

Design & field-test of an operational low-cost & open-source sensor for river water quality monitoring

**Perret Franck¹, Krieg-Rabeski Pascal¹, Maurer Lucas¹, Namour Philippe^{2*},
Legout Cédric³, Freche Guilhem³, Guyard Hélène³, Navratil Oldrich¹**

1) Univ Lyon, Université Lumière Lyon 2, CNRS, UMR 5600 EVS, F-69635 Lyon (France)

2) Irstea Lyon-Villeurbanne, UR RiverLy, 5, rue de la Doua, 69626 Villeurbanne cedex 20244 (France)

3) - Université Grenoble Alpes, Institut des Géosciences de l'Environnement (IGE) BP 53, 38041-Grenoble Cedex 9 (France)



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Low-cost river monitoring

Outline

1. **Current river monitoring**
2. **New low-cost & open-source tool**
3. **Field application: turbidity**
4. **Conclusions & Perspectives**



The start of the art

3

Nowadays, the state of the art with regard to the physicochemical and biological monitoring of rivers is:

- **Grab sampling** at time t (usually during working hours)

The high cost of this protocol makes it impossible to obtain any satisfactory spatial relevance

- **Integrative sampling**

Equilibration time: 15-30 days

POCIS (Polar Organic Chemical Integrative Sampler)

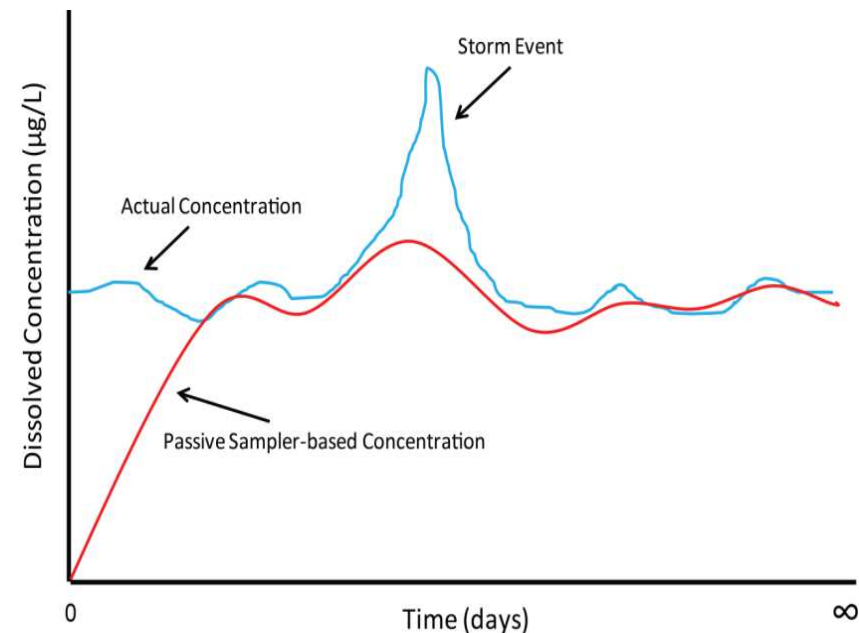
DGT (Diffusive Gradient in Thin film)

SPME (Solid Phase Micro-extraction)

SPMD (Semipermeable Membrane Device)

...

Average sample obscures the essentially dynamic character of a polluting event



Stuer-Lauridsen 2005 Environ. Pollut., 136, 3, 503-524, Kot-Wasik et al. 2007 Anal. Chim. Acta, 602, 2, 141-163, Soderstrom et al. 2009 J. Chromatogr. A, 1216, 3, 623-630



Current Monitoring Techniques

Deduce a river's Chemical Status from
monthly grab samples or integrative samples

It's like to

***“Try to understand a symphony by
listening only one or two notes
every minute!”***



Imagine new water monitoring tools

Properly monitor a river is a huge meteorological challenge

A dream monitoring tool must be:

1. **Cheap**: multiply measurement points
2. **Autonomous**: limit maintenance costs
3. **Fast**: monitor transient events in real time
4. **Integrated**: several laboratory functions (reduce risks of errors)
5. **Reliable & Accurate**: keep current data quality
6. **Non destructive**: not modify its surrounding

And include software for subsequent data validation,
management & interpretation!



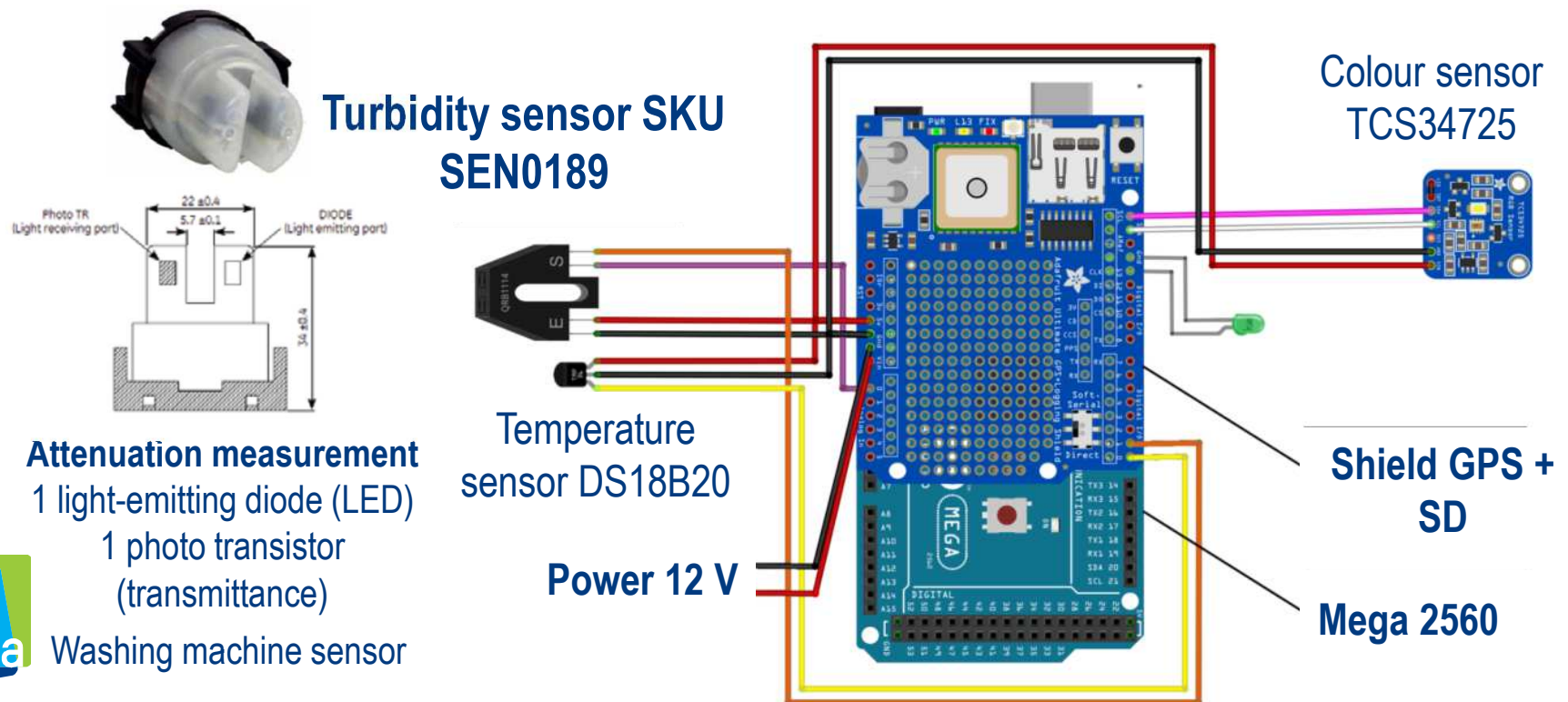
Hardware & Software



Open-source electronics platform
based on **Easy-to-use** hardware & software
available as **DIY kits** (kid's electronics)
or in preassembled forms

Overall set-up

Microcontroller board Arduino Mega 2560 (powerful CPU > UNO)
Shield GPS + SD (timestamped logging & localisation)



Encapsulation

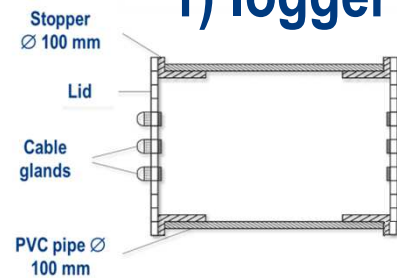
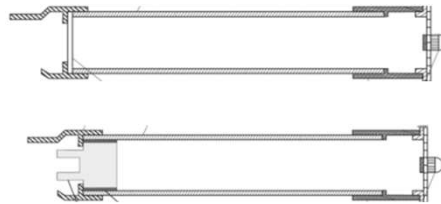
Insulate the electronics from the environment

2- New Tools

2) temperature & turbidity sensors

3) colour sensor

1) logger



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According EN 60529
IP 68
6: dust
8: water

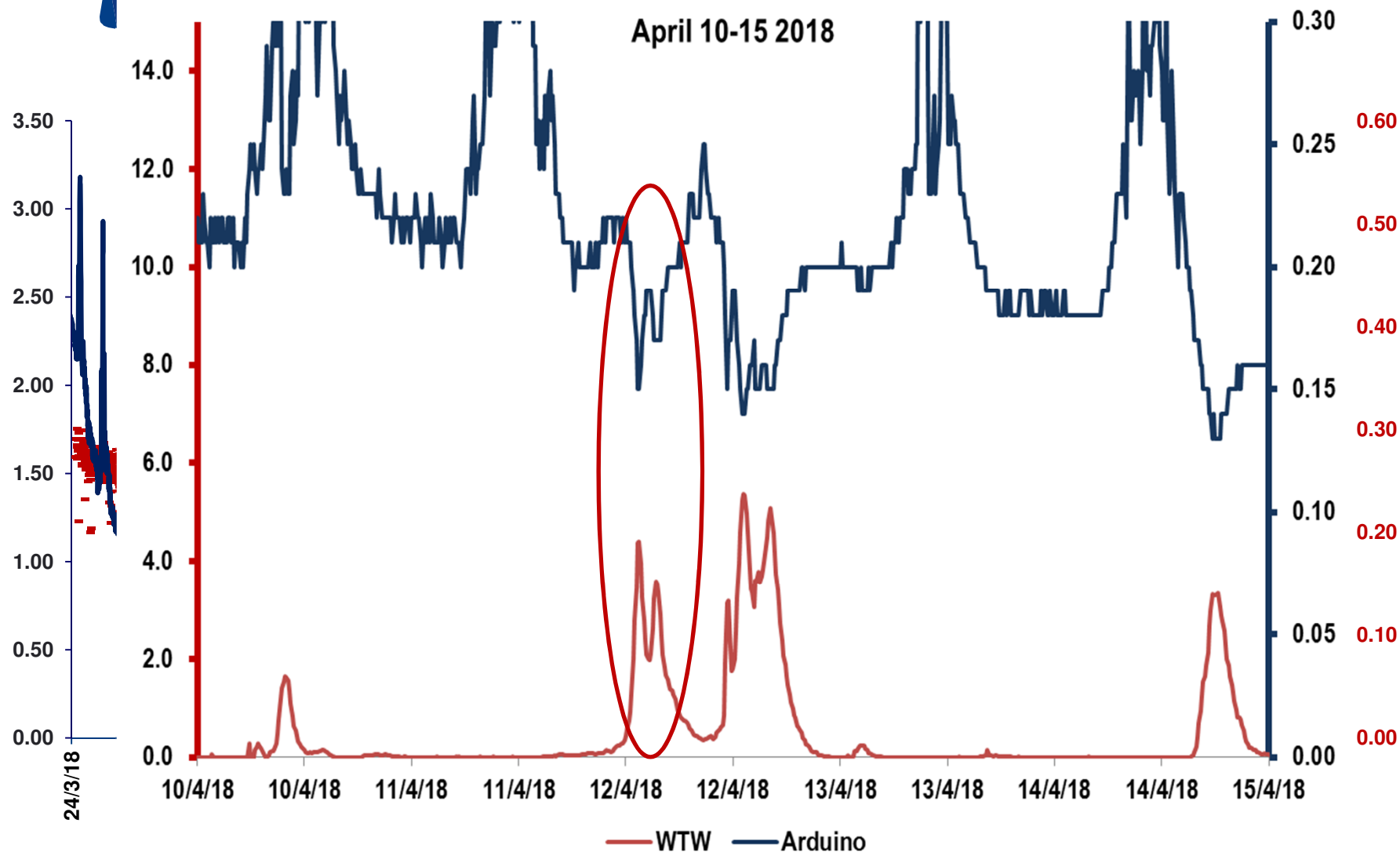
Field monitoring site



OZCAR – (France site)

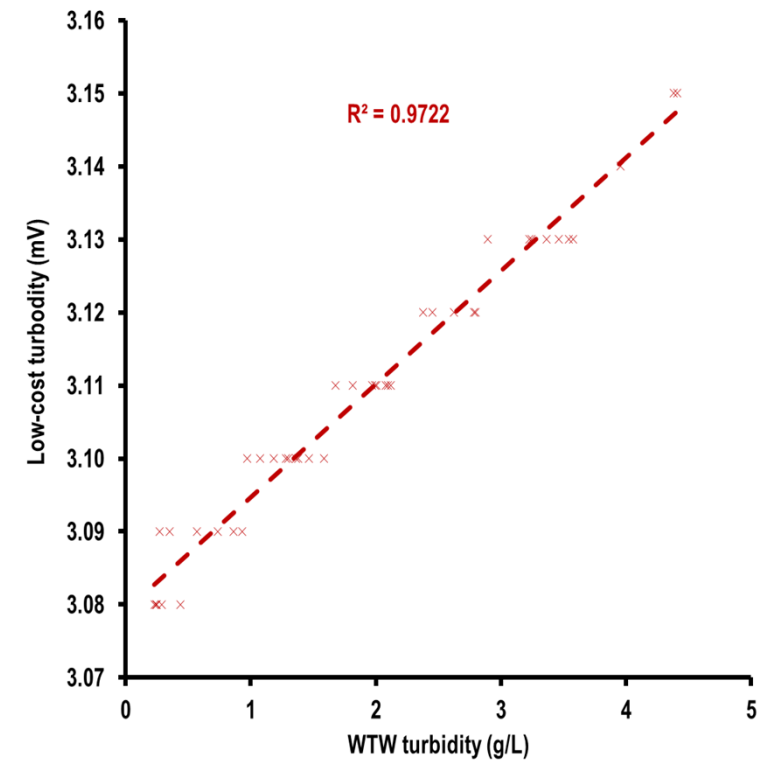
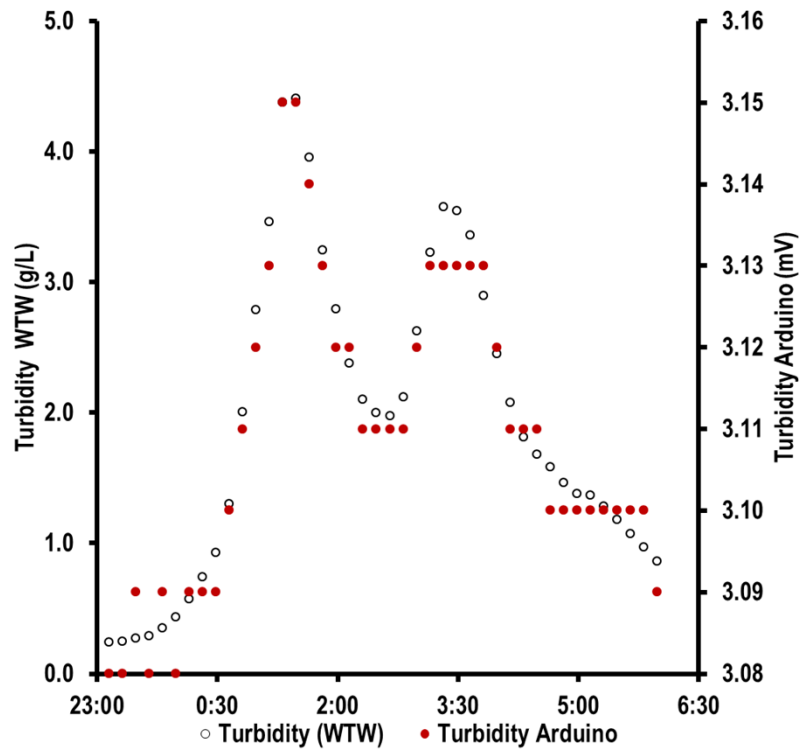
(<https://oredraixbleone.Irstea.fr>)

Turbidity first results (March 23 to May 18)



3- Field applications

Turbidity first results



Good correlation ($R^2 = 0.9722$) with the commercial sensor

Low sensitivity : slope = 0,016 mV.L/g

Solar interference to decrease (suppress)

4- Conclusions

Cost comparison

Pieces of equipment used	Cost (€)
Arduino MEGA 2560	38.90
Shield GPS/SD	20.25
Micro SD 16 GB	9.22
Turbidity sensor (SKU SEN0189)	10.85
Temperature sensor (DS18B20)	1.59
Colour sensor (TCS34725)	6.50
Shield Proto	6.90
Field equipment (PVC, wires...)	68.00
TOTAL	162.21

Compare with WTW's device cost : 6000 €

- WTW VisoTurb® 700 IQ
- Sensor net data logger DIQ/S 282



4- Conclusions

Conclusions

- **Good correlation ($R^2 = 0.9722$) with the brand sensor (WTW)**
(WTW VisoTurb® 700 IQ + sensor net data logger DIQ/S 282)
- **Low cost < 200 € compared to ≈ 6000 €**
- **Need to increase the low-cost sensor sensitivity $\approx 1 \mu\text{V.L/g}$**
Cost / benefit analyse:
Balance between required sensitivity and available money
- **Decrease (suppress) solar interference**
Stray light filters
proper encapsulation

4- Conclusions

Over all perspectives



- Low production & energy use costs (self powered with solar power)
- Software & hardware under control (fitted to aims)
- Rugged housings fitted to field conditions
- Monitoring point number increase

- Needs skills in electronics & programming
- Some limits to overcome as energy supply & precision
- Need upgrades to give usable data
- Data quality fall risks

- Large user community
- Share knowledge & develop low-cost instrumentation
- Adapt other sensors (pH, conductivity, pollutants, ...)
- New job creation

- Trade brands hit back with new own low cost equipment
- Needs software for big data validation, processing & interpretation

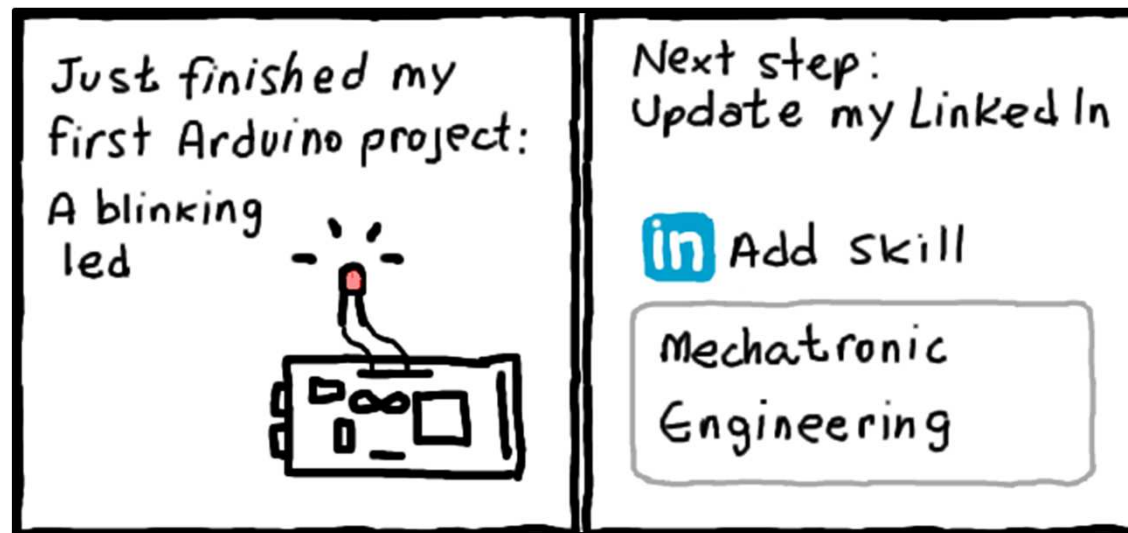


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Thanks for your attention



2- New Tools

Need new monitoring tools

New **robust** and **flexible** tools

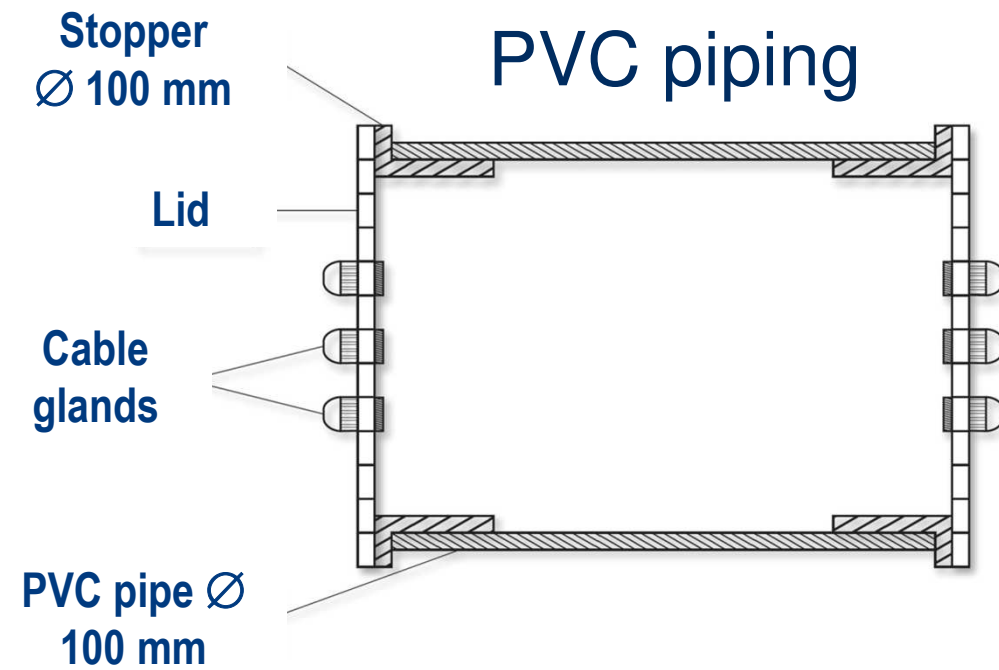
Able to detect the transitory
hot moments and spots,

In order to

Assess activity of **bioactive element** in
biogeochemical cycles

Improve **our ability to predict** pollutant
occurrence, and finally to **better
manage water resource**





2- New Tools

Turbidity & colour sensors



Turbidity sensor
SKU SEN0189

attenuation measurement

- 1 light-emitting diode (LED)
- 1 photo transistor (transmittance)

Only receptor is waterproof



Colour sensor
TCS34725

Measurement:

- 1 light-emitting diode (LED)
- 3 filtered photo transistors (Red, Green, Blue)
- 1 unfiltered photo transistor (Brightness)

Not waterproof

