



***Sipibel Project :***  
***a global research for an efficient***  
***monitoring of pharmaceutical***  
***effluents***

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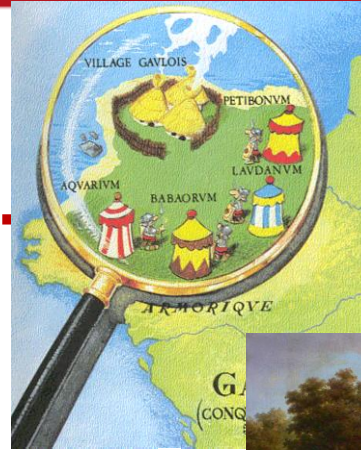
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# The Sipibel Project

Once upon a time  
in a small French village...

CHAL



US



AUTHORITY



ARVE





## Site Configuration

- ❑ **1 hospital:** The Alpes Léman Hospital Center (CHAL), 450 beds, commissioned in 2012
- ❑ **A WWTP:** with two treatment streams, one of which can be entirely dedicated to hospital effluent
- ❑ **The Arve river** and the **Geneva groundwater** which supplies a part of the water resources intended for the human consumption of Geneva



# SIPIBEL Experimental Site

SIPIBEL :  
Annemasse

Geneva

Arve River



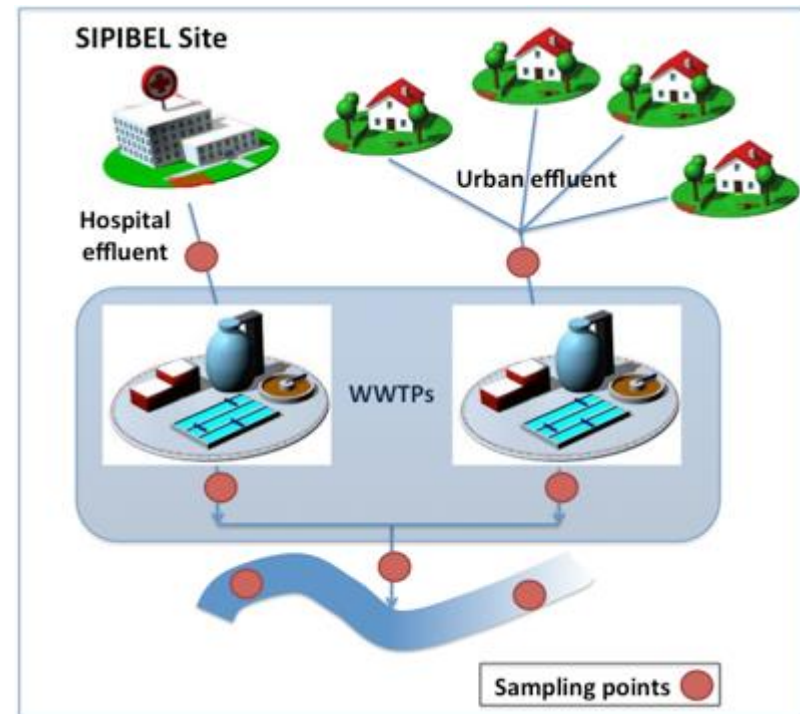
SWITZERLAND



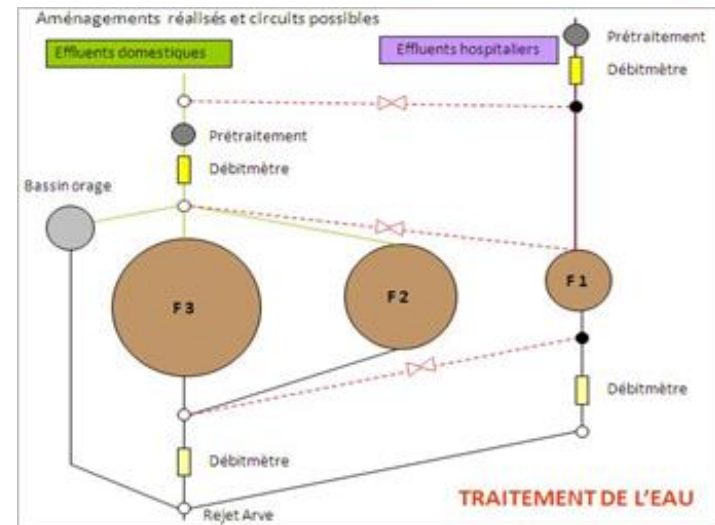
WWTP SIPIBEL

- 13 municipalities
- 25,000 inhabitants
- 230 km of networks
- WWTP:  
32,000 Eq capita

## SIPIBEL (France)



# An exceptional site of experimentation



**A WWTP with 3 treatment Files:**

- **File 1** with a capacity of 5 400 per Capita entirely dedicated to hospital effluents / 3 years
- **File 2 and 3** with capacities 10 600 Eq and 16 000 Eq

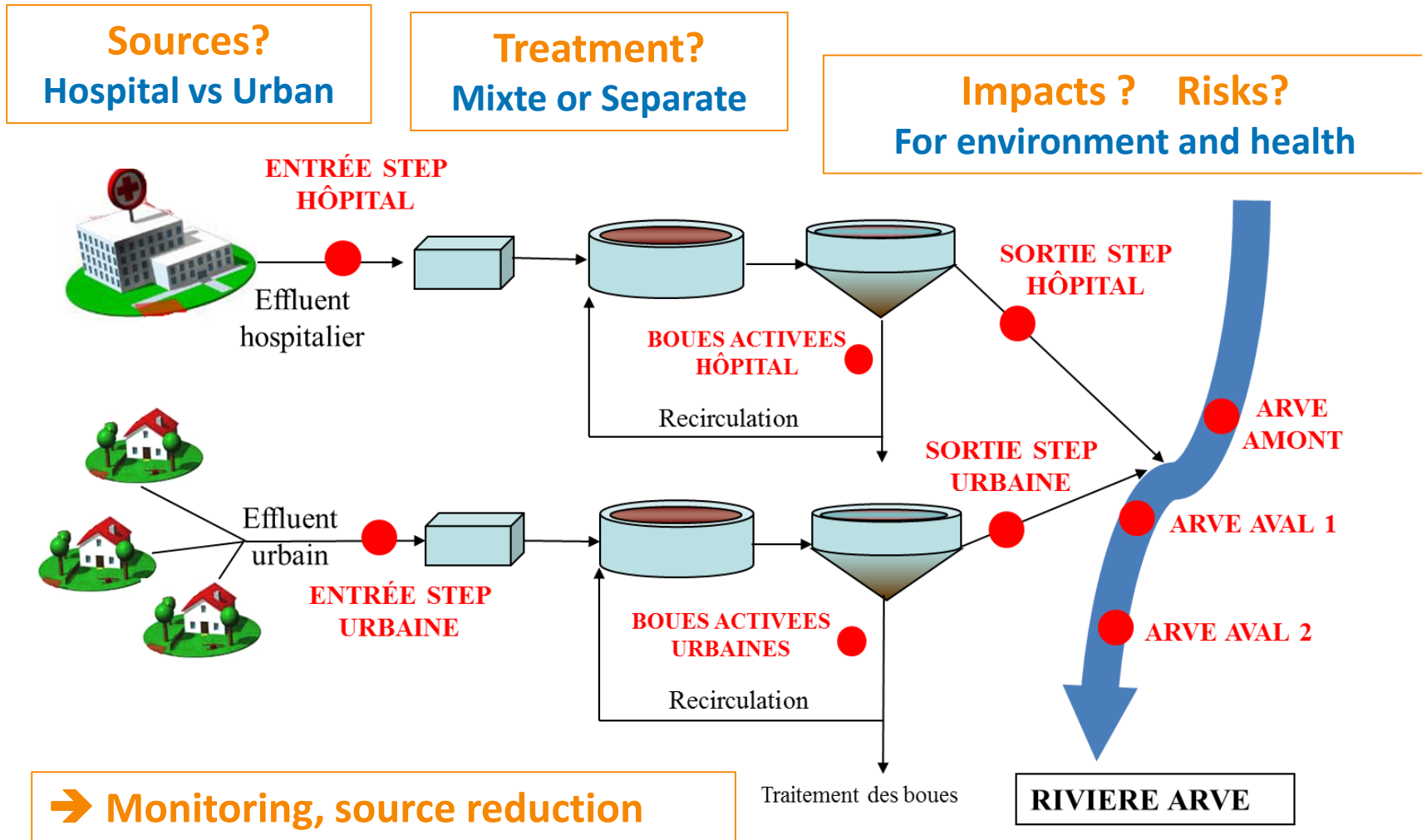


- **Zero state**
- **Observatory**
- **Research**
- **Valorization – action !**



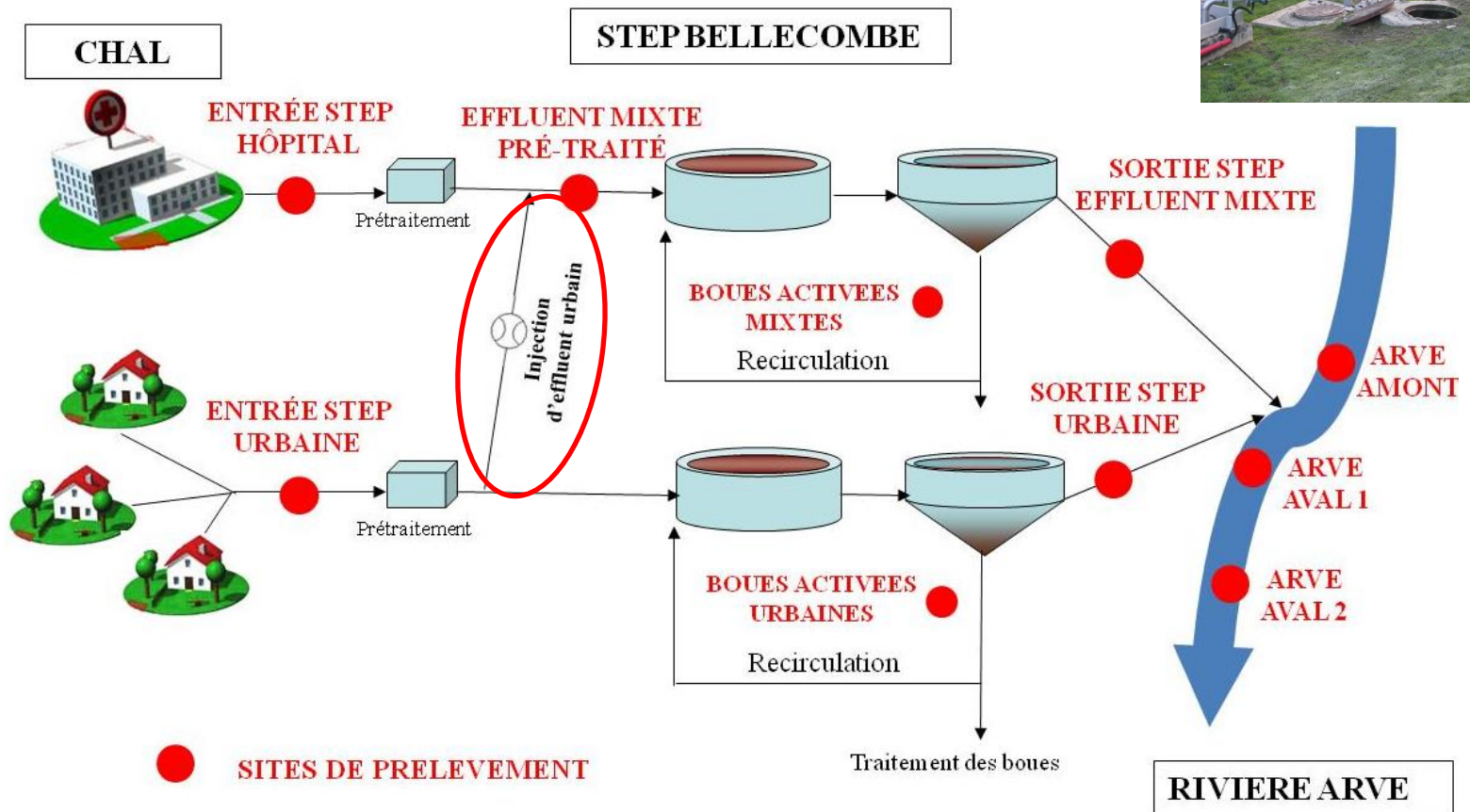
# An exceptional site of experimentation

From february 2012 to september 2014 :  
Separate tretment of the effluents



# La stratégie SIPIBEL : la mise en place d'un observatoire

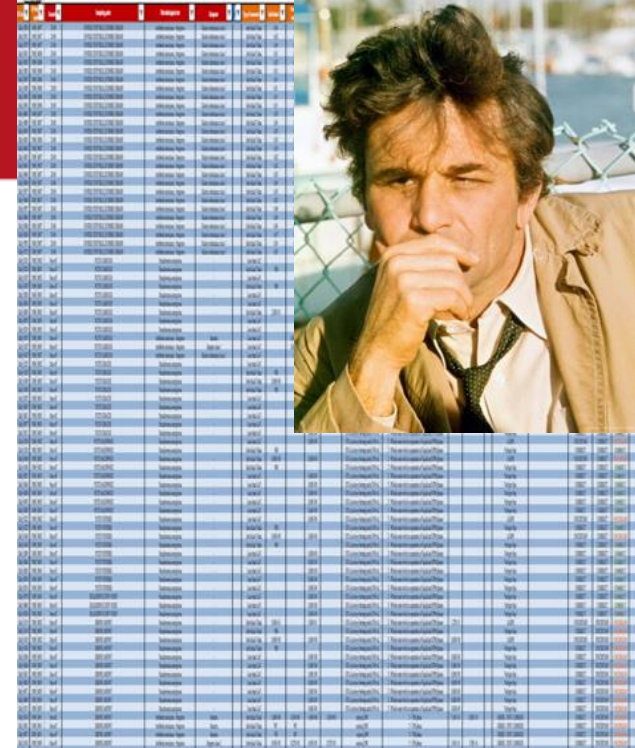
From october 2014 to april 2016 :  
Mixing of effluents



# Monitored parameters

- ❑ **Classical parameters** (BOD, COD, VSS, N,...)
- ❑ **Micropollutants:** detergents, alkylphenols, VOC, drugs, Halogen (AOH), metals
- ❑ **Microbiologie:** multirésistantes bacteria, *Pseudomonas aeruginosa*
- ❑ **Bioessays:**
  - Acute or chronic ecotoxicity micro-crustacean et micro-algaa
  - Génotoxicity
  - Endocrine disruptors

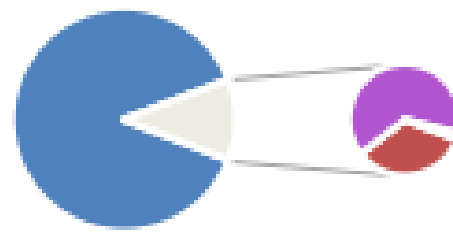
**Followed since March 2012**  
**45000 data**  
**200 sampling campaign**  
**1000 samples**  
**47 sampling points**



Time	Location	Parameter	Value	Unit	Quality
12/12/12	Paris	BOD5	150	mg/l	OK
12/12/12	Paris	COD	250	mg/l	OK
12/12/12	Paris	VSS	100	mg/l	OK
12/12/12	Paris	N	10	mg/l	OK
12/12/12	Paris	AOH	0.5	mg/l	OK
12/12/12	Paris	Microbiologie	10^6	CFU/ml	OK
12/12/12	Paris	Bioessays	100	%	OK
12/12/12	Paris	Hydrobiologie	100	%	OK



**DATA BASE**

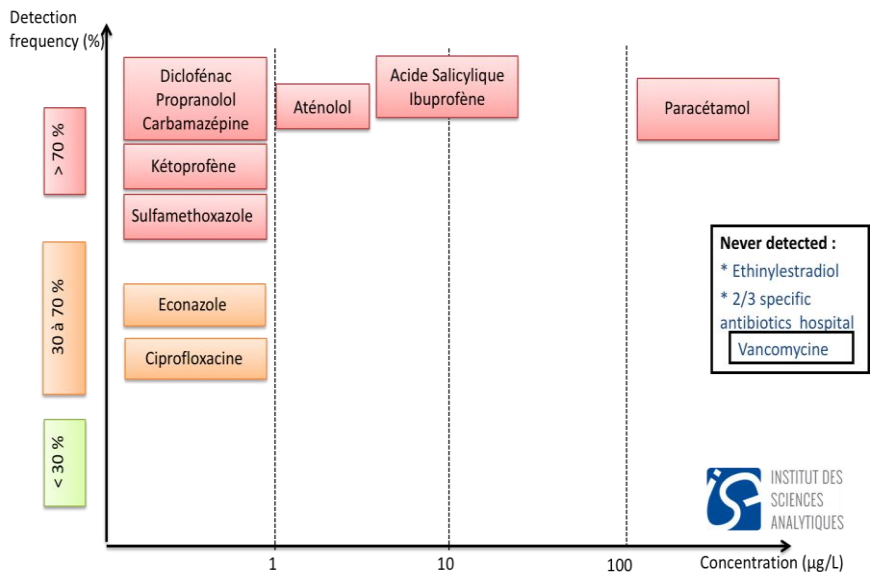


- Physico-chemistry
- Bioassays
- Microbiology
- Hydrobiology



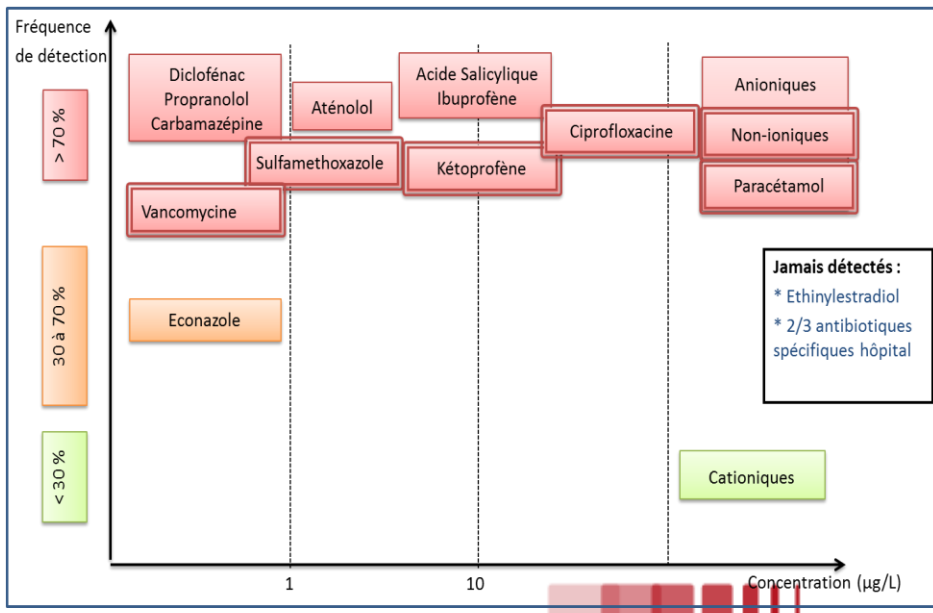


# Drugs concentrations ( $\mu\text{g/L}$ )

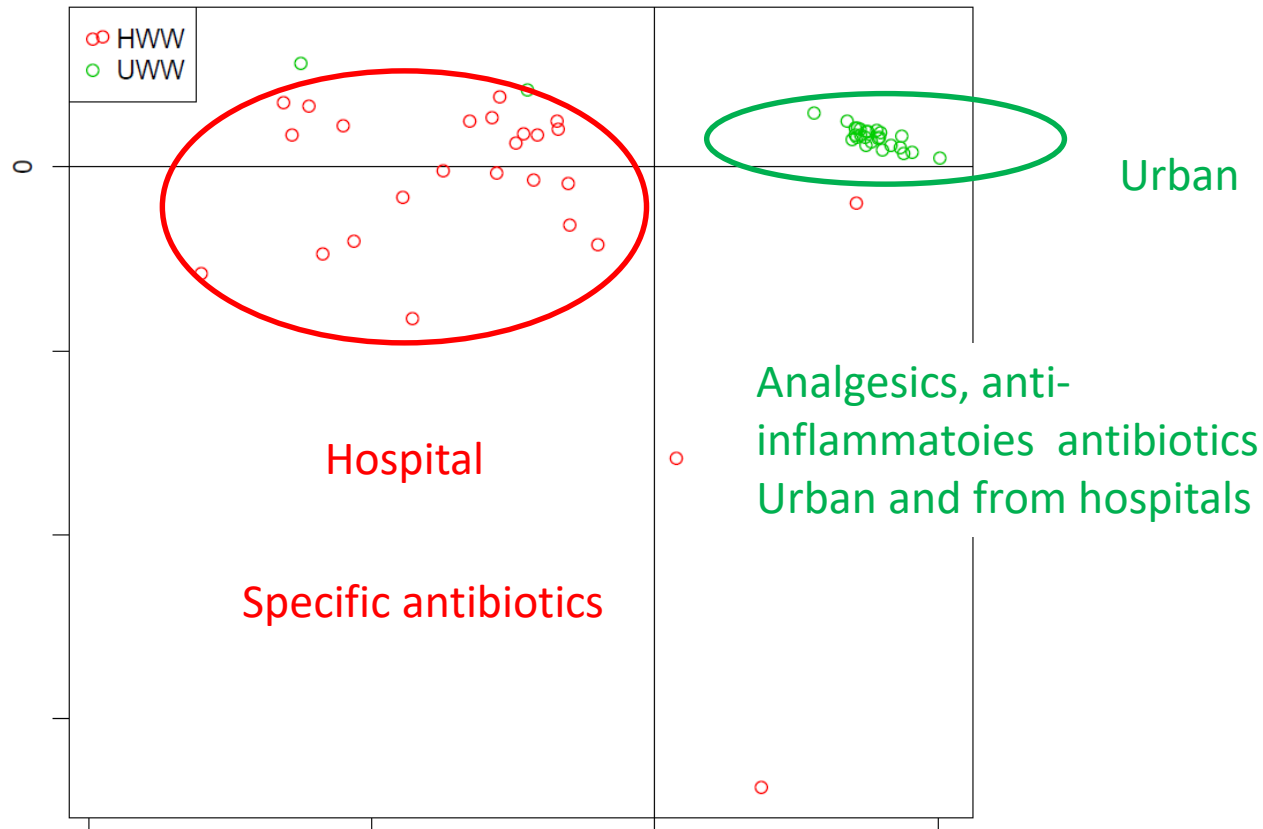


15 molécules

Hospital



# Drugs concentrations ( $\mu\text{g/L}$ )



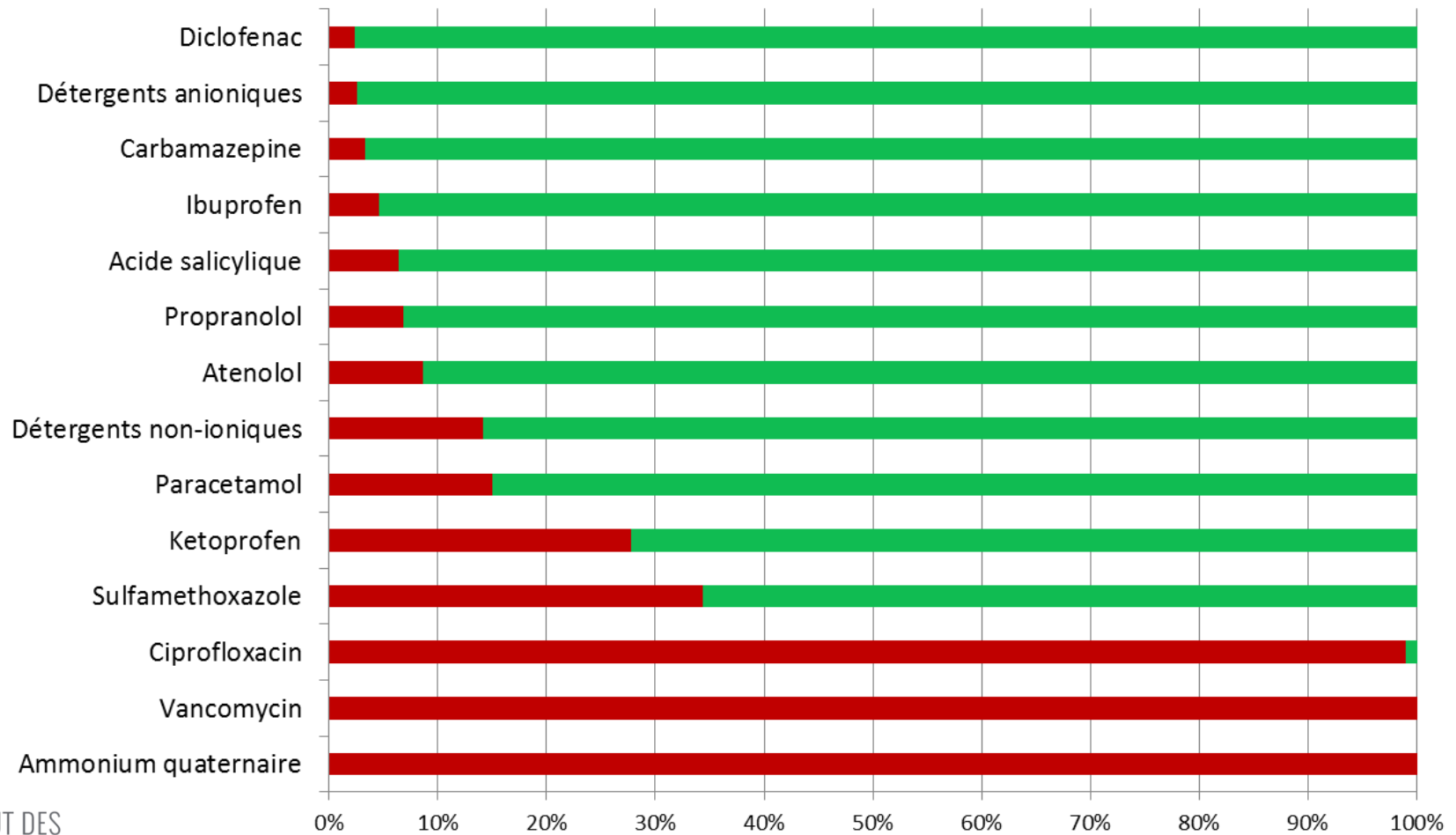
Hospital and Urban data are well separated.



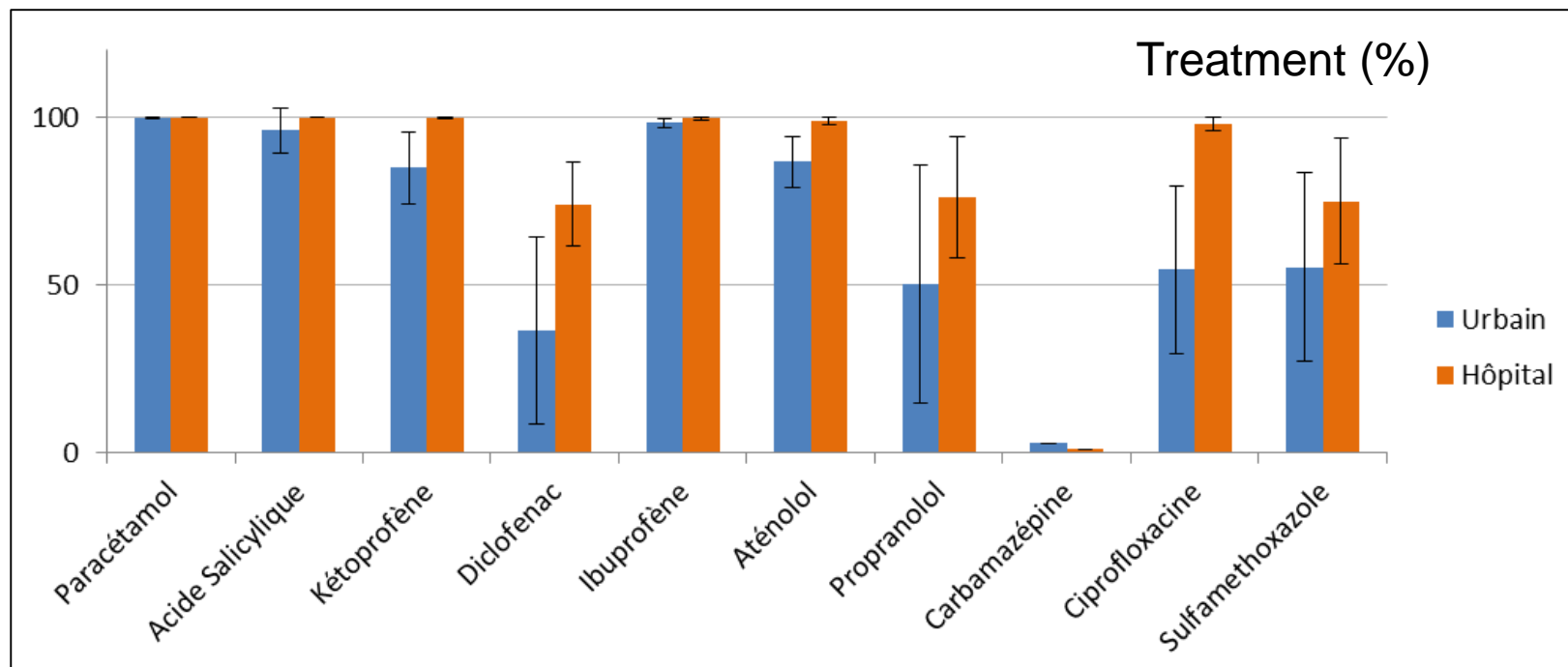
This difference comes mainly from high concentrations of antibiotics

...in flux  $((g.J^{-1})_U / (g.J^{-1}))_H * 100$

## Hopital / Urban



# After treatment (classical activated sludge)



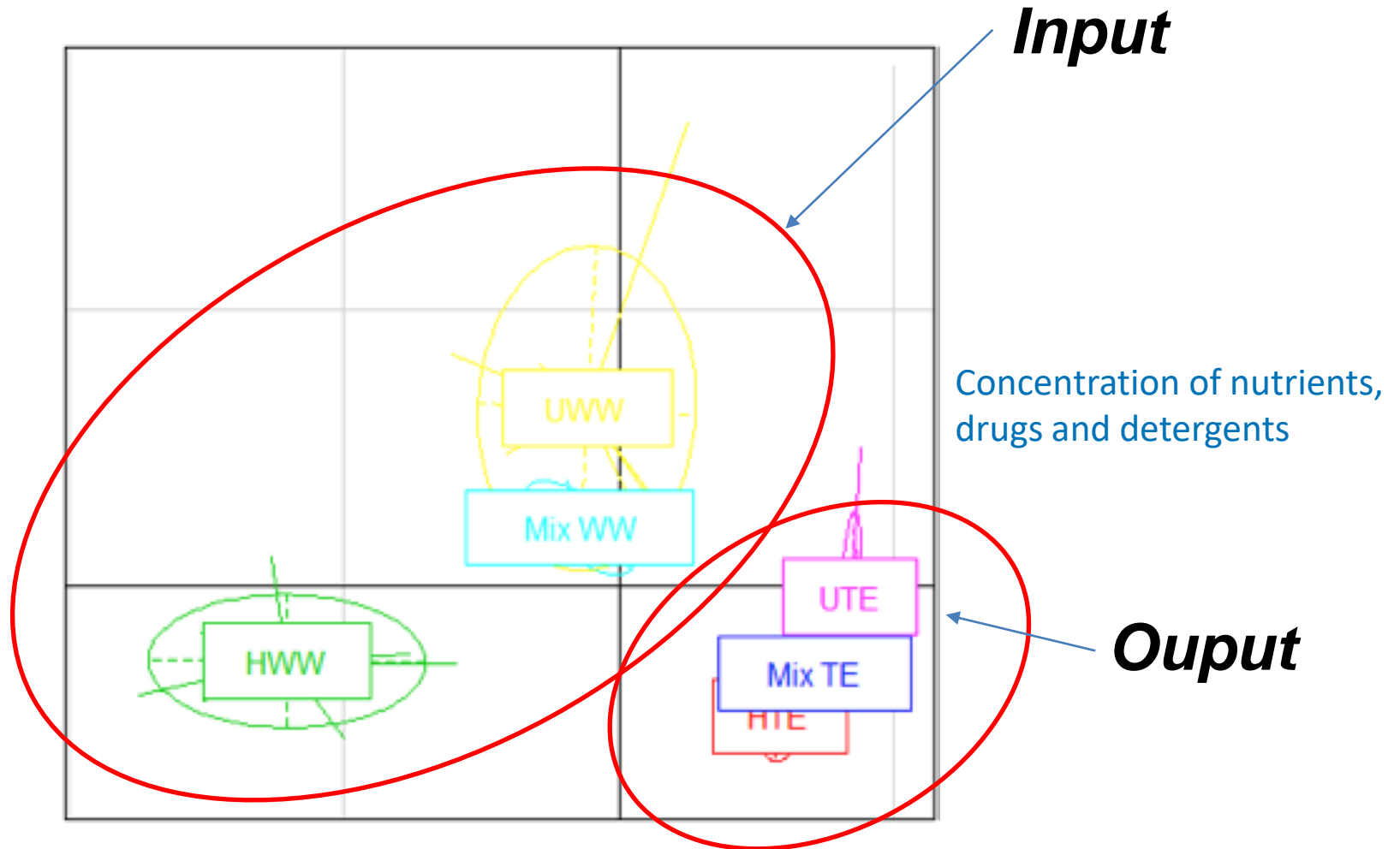
Compounds eliminated but present in high concentrations

Compounds not or slightly degraded

- Paracetamol
- Alkylbenzene sulfonate

- Diclofénac
- Carbamazépine
- non-ionic detergents

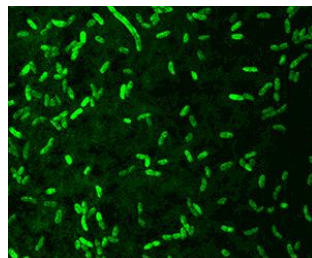
# Hospital and urban effluents : mixing or not mixing ?



**But what is the risk?**



- High reduction in ecotoxicity and estrogenomimetic activity for both effluents
- But the residual estrogenomimetic activity measured in the treated effluents is still likely to induce low disturbing effects on aquatic fauna (before dilution in the river)

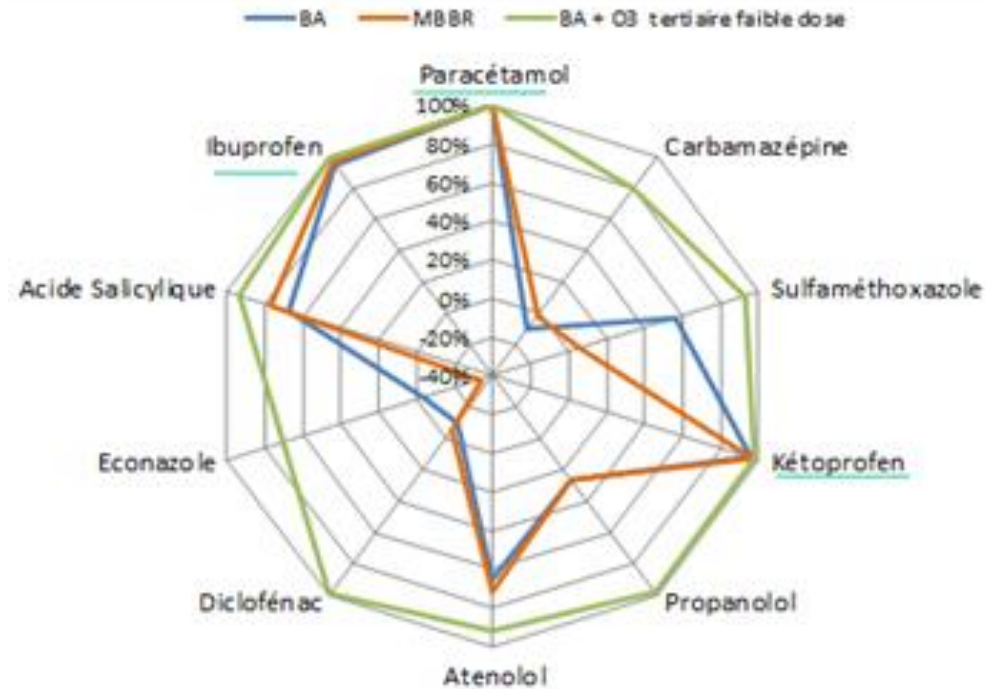


Campagne de mesure de novembre 2013		EFFLUENT HOSPITALIER		EFFLUENT URBAIN	
		ENTRÉE	SORTIE	ENTRÉE	SORTIE
Daphnies	(CE <sub>50</sub> ) (%)	9,9	> 90	78,8	> 90
Algues	(CE <sub>20</sub> ) (%)	15,1	80	> 80	80
Rotifères	(CE <sub>20</sub> ) (%)	4,5	20	34,1	> 100
Ostracodes	Inhibition croissance (%)	66,2	0	0	0
Essai des comètes (sur extrait)	(% tail DNA)	NS	NS	NS	NS
SOS Chromotest (sur extrait)	(Induc. factor)	1,2	1,2	1,1	1
Essai micronoyaux (sur extrait)	(nb noyaux)	2,5	1,25	12,5	1,3
Perturbateurs endocriniens (hormones thyroïdiennes) (extrait)	(ng/L Eq T3)	NS	NS	NS	NS
Perturbateurs endocriniens (oestrogènes) (extrait)	(ng/L Eq E2)	114	0,55	28	1,5

# Tertiary treatments

- ❑ The implementation of complementary treatment devices (ozonation and activated carbon in particular) on effluents is globally effective ...

## TRIUMPH project (Suez) Ozonation low dose



- ❑ but at significant environmental (waste, energy) and financial costs



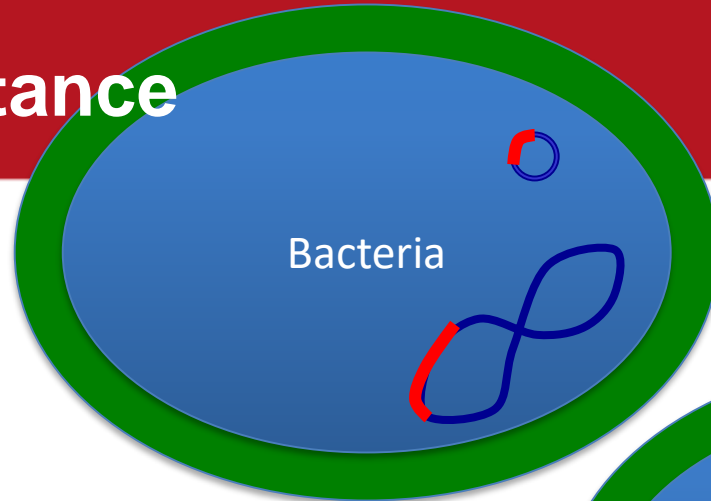
# Antibioresistance



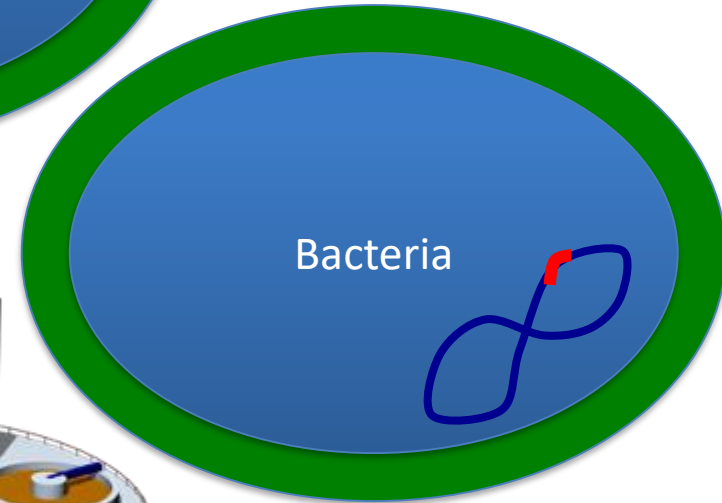
Evaluate the spatio-temporal spread of multiresistance in the environment



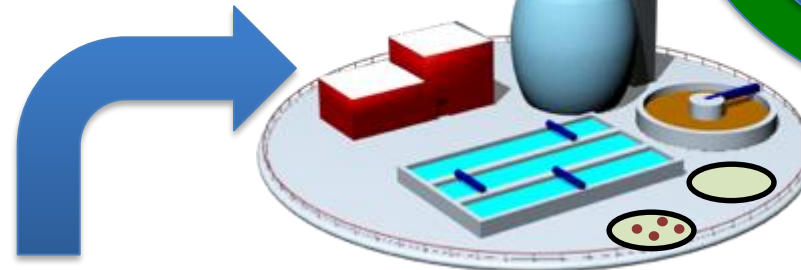
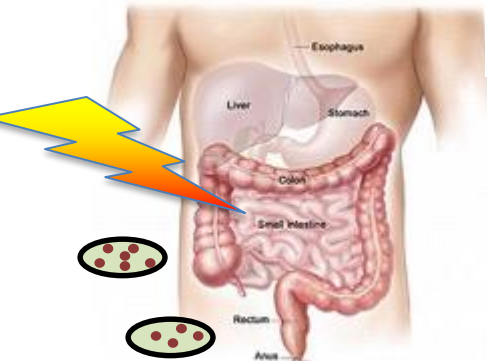
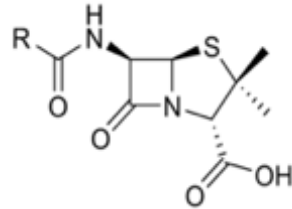
# Antibioresistance



**Selection of resistant bacteria**



**Selective pressure**



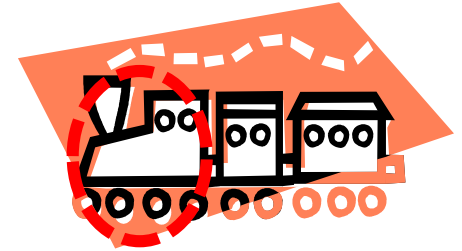
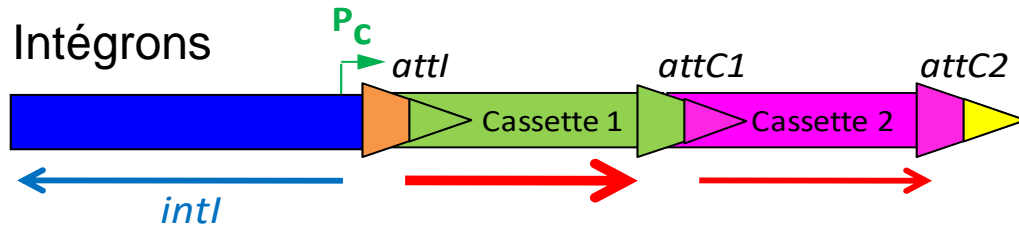
**Microbiome/Resistome  
Human/ animal**



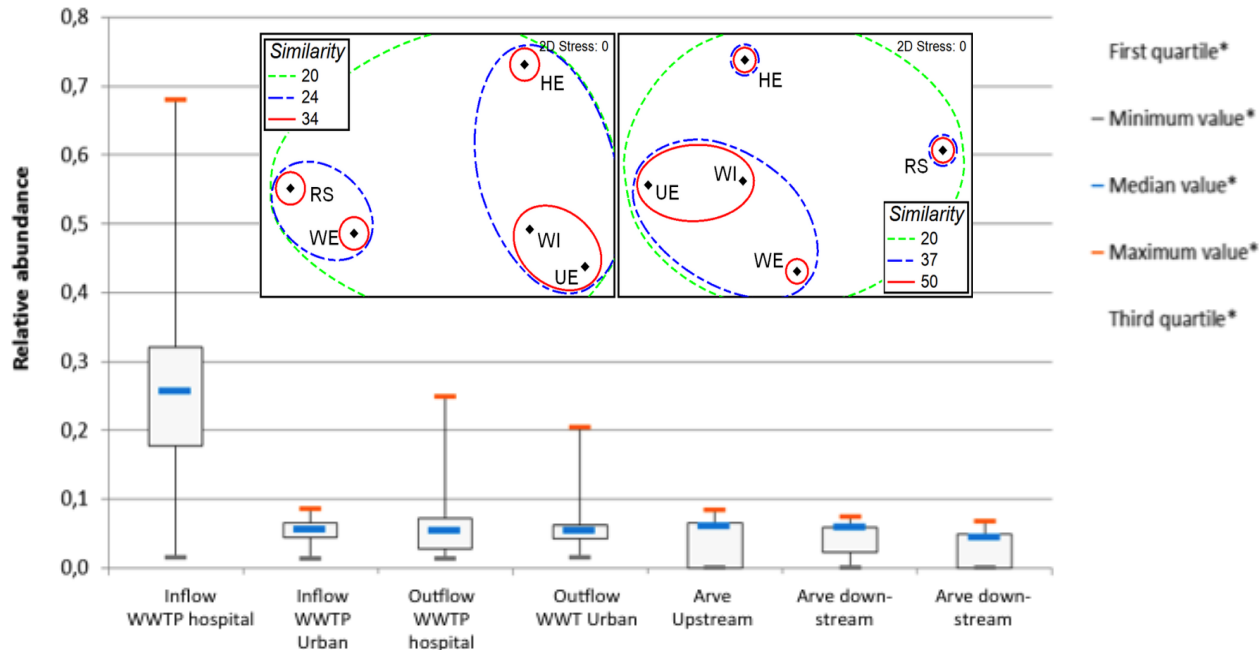
# Pathways of resistance in context with the water cycle



# Antibiorésistance



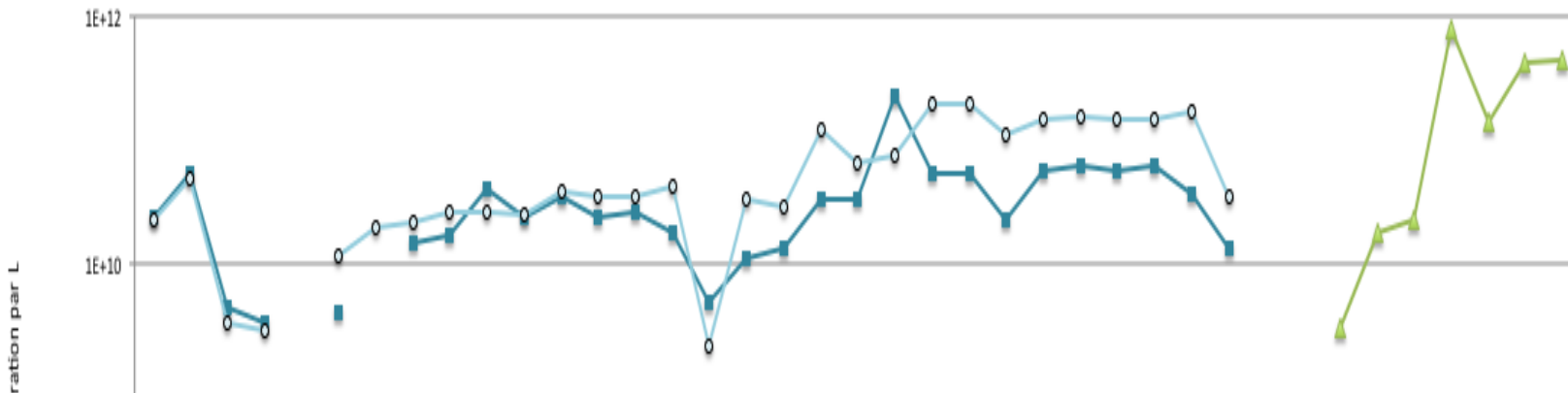
Relative abundance for different samples



## Occurrence of resistance germs:

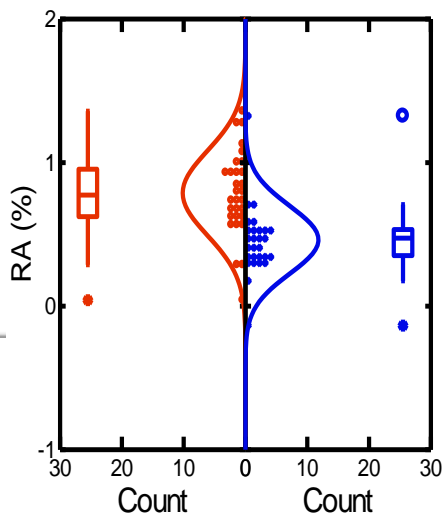
- « Labelling » of hospital effluents
- Labelling of hospital sludge
- Reduction of 2 to 3 log, nonspecific

Concentration boue

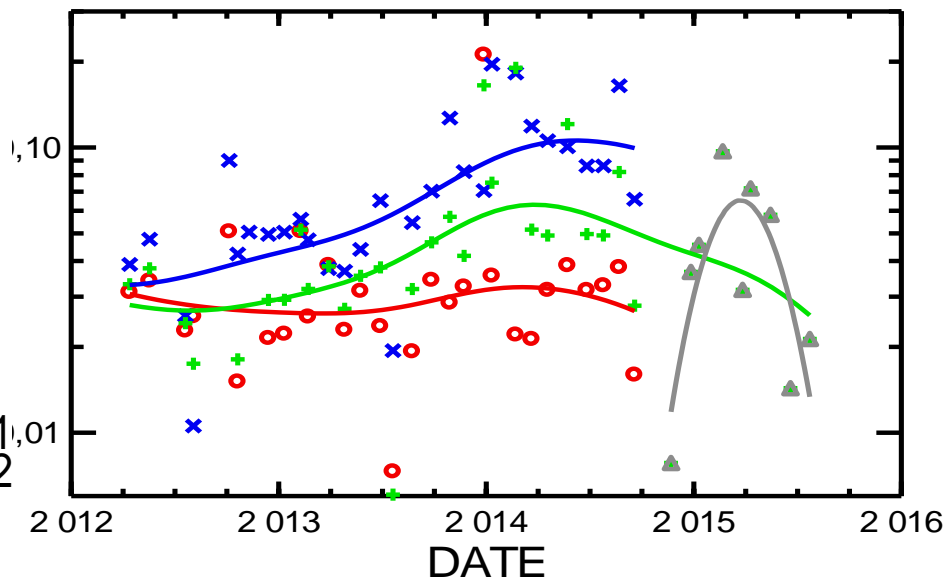


HE is different from UE effluent in term of Integron (ie ARB)  
 WWTP reduces the quantity of Integron : is it enough ?  
 (Quality criteria)

*Although the WWTP seemed to reduce ARB in the treatment processes, it is not enough, if we consider the release of multiresistant bacteria (Newcastle Univ.)*



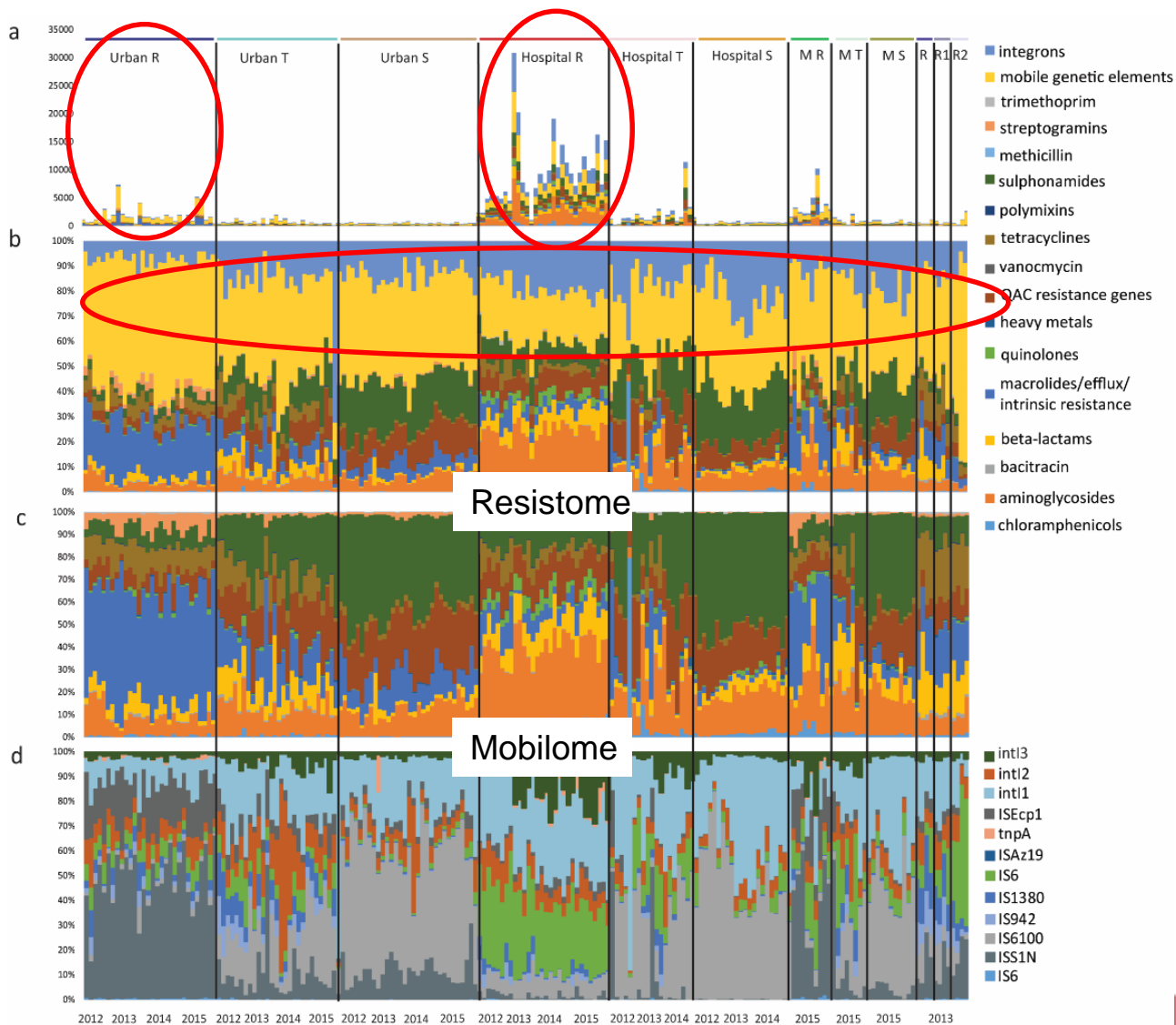
IDLOC\$  
 ○ SP\_0021,01  
 × SP\_0022



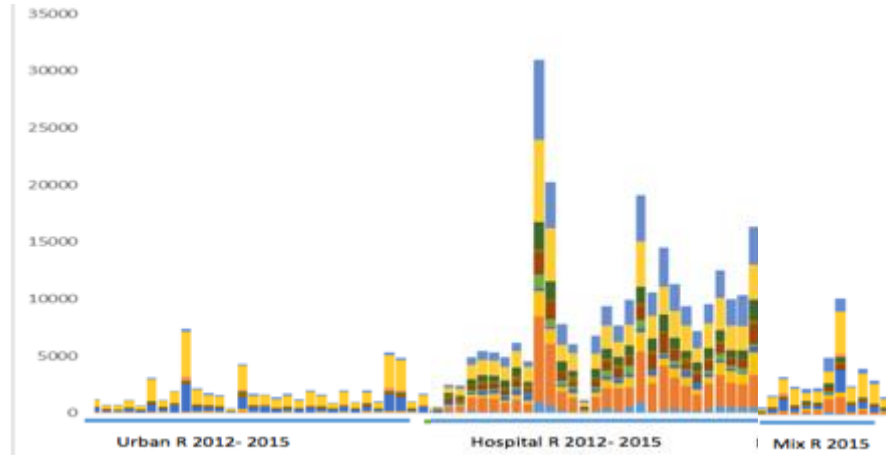
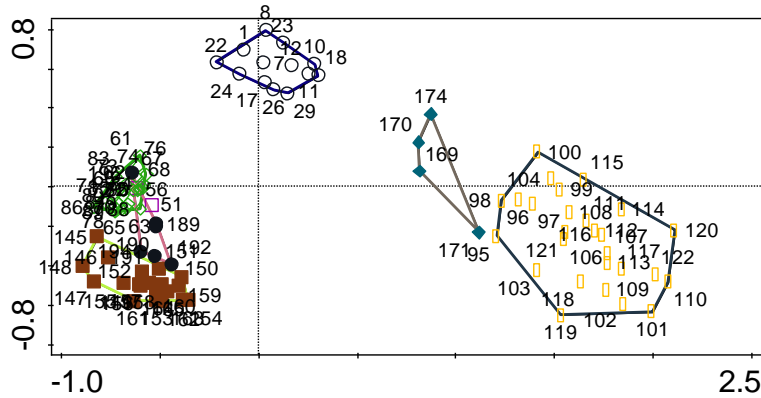
○ RATIO\_SP  
 × RATIO\_SP  
 + RSIM\_SM  
 △ RATIO\_SP

# Urban and hospital effluents are a source of genes (ARGs) and bacteria (ARB) dissemination

Proportion of gene families present / sample type



# Urban and hospital effluents are a source of genes (ARGs) and bacteria (ARB) dissemination



**ARGs** are significantly more abundant in hospital wastewater

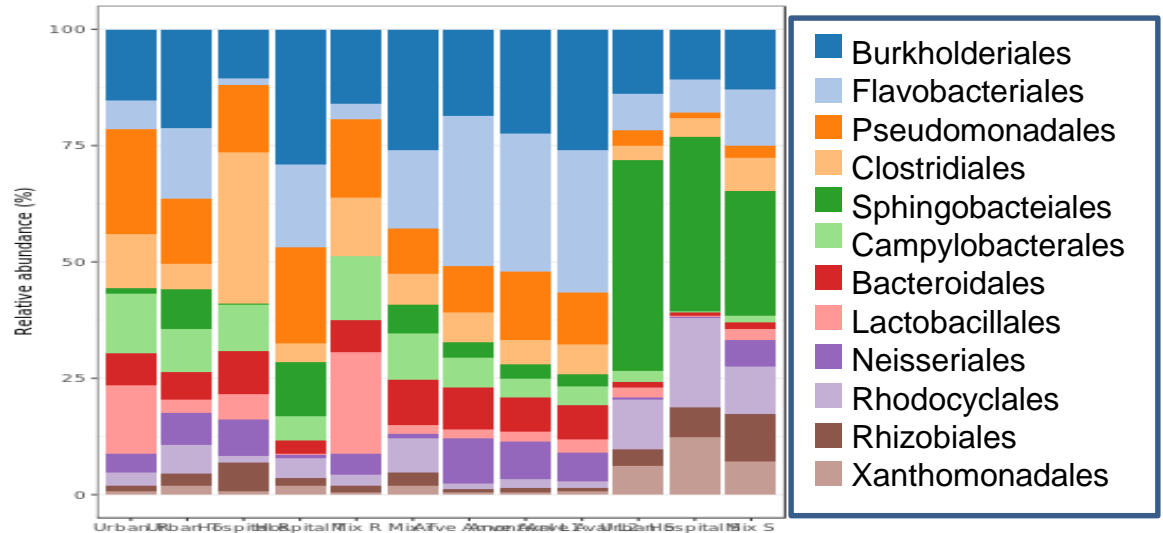
Relative and proportional abundance of ARGs does not change significantly over time (4 years)

Distinct resistome signature

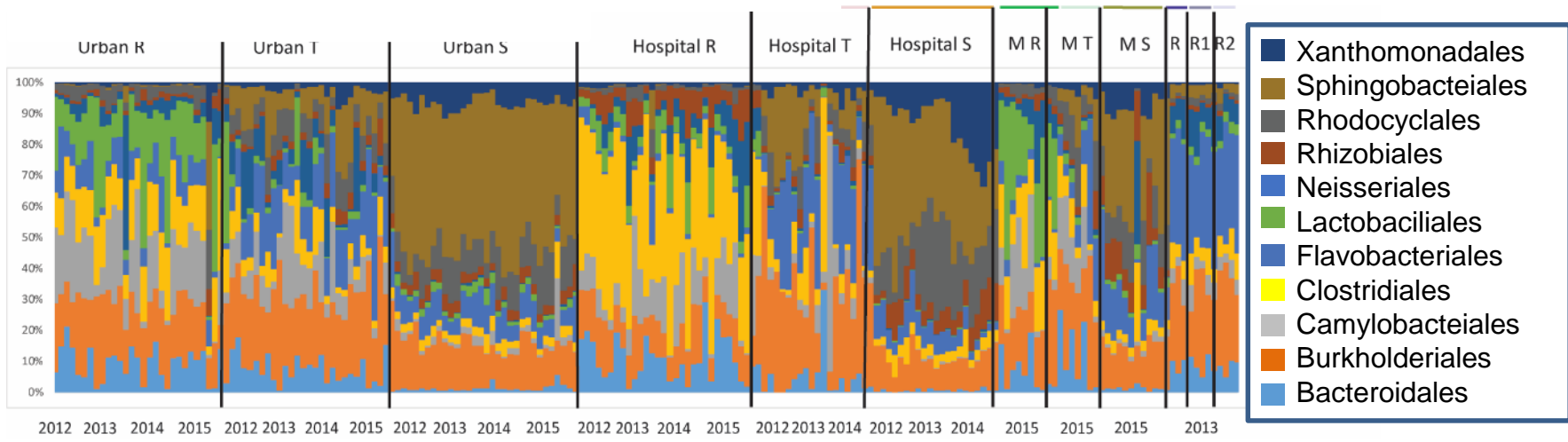
**MGEs** (transposases and integrons) are highly abundant in all waste and surface waters (represent up to 60% of detected genes in urban wastewaters)



# Microbiome



Microbiome is stable during the 4 years  
 Specificity ?  
 Relationship with resistance?



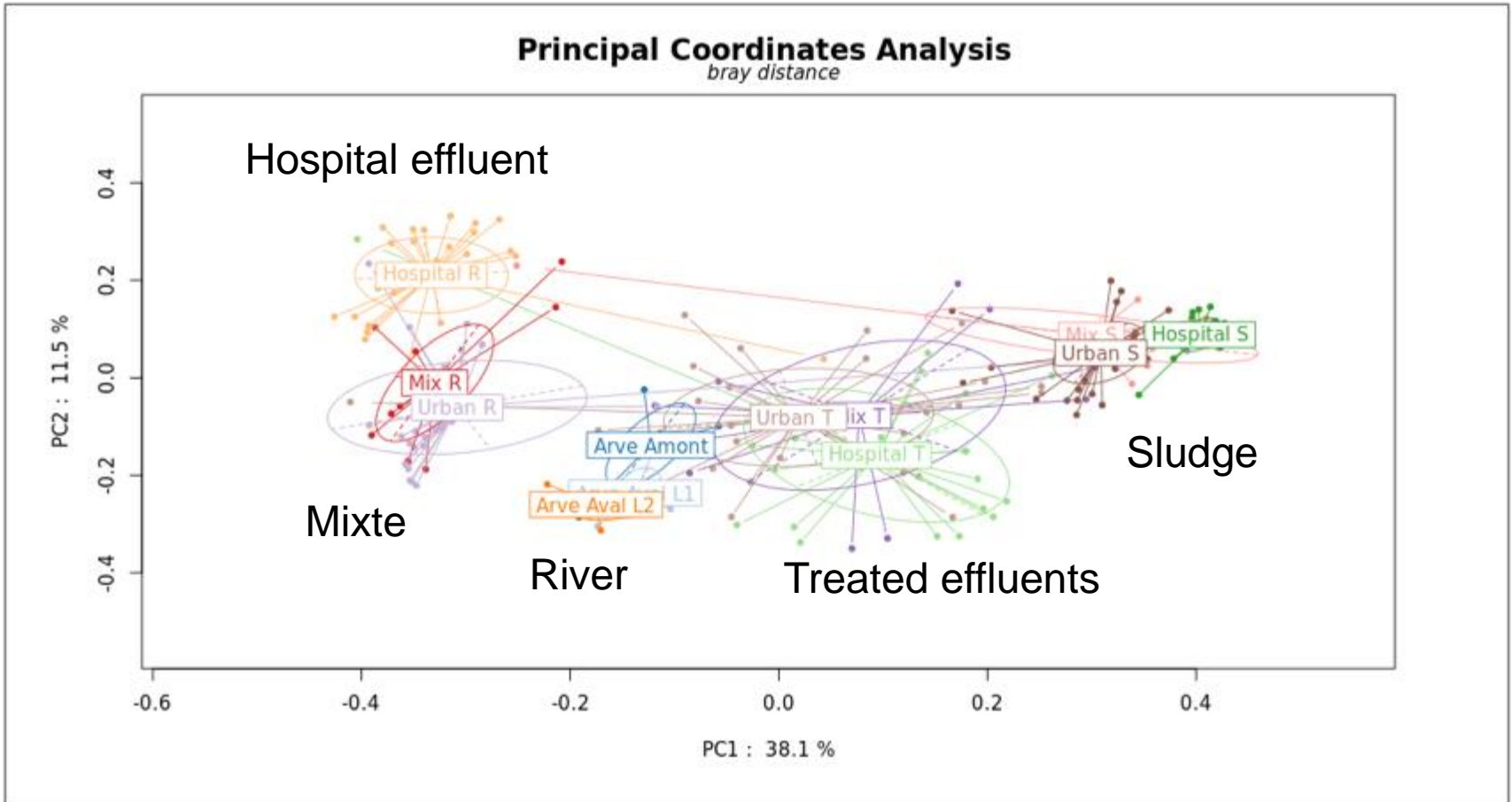
Significant correlations between genes / gene families and bacterial orders?



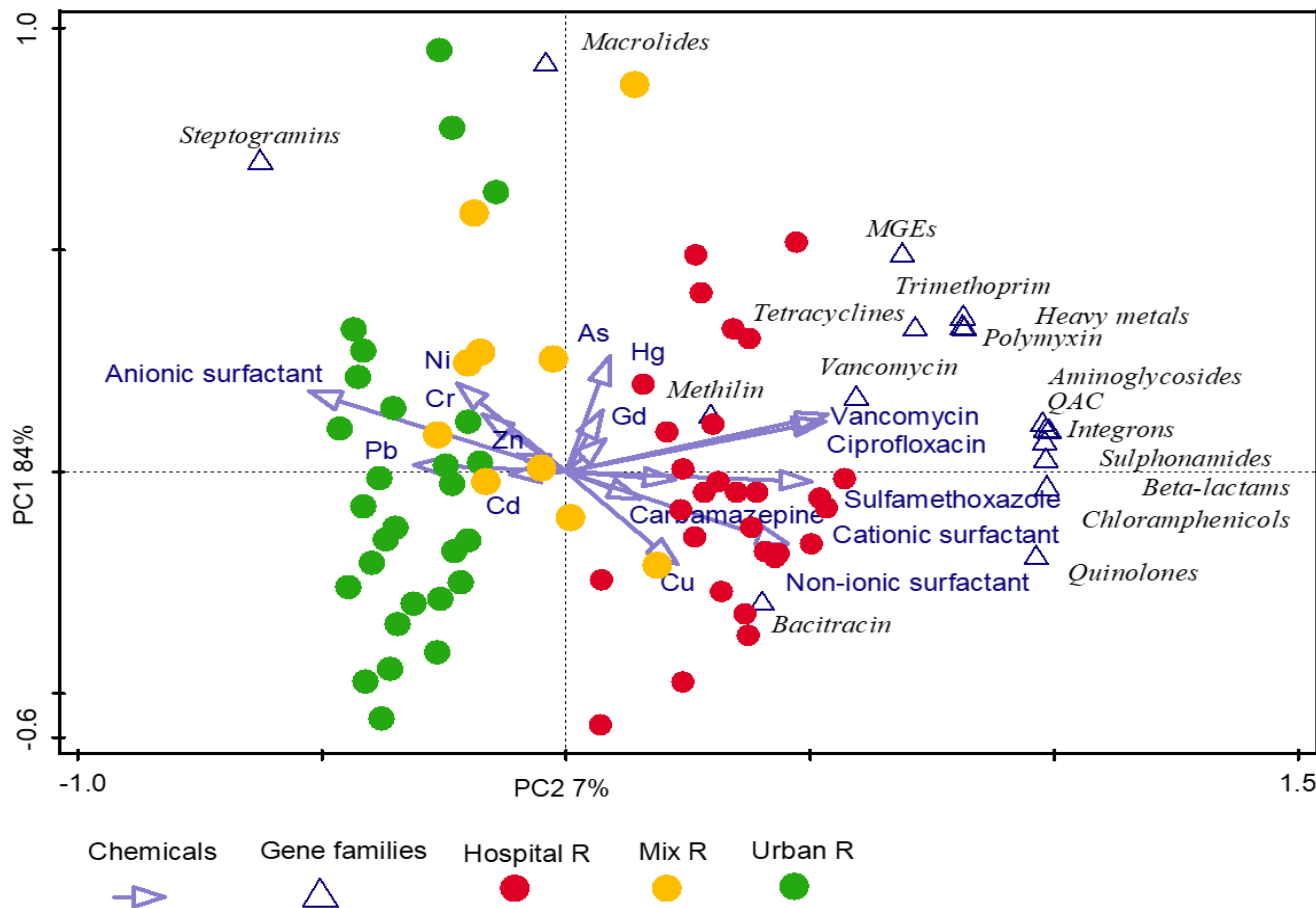


# Specificity of the microbiote

Analysis based on type



# Relationship between taxa, resistance genes and pharmaceuticals?



Significant correlations

Indicate environment does shape resistome and microbiome



# Teachings of SIPIBEL

Hospital effluent has certain specificities

Most of the flow of drug and detergent residues comes from the urban effluent

The treatment of STEP is effective ... but does not eliminate everything ...? In urban or hospital

The mixture does not affect the treatment and overall the quality of the outflow water

Separate treatment of hospital effluent is not the appropriate solution and complementary treatments are effective

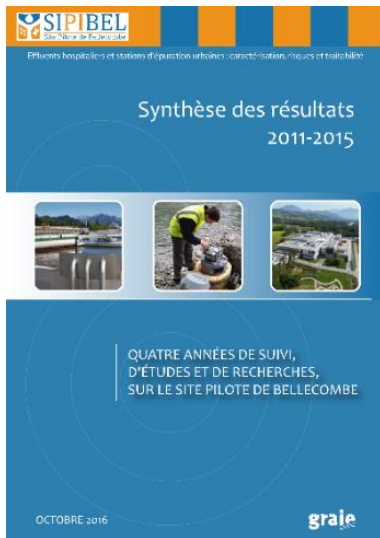
Need for monitoring, research and experimentation:

- Sludge
- The potentialities of reduction at the source
- Drug metabolites





# Thanks to all partners



INSTITUT DES  
SCIENCES  
ANALYTIQUES



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# And for your kind attention