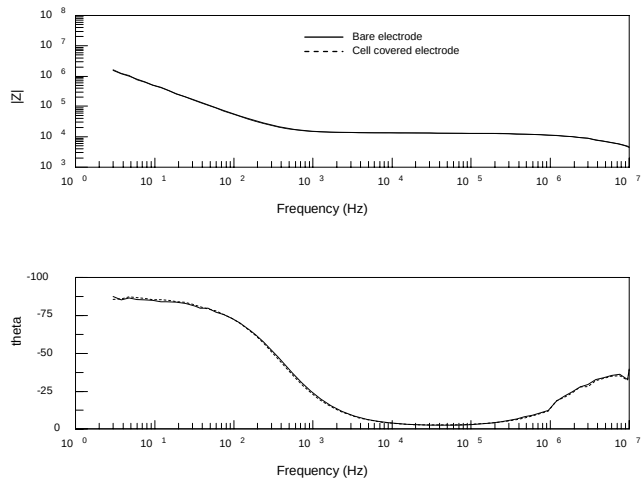


$Z[\ ] - Z[\ ] = Z[\ ]$

Evaluation of adherently growing cell monolayers using EIS

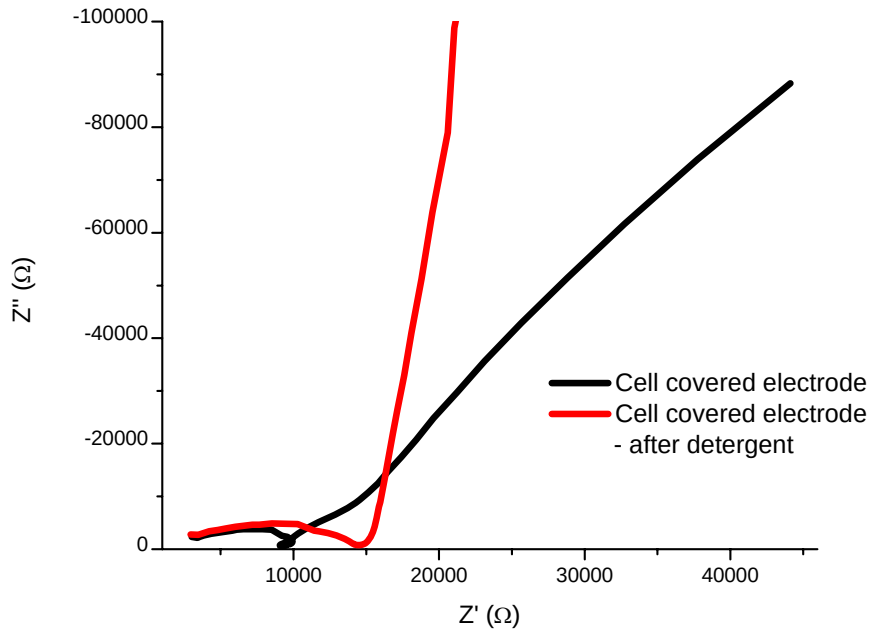


Impedance spectra (magnitude and phase) of the electrodes with (black line) or without cell (gray line)



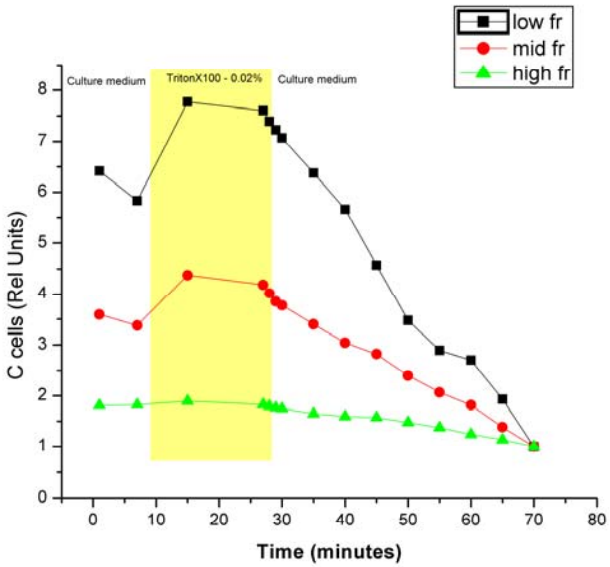
Impedance spectra (magnitude and phase) of the electrodes (black with cells, gray without cells) after trypsin induced cell detachment

The effect of stress factors (detergents)

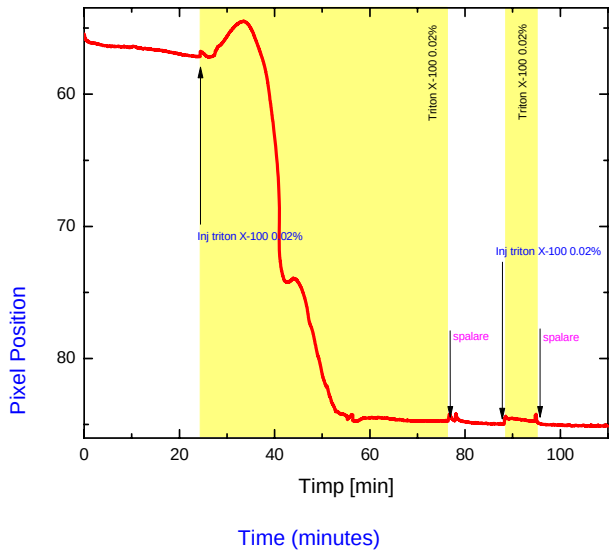


Evaluation of cell monolayer when treated with detergent – Cole-Cole representation

The effect of stress factors (detergents)

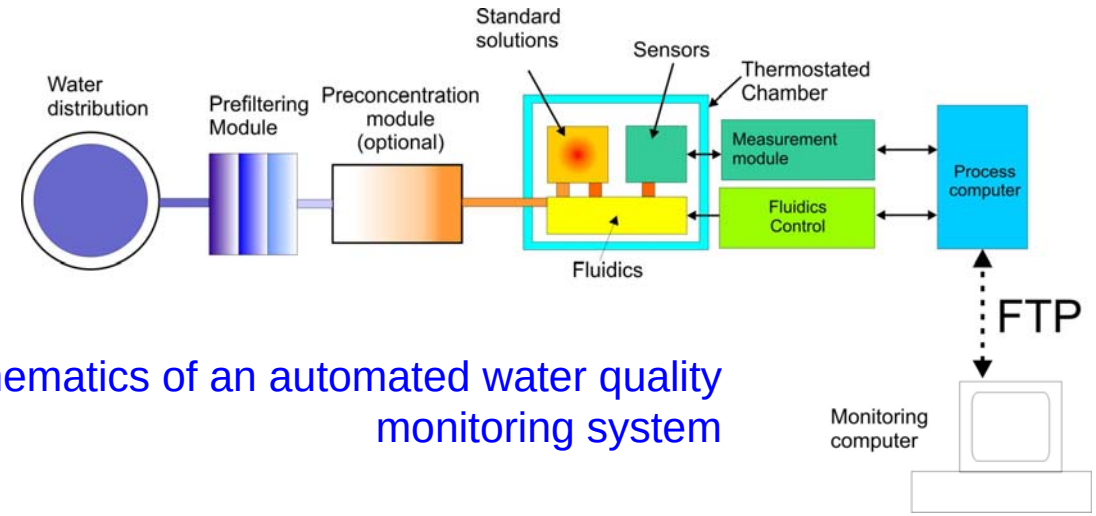


Evolution of electrical capacitance of adherently growing MDCK cells when challenged with detergent

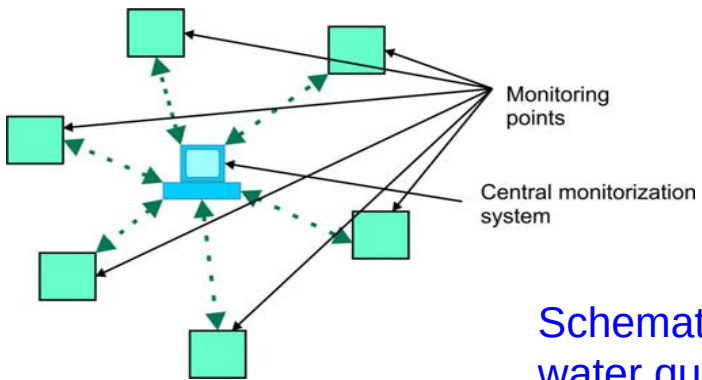


Behavior of adherently growing MDCK cells challenged with detergent as monitored with SPR

Future development



Schematics of an automated water quality monitoring system



Schematics of an automated water quality monitoring network

Conclusions

• In this study we advance the state of the art on bioaffinity sensors and cellular platforms using SPR and DIS by providing a dual measurement set-up with appropriate sensorics and flow through measurement channels.

• Monitoring the impedance of the cell layer was successfully used to investigate the action of stress factors (such as detergents) that destabilize the cell layer by inducing apoptosis.

• SPR measurements (which are sensitive to modification of the refractive index in the close vicinity of the chip's surface) also allow monitoring the behavior of the cells in the presence of stress factors.

Conclusions

• Having in view the versatility and portability of the method and of related equipment enabling remote control of the sensing equipment, we stress on the possibility to develop this approach into a distributed system to monitor water quality by further development of

- *tests by simultaneously measuring different biochemical processes in near real-time;*
- *engineered surfaces for better cell adhesion*
- *portable, microfluidics-based system for maintaining cells;*
- *portable equipment for electrochemical experiments;*