UNIVERSITÉ PARIS-EST

French-Swedish Workshop on Research, Innovation and Education 2019

French-Swedish Workshop - Smart Cities and Mobility

Water Resource Sustainability:

Smart Water Networks

versus

Low-tech Solutions

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ESYCOM Equipe Systèmes de Communication et Microsystèmes

ESIEE PARIS

UPEM UNIVERSITÉ PARIS-EST MARNE-LA-VALLÉE

cnrs dépasser les frontières

Sustainable Cities / Sustainable Water Ressources

Water Global Challenges

WATER SCARCITY

- **2.1 billion people** cannot access safe drinking water in their home

WATER QUALITY

- **2 million people** die each year due to poor water-quality

Source: World Health Organization, UN and UNICEF

Drinking Water Networks: The Need for Monitoring

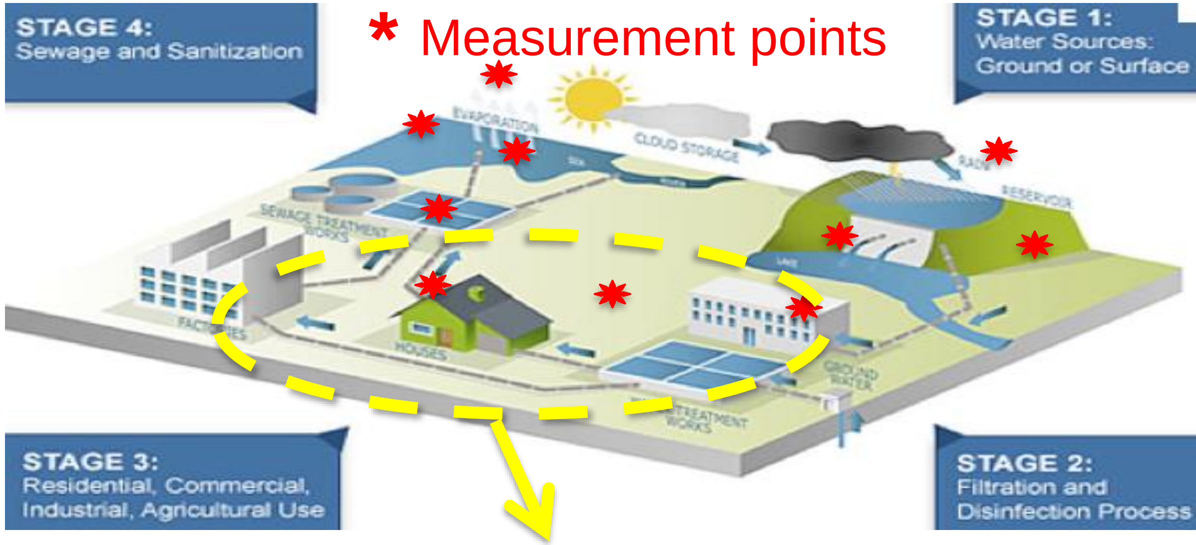
WATER CONTAMINATION

- Chemical, Biological and Particulate contaminants

WATER LEAKAGE

- **6%** up to **63%** of the produced water is lost due to the **leakage in distribution infrastructure.**

Source: Water and Wastewater Utility Data- 2nd edition



Water Cycle
from production to Distribution

Some Challenges towards Monitoring Drinking Water Networks:

- Need for measurement of Multiple Physical, Chemical and Biological parameters
- Need for Mapping all those parameters all over the water network
- Needs for Low-cost Multi-parameter sensors for large scale dissemination
- Needs for dedicated IoT platforms

ESYCOM
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IFSTTAR ESIEE PARIS

PROTEUS

H2020 project - 2015-2018

4M€ grant agreement No 644852

Delivering an **autonomous,** highly **multifunctional MEMS- and nano-enabled** sensor node for **adaptive and cognitive** drink & waste water quality monitoring.

Cheaper
(X25 decrease)

Smaller
(X10 decrease)

Reconfigurable
(wireless, on-chip data..)

9
parameters in one chip

➔Start'up Sens'hydre

www.proteus-sensor.eu

IFSTTAR UNINOVA SMAS Município de Almada Serviço Público Municipal de Excelência PONSEL Groupe Aqualabo WINGS ICT Solutions easy global market UNPARALLEL INNOVATION ESIEE PARIS NiPS Laboratory Noise in Physical Systems

Illustration ofTechnology Upscaling From the Nanosensor to the City

(1) From **Prototype** to **Large-Scale Production of Low-Cost Sensors**

An illustration of ESIEE's Know-How

(2) From **Concept** to **Field deployment**

An illustration of IFSTTAR's Know-How

MEMS Sensors & Smart CITIES

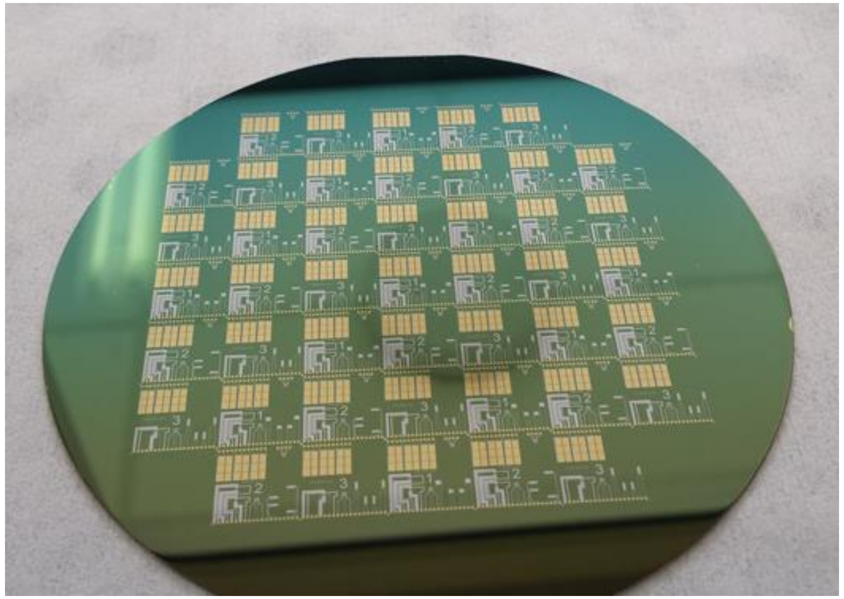
sense CITY

ESIEE-Connect (IoT) PIA 2
Cleanrooms for Sensor Prototyping

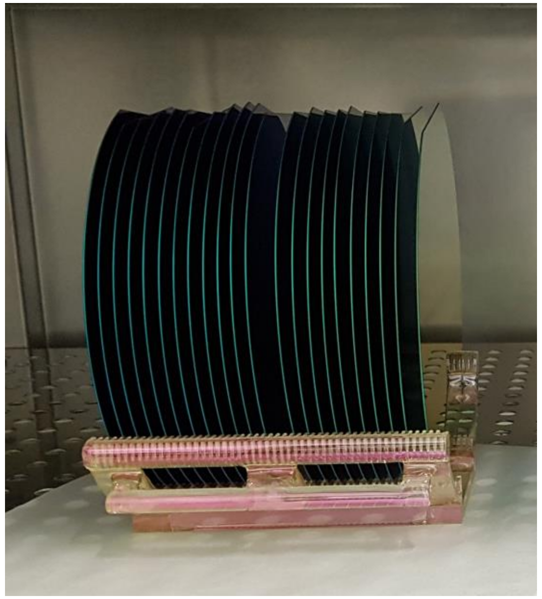
SENSE-CITY : EquipEx PIA 1

World-class Experimental platforms

From prototype to Batch Fabrication



Fabrication
collective



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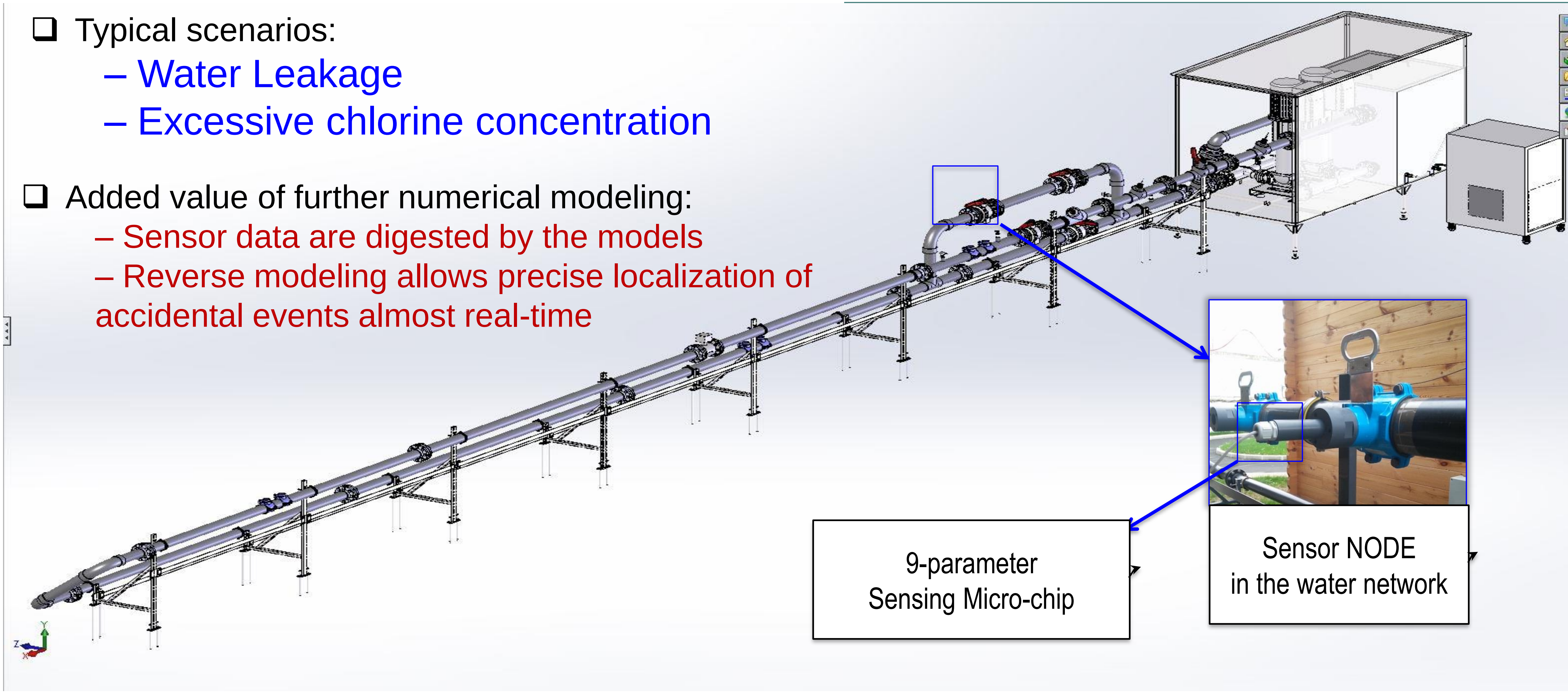
Tests in SENSE-CITY Drink water loop

- Typical scenarios:
  - Water Leakage
  - Excessive chlorine concentration
- Added value of further numerical modeling:
  - Sensor data are digested by the models
  - Reverse modeling allows precise localization of accidental events almost real-time



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Field Testing in ALMADA, Portugal

City of ALMADA, Portugal 175000 inhabitants

Data recorded using our PROTEUS PROBES

Parameter	Unity	Average	Minimum	Maximum
Calcium	mg/L Ca	33.44	31.40	35.40
Magnesium	mg/L Mg	8.60	6.00	10.00
Total hardness	mg/L $CaCO_3$	154.00	110.00	440.00
Free Chlorine	mg/L Cl	0.39	0.08	0.55
Condutivity (20ºC)	µS/cm a 20ºC	433.40	411.00	457.00
Nitrates	mg/L NO3	14.29	8.79	15.85
pH (20ºC)	Escala Sorënsen	7.12	6.99	7.39
Temperature	ºC	20.07	13.50	26.20
Pressure	Bar		1.00	5.50
Velocity	m/s		0.04	1.02
Flowrate	m^3/s		0.80	18.40

LOTUS

LOW-COST INNOVATIVE TECHNOLOGY FOR WATER QUALITY MONITORING AND WATER RESOURCES MANAGEMENT FOR URBAN AND RURAL WATER SYSTEMS IN INDIA

From Proteus to LOTUS

Co-creation of innovative low cost technologies for India’s water challenges

Dr. Bérengère Lebental, Ecole Polytechnique, IFSTTAR, CNRS, France

New Delhi, February 13, 2019

LOTUS is co-funded by the European Commission under the Horizon 2020 research and innovation programme under Grant Agreement N° 820881 and by the Indian Government, Ministry of Science and Technology.

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The NANO-4-WATER *Programme*

WATER TECHNOLOGIES: « High Tech » versus « Nature-based » Solutions

Information and Communication Technologies for **Environment Science (Water)**

Objective 1 – Comprehensive physical and chemical multi-parameter for smart management of drinking water networks

- Field-testing in SENSE-CITY platform of hetero-integrated multi-parameter sensors
- Nano-sensors for heavy metals detection: from lab prototypes to field-test sensors

Objective 2 – Opto-fluidic technologies for detection of particulate and biological contamination of water

- Particulate matter pre-concentration and analysis based on optofluidic devices
- Detection of specific biological contamination in drinking water based on deep learning approaches

Objective 3 – Decentralized production of natural resources: water, energy and nutrients

- Solar-energy and gravity-driven dual-approach for autonomous water purification
- Urine recycling for production of both energy and nutrient for urban agriculture

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NANO-4-WATER

An open ***Academic Research*** collaboration platform

5 laboratories within Université Paris-Est: ESYCOM, LISIS-IFSTTAR, LEESU-ENPC, LIGM, ICMPE

5 international partners: Univ. Minnesota (USA), NTU (Singapore), Ain-Shams Univ. (Egypt), North Western Polytechnic Univ. (Xi'An, CHINA) and Hong-Kong Polytechnic University (HONG-KONG)

2 New partners in 2019: LIED Lab. @Paris Diderot and PMMH Lab. ESPCI

Co-Funding: NTU-Singapore and Fondation ENS

(1) HARVESTING WATER PLANTS

HARVESTING WATER from RAIN, FOG and DEW

Nilsson, T., Vargas, W.E., Niklasson, G.A., Granqvist, C.G.,
Condensation of water by radiative cooling.
Applied Sol. Energy 5 (1994)

G. Sharan, A.K. Roy, L. Royon, A. Mongruel, D. Beysens
Dew plant for bottling water,
Journal of Cleaner Production 155 (2017)

https://inhabitat.com/worlds-largest-fog-harvester-produces-water-from-thin-air-in-the-moroccan-desert/

(1) DEW WATER HARVESTING PLANTS

Experience of French Partners (Daniel BEYSENS et al., ESPCI)

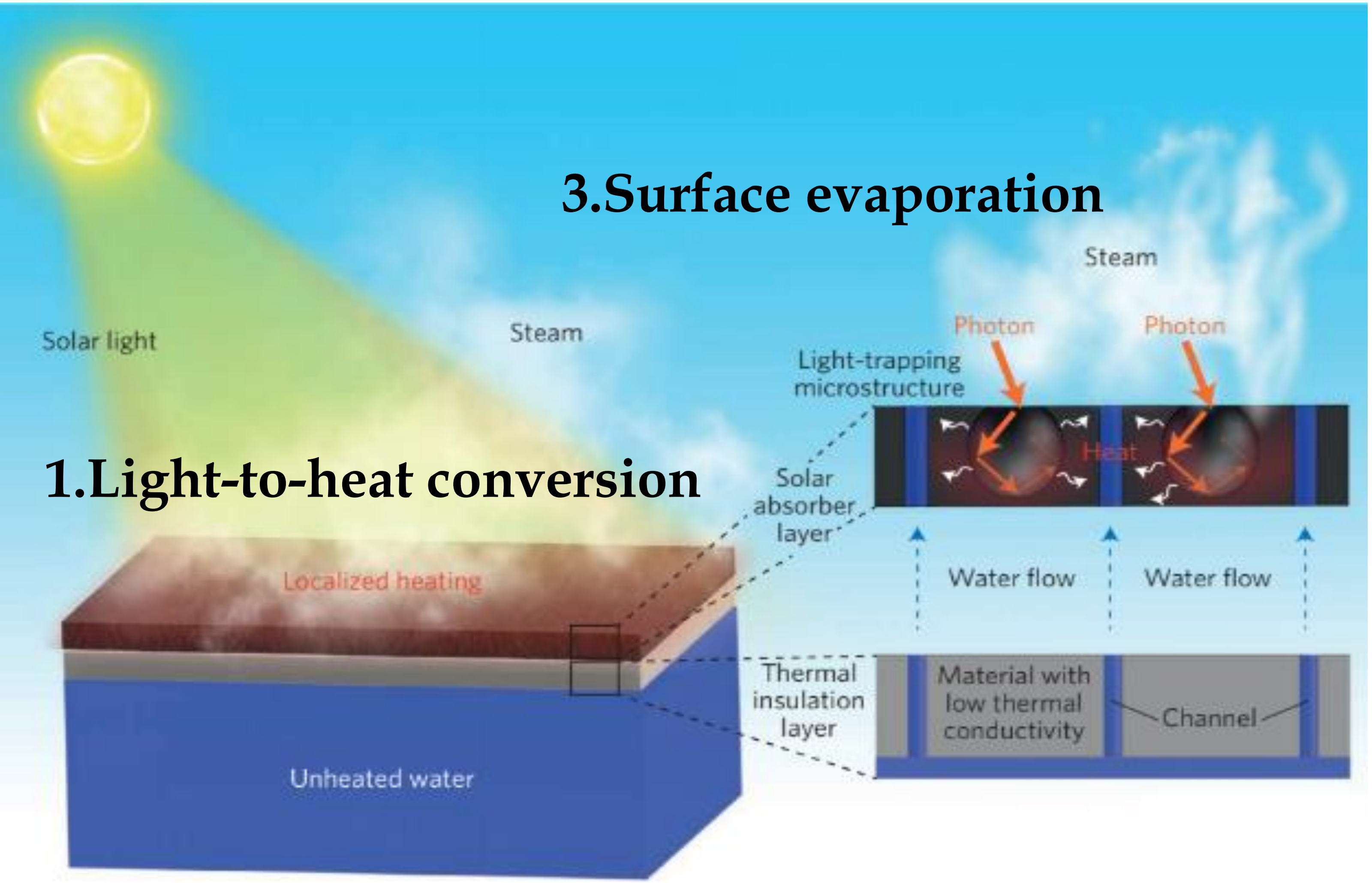
- Typical implementations of Dew water harvesting plants involving the French team of Daniel Beysens.

  D. Beysens, *Dew Water*, River Publishers, Aalborg (2018)

- Water Harvesting is the first block of the proposed architecture for the Water Panel

Water Purification by Solar Energy

1 – Steam Generation

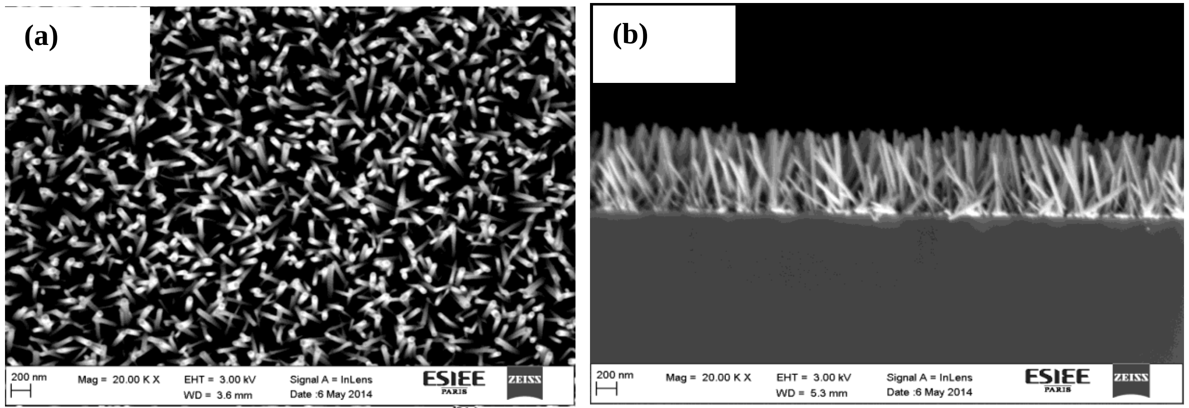


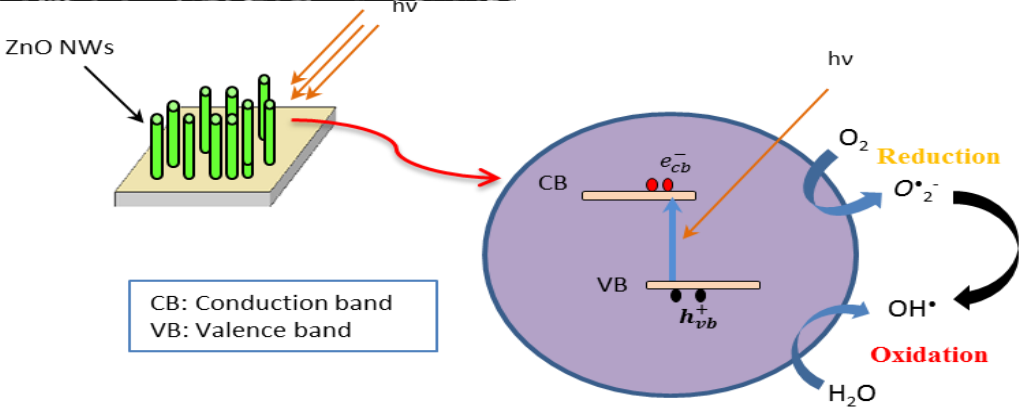
2.Porous structure: capillary effect

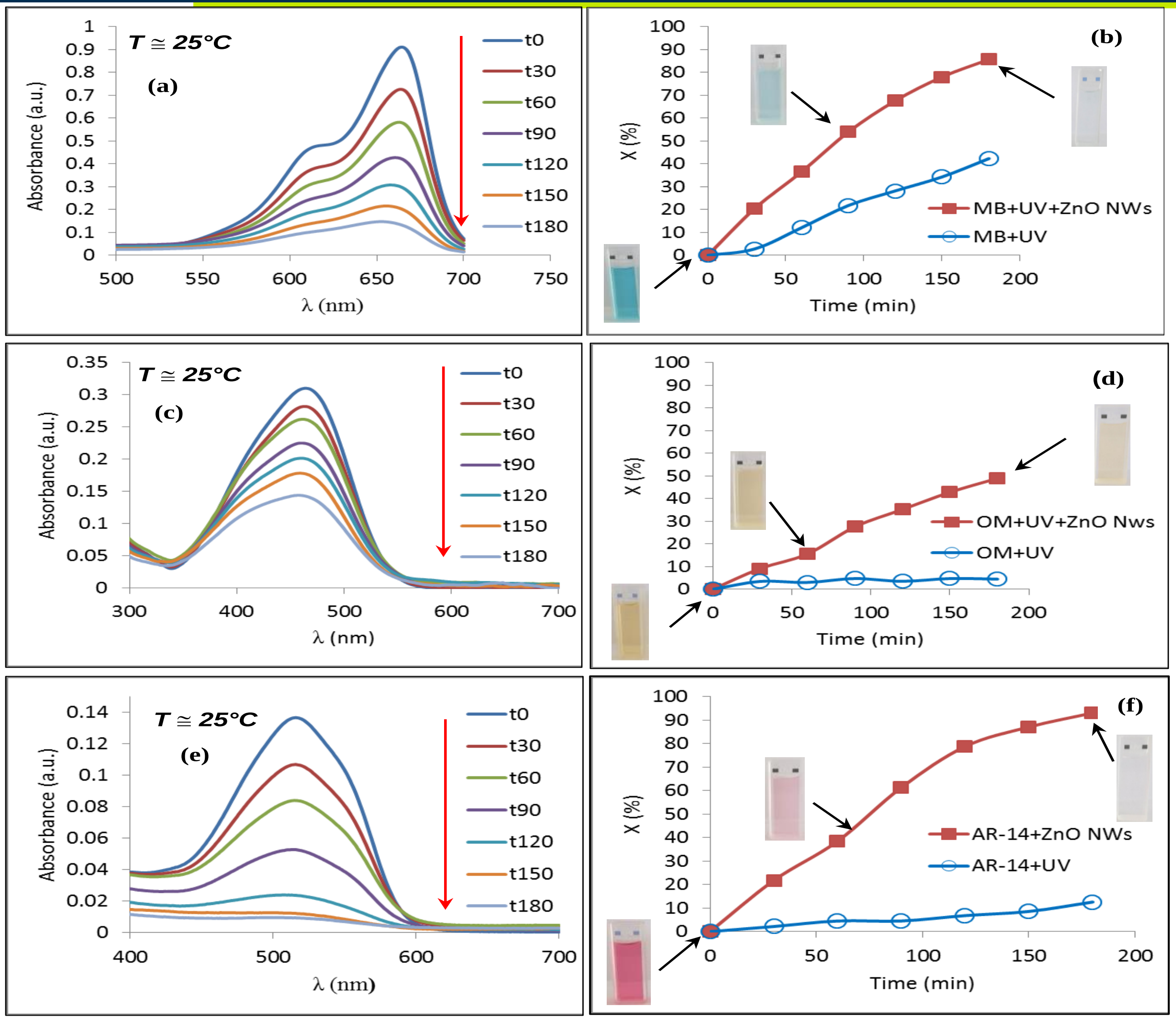
Steam generation under one sun enabled by a floating structure with thermal concentration
G. Ni, G. Li, S.V. Boriskina, HX Li,WL Yang, TJ Zhang and Gang Chen, ***Nature Energy, 2016***

16

Water Purification with Zinc Oxide (ZnO) Photocatalysis







$OH^{\bullet}$ + pollutant ➔ Intermediate products ➔ CO_2, H_2O, N_2, … No toxic by-products

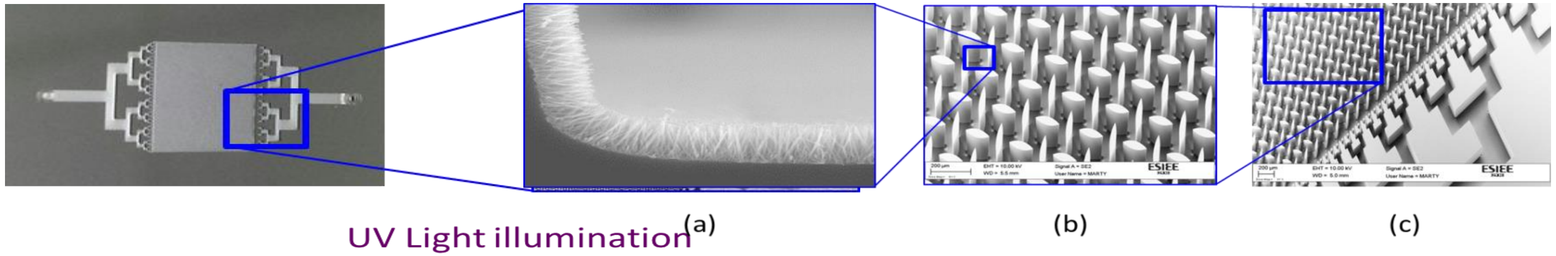
First study performed on 3 dies :

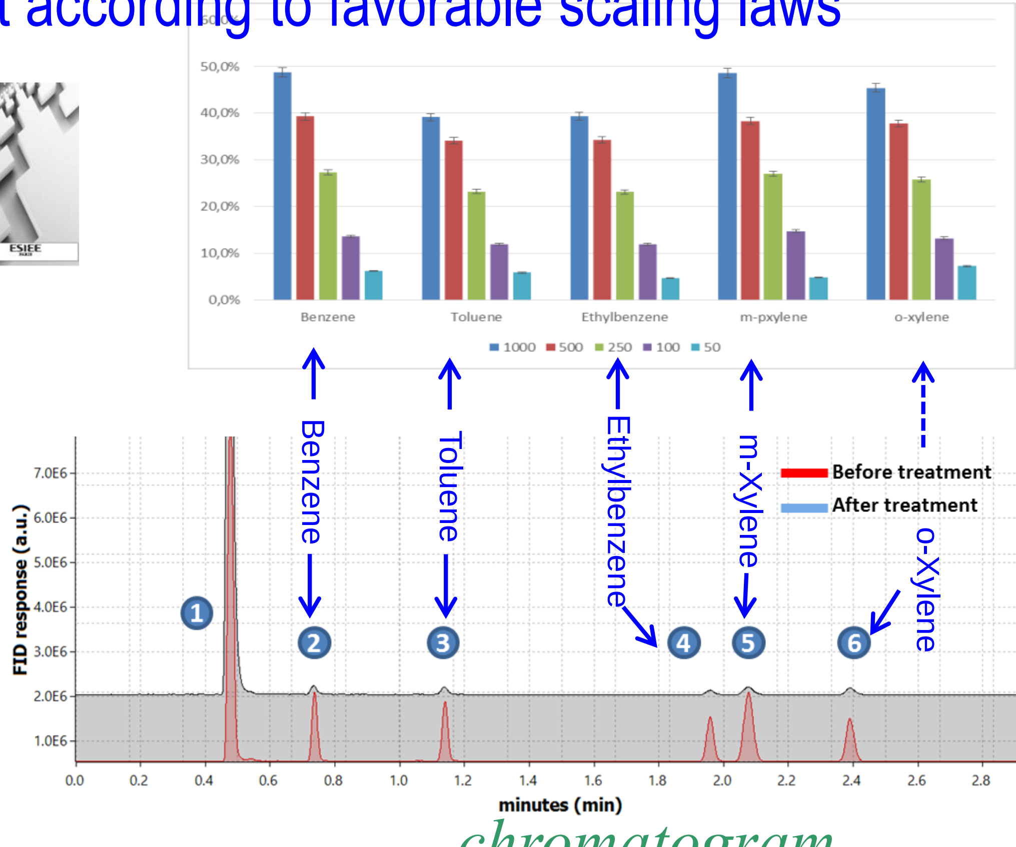
- Methylen Blue (MB): $C_{16}H_{18}N_3SCl$
- Methyl Orange (MO): $C_{14}H_{14}N_3NaO_3S$
- Acid Red14 (AR14): $C_{20}H_{12}N_2Na_2O_7S_2$

Y.G. Habba, M. Capochichi-Gnambodoe, Y. Leprince-Wang, "Applied Sciences, 7 (11) (2017) 1185*

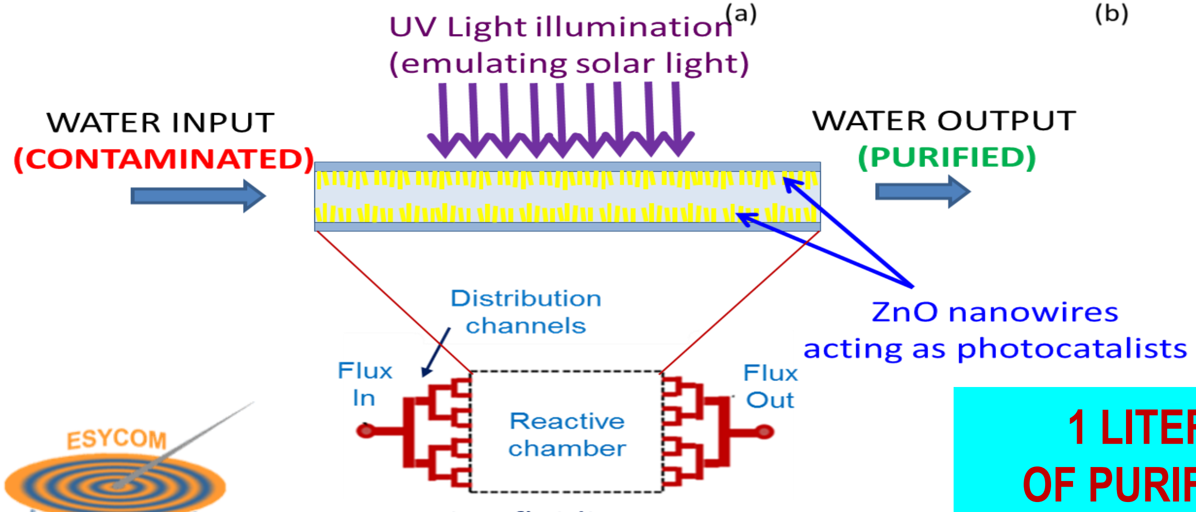
Ultra-fast WATER PURIFICATION of Dissolved VOCs in a ZnO Nano-enabled Microfluidic Reactor

- **Initially, VOCs are diluted in water @ 10 ppm concentration each**
- After only 5 seconds transit time in the microfluidic platform more than 95% of the VOCs diluted in water were degraded by photocatalysis with no chemical by-product according to favorable scaling laws





chromatogram



Microfluidic reactor (for fast photocatalysis)

1 LITER per DAY OF PURIFIED WATER ON A 1 cm^2 CHIP

I. Azzouz,, Y.G. Habba, M. Capochchi-Gnanbodoe, F. Marty, Y. Leprince-Wang, T. Bourouina, ***Nature Microsyst. Nanoeng (2018)***

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Collaboration Welcome

FUTURE

French UniversiTy on Urban Research and Education

INVENTING THE CITY OF TOMORROW

IFSTTAR · UPEM Université Paris-Est Marne-la-Vallée · ESIEE Paris · EIVP École des Ingénieurs de la Ville de Paris, École Supérieure du Génie Urbain · Éa v&t · IGN Institut National de l'Information Géographique et Forestière · École des Ponts ParisTech