The Role of Science, Technology and Innovation in Global Water Challenges

March 20, 2018

Brasília/DF - Brazil

OPENING CERIMONY

Prof. Dr. Alvaro Prata
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Dr. Dominique Darmendrail
Water Joint Programming Initiatives / European Commission (JPI Water / EC)

Dr. Sanderson Leitão
Ministery of Science, Technology, Innovation and Communication (MCTIC)

Panel 1 –Science, Technology and Innovation (STI) contributions to tackle challenges in sanitation

Emerging pollutants and risks for water and sanitation challenges: the case of Europe

Prof. Dr. Christian Kazner

University of Applied Sciences and Arts, Northwestern Switzerland, Institute of Ecopreneurship

STI contributing to the solution of water and sanitation challenges: the Brazilian case

Prof. Dr. Charles Carneiro

SANEPAR – Paraná State Water & Sanitation Company and Getulio Vargas Foundation – FGV/ISAE

Dialogues
EUROPEAN UNION · BRAZIL

Emerging Pollutants and Risks for Water and Sanitation Challenges: the Case of Europe

Christian KAZNER

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MINISTÉRIO DAS RELAÇÕES EXTERIORES
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA, INOVAÇÕES E COMUNICAÇÕES
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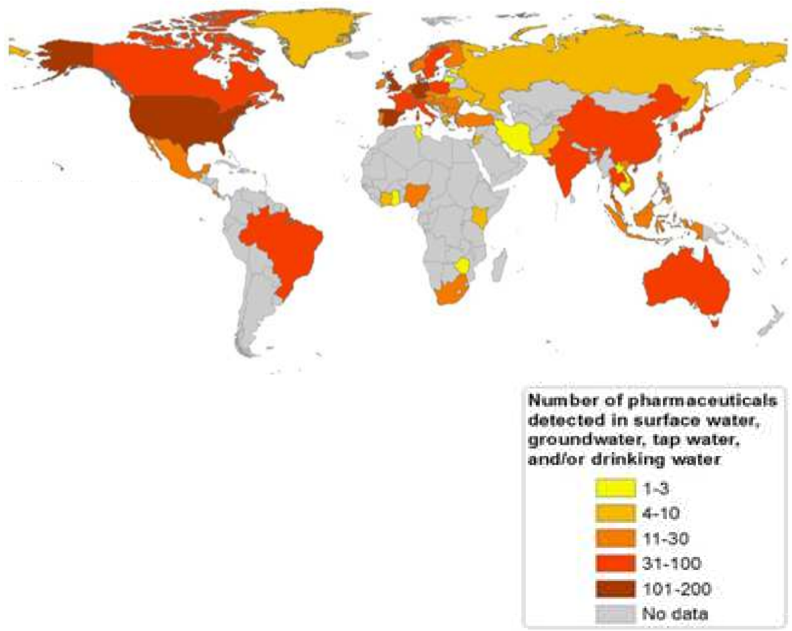
Content

1. Introduction
2. Micropollutants in the water cycle
3. Impacts
4. Mitigation measures and source control
5. Wastewater Treatment and Water Reuse
6. Regulatory trends
7. Conclusions



Background on emerging pollutants

100’000 chemical compounds are registered in the EU,
3000 are “new compounds” of the last 20 years.

30’000 chemical compounds are produced in quantities of **>1 t/a**.

5000 chemical compounds are distributed in quantities of **>100 t/a**.

8700 different food supplements exist.

3300 chemicals are used as human pharmaceuticals.

More than 100 active agents of pharmaceuticals and their metabolites were found in WWTP effluents up to a few µg/L in studies around the world.

Growing concern about **micro-plastic** in the water cycle.

Proliferation of **antimicrobial resistance** genes and bacteria in the water cycle.

Transfer pathways of emerging pollutants

Water cycle with unintended and intended water reuse:

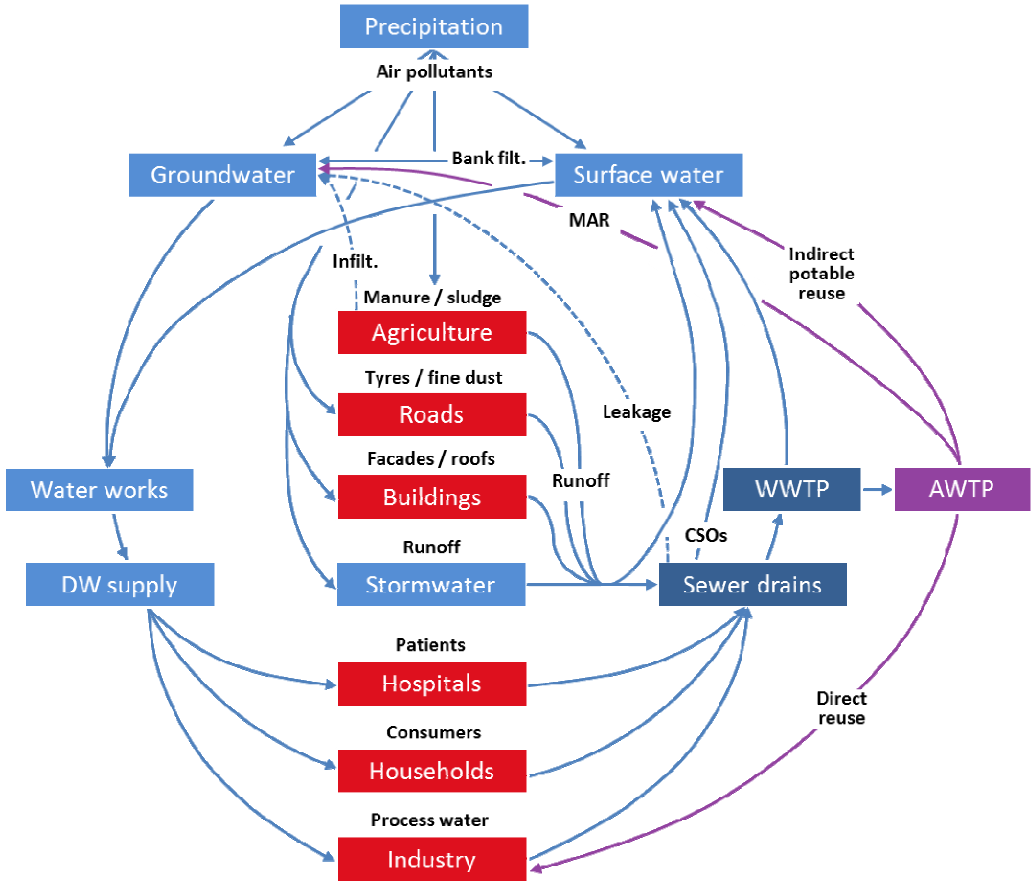
Main routes and sources of pollutants:

1. Diffuse sources

Washed off pesticides from surface runoff, roof runoff, flushed aerosols, washed off organic pollutants from asphalt, construction materials and paints, microplastics from worn tires, …

2. Point sources

Wastewater treatment plants WWTPs
Combined sewer overflows CSOs



Abbreviations: MAR = managed aquifer recharge, CSO = combined sewer overflow, WWTP = wastewater treatment plant, AWTP = advanced water treatment plant., Infilt. = Infiltration


Pharmaceuticals
Endocrine disrupting compounds
Household chemicals
Cosmetics
Organic micropollutants
Concentrations ng/L - µg/L
Contrast media
Pesticides
Polyaromatic hydrocarbons
Industrial chemicals
WHO
ruilan

Possible adverse environmental effects of pharmaceuticals

Compound class	Application	Possible or known adverse environmental effects
Analgesics and anti-inflammatory drugs	Pain relief	Side effects on kidneys, proven **toxic effect on vultures**
Antibiotics	Antimicrobial effects, e.g. bacteriostatics and bactericides	Development of **antibiotic resistance** via the compound directly or via transfer of antibiotic resistance genes, mutagenicity, acute and chronic **toxicity**
Psychotropic drugs	Neurological or psychiatric medications, e.g. anti-epileptics, antidepressants, anti-convulsants, drug abuse, e.g. stimulants opiates	Possibility of **neurotoxic effects**, alterations of behaviour or enzyme induction
Sex hormones	Sex steroids, e.g. contraceptives, testosterone	Reduced reproductive success, mutation, changes in the gender, e.g. **feminisation of fish**
Cytostatics	Therapy of cancer and autoimmune diseases	**Mutagenicity, carcinogenicity, teratogenicity**, infertility

Source: Kazner 2012, modified from Sattelberger, 1999, BLAC, 2003 and Fent et al., 2006; Pal et al. 2014

Emerging pollutants from point sources

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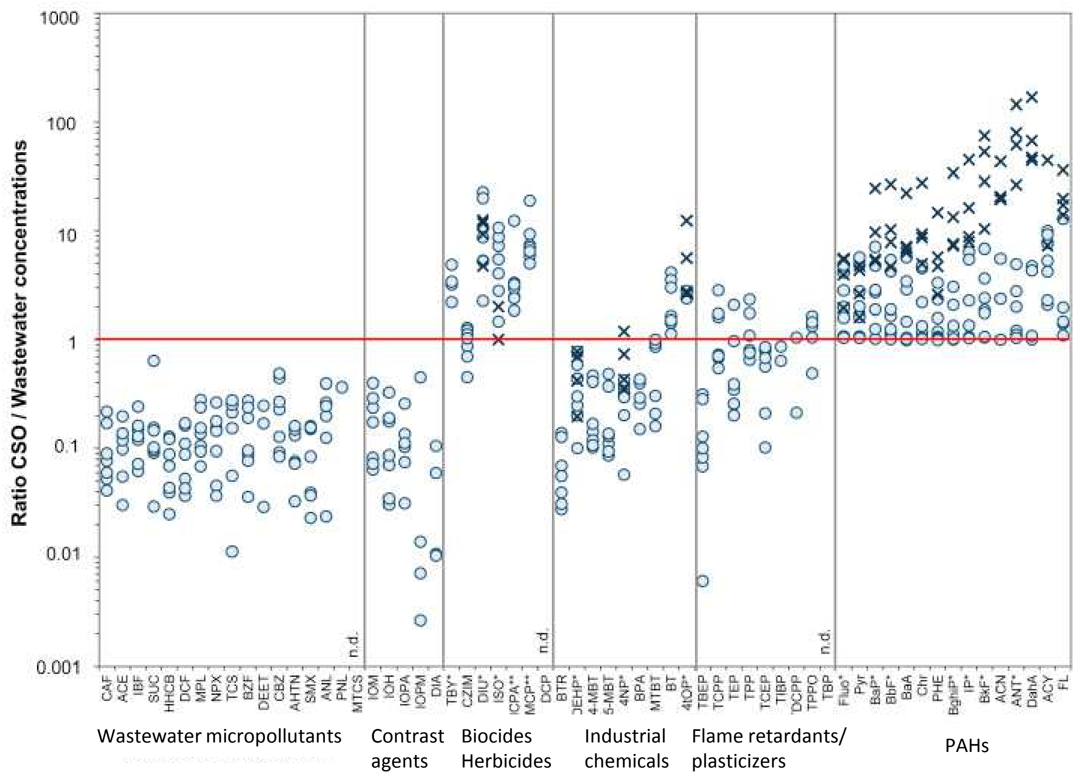
Wastewater treatment plants are mainly responsible for the emission of

- **Pharmaceuticals** and contrast media
- **Household chemicals** and personal care products
- **Industrial chemicals**

Combined sewer overflows and stormwater overflows discharge primarily:

- **Pesticides** (herbicides and biocides)
- Some industrial chemicals and flame retardants
- **Polyaromatic hydrocarbons**



Source: Launay et al. 2016, Gasperi et al. 2012

Measures to reduce pharmaceuticals

Reduction measure	Potential / limitations	Effect
Substance substitution / use of more environmentally-friendly pharmaceuticals	• **large-scale effect** but • very long-term • costly • R&D required	large, but substance-specific
Change in application (modified prescriptions, alternative, non-pharmacological therapies)	• low costs (?) • tried and tested but • only applicable to some extent	small-moderate
Information activities (specialists + general public)	• low costs • existing experiences but • effect only limited and possibly only temporary	small-moderate
Decentralised waste water treatment of e.g. medical facilities	• captures **hot-spots** but • unresolved cost allocation	large
4th treatment stage in WWTPs	• effect for **complete catchment area** but • removal of pharmaceuticals only partially possible for specific substances	small-large

Source: German EPA, 2015

Removal of emerging pollutants in WWTPs

4th Treatment Stage

Adsorption on activated carbon

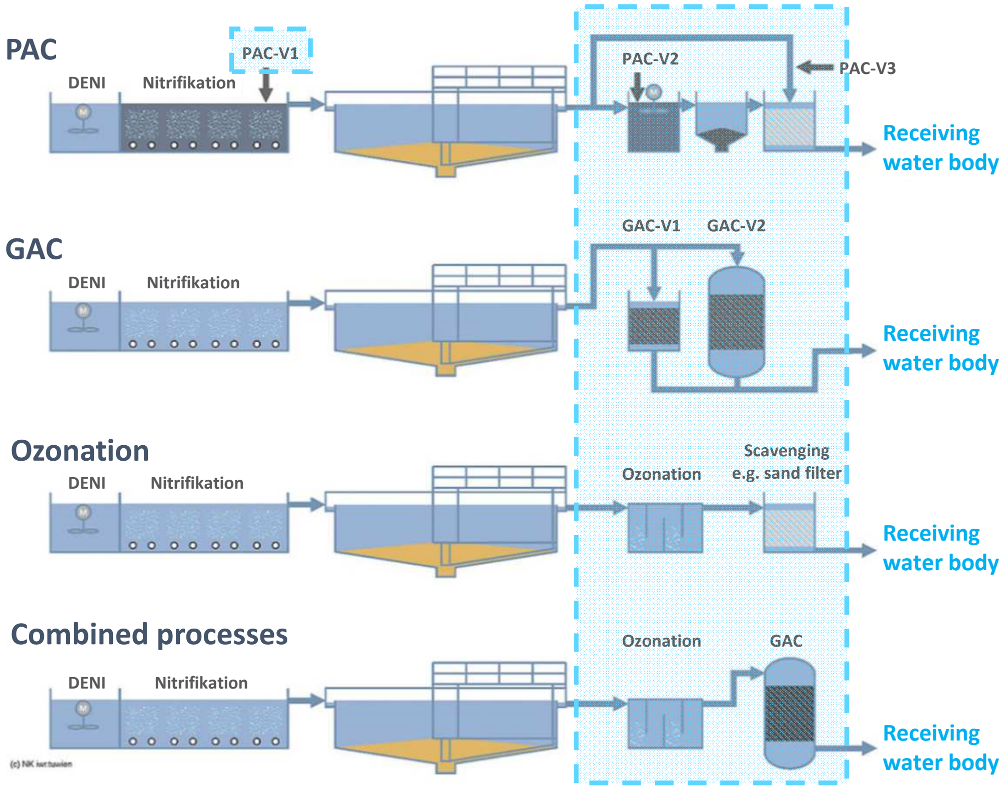
- Powdered activated carbon (PAC)
- Granular activated carbon (GAC)

Chemical oxidation

- Ozonation (O_3)
- Advanced oxidation processes (AOP)

Combined treatment

- Ozonation followed by GAC or PAC



Source: modified from Schaar & Kreuzinger, Österr Wasser- und Abfallw 2017 · 69:340–345

WWTPs with removal of emerging pollutants

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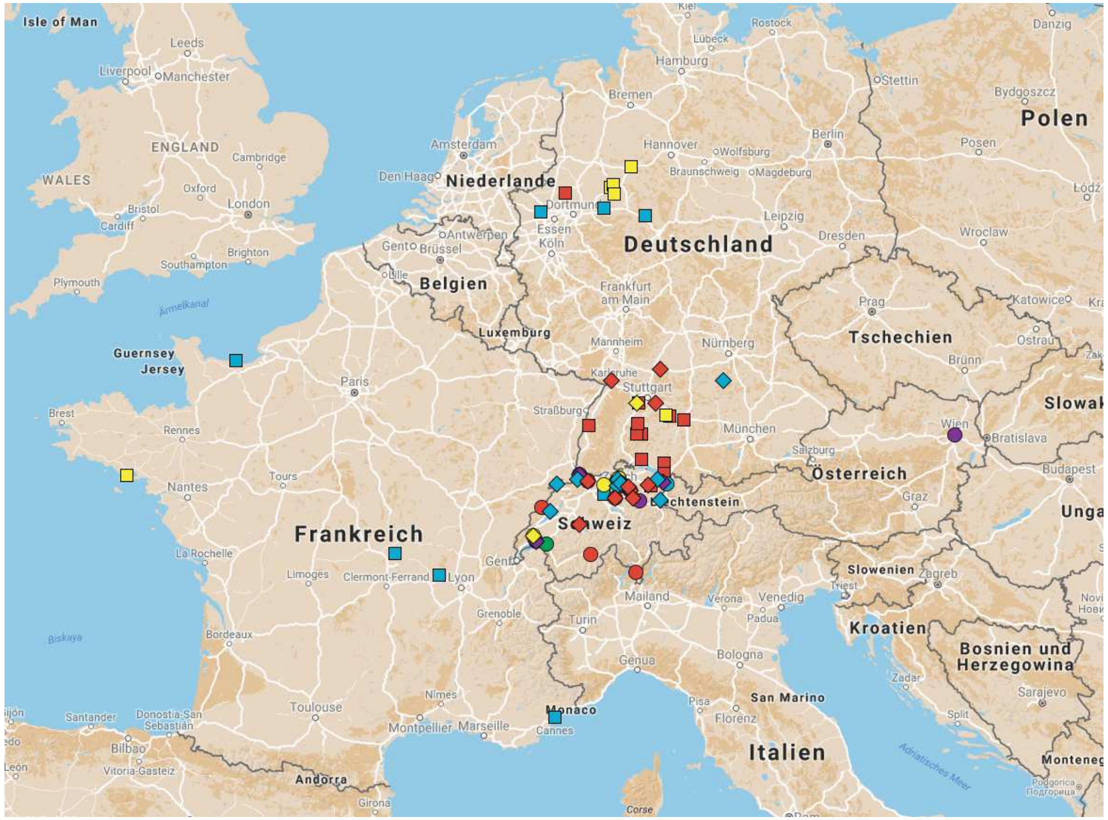
No. of WWTPs with...	Germany	Switzerland	France
PAC			
Operating	12	1	-
Under construction	5	11	-
Piloting	5	7	-
GAC			
Operating	3	-	1
Under construction	3	2	-
Piloting	2	5	-
Ozone			
Operating	3	2	4
Under construction	3	10	-
Piloting	4	4	-
Combined processes			
Operating	-	-	-
Under construction	-	3	-
Piloting	1	3	-



Source: https://www.micropoll.ch/anlagen-projekte/uebersichtskarte/

Advanced treatment processes for micropollutant removal

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	Ozone	Powdered activated carbon	Nanofiltration / Reverse osmosis
Reference dose for 80% MP removal	3 – 5 g O_3/m^3 (0.7 – 0.9 g O_3/g DOC)	12 – 15 g/m^3	Not applicable
Ecotoxicity	Transformation products!	Significant reduction	Significant reduction
Impact on pathogens	Partial disinfection	Some removal	Significant reduction
Impact on TOC	Marginal	About 40% removal	ca. 95% removal
Post-treatment	Biological post-treatment required	Filtration	In wastewater not
Auxiallaries	Oxygen, electricity, cooling Water	PAC, coagulant, flocculant, power	Electricity, anti-scalants, cleaning agents
Energy demand	0.06 – 0.09 kWh/m^3	0.01 – 0.04 kWh/m^3	0.4 - 1 kWh/m^3
Cost	0.08 EUR/m^3 8 EUR/cap/a	0.12 EUR/m^3 12 EUR/cap/a	0.4 – 0.8 EUR/m^3

Source: modified from Swiss FOEN, 2012

Potential biodegradation pathway of Iopromide

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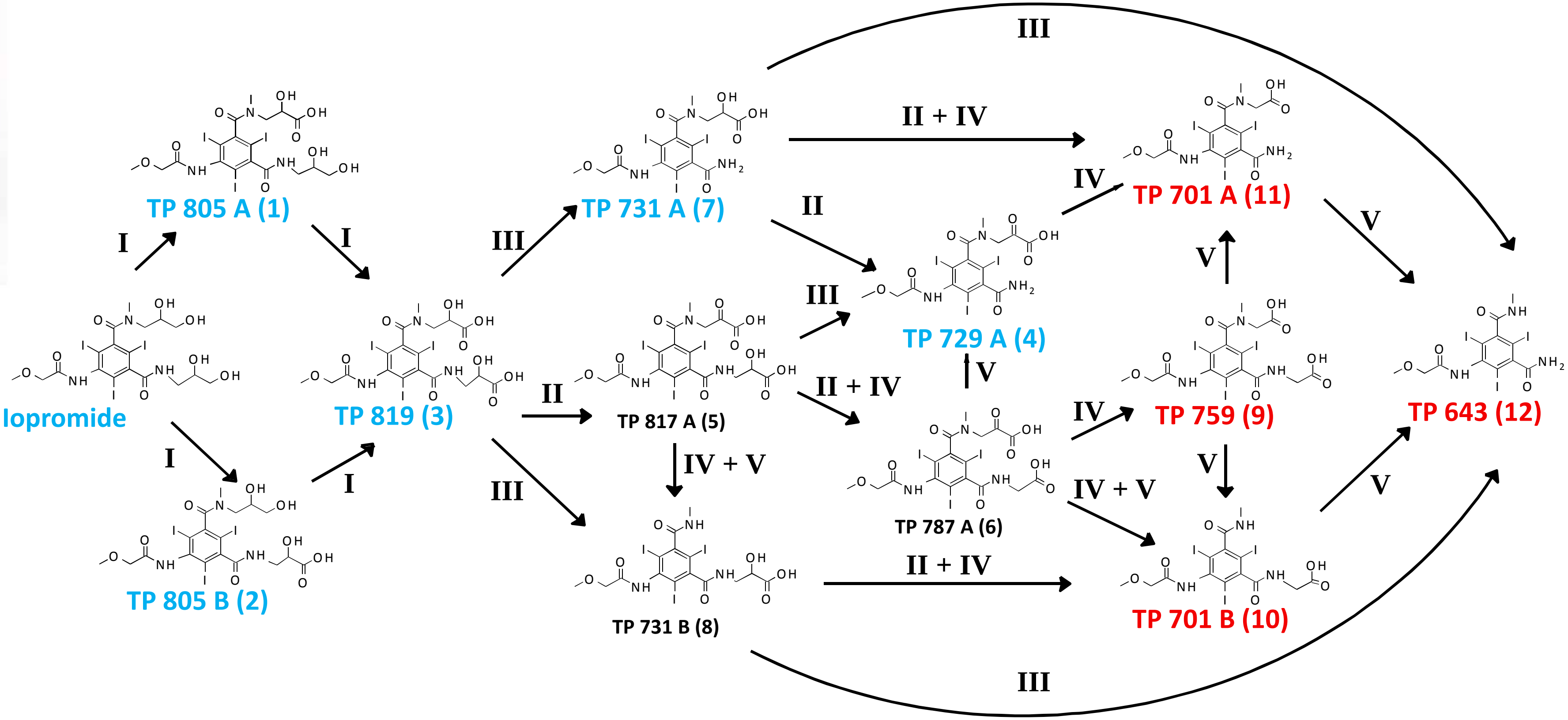


Degradation occurs, but stable intermediates persist in the environment.

Source: Schultz et al., 2009

Modeled Diclofenac risk potential in Swiss rivers

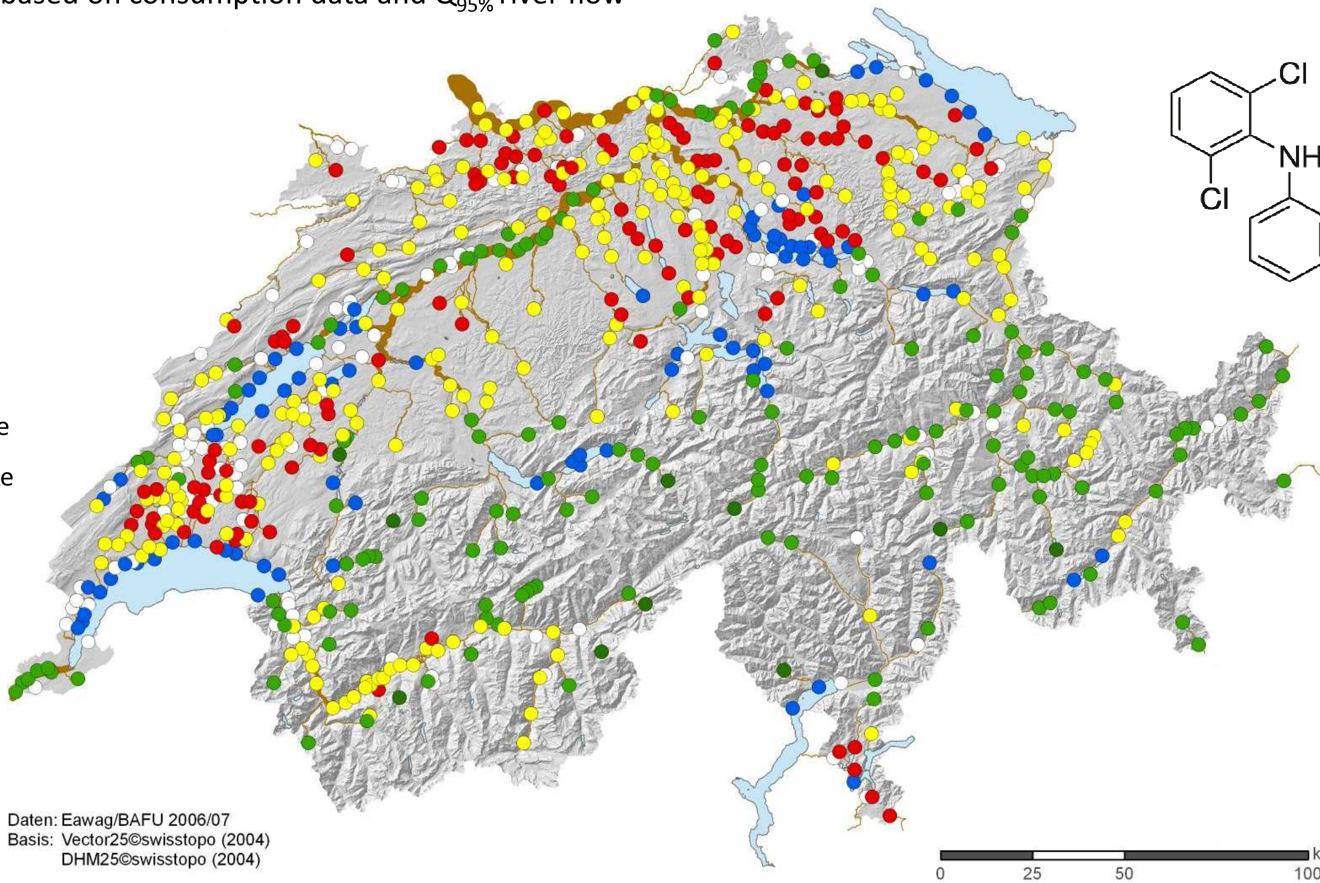
Estimated concentrations based on consumption data and $Q_{95\%}$ river flow

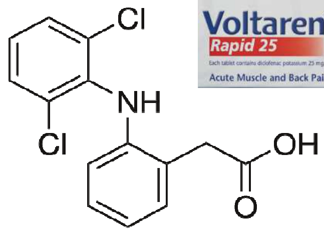
$\frac{PEC_{DCF}}{PNEC_{DCF}}$

[mg/L]

- **< 0.001**
- **0.001 - 0.01**
- **0.01 - 0.1**
- **0.1 - 1**
- **> 1**
- no $Q_{95\%}$ available
- discharge to lake

downstream of 125 WWTP (15% of total pe)**





Source: Götz et al. EST 2012, PEC = predicted environmental concentration, PNEC predicted no effect concentration

Micropollutant strategy in Germany

Integrated approach: All the relevant stakeholders should be involved in a fair and representative way.

Primary objective: compliance with the existing water protection quality targets (e.g. Water Framework Directive)

Three pillars:

- **Source-oriented measures** e.g. import restrictions on textiles treated with pollutants, limitations of PAH emissions or information activities regarding the application and use of pharmaceuticals and biocides
- **Decentralized measures** reduce emissions of micropollutants at the point of discharge from e.g. medical facilities, industries, etc.
- **End-of-pipe measures** mainly address emissions from municipal sewage treatment plants and from discharging rainwater or combined waste water and stormwater run-off.

Source: German EPA, UBA TEXTE 87/2014 „Measures to reduce micropollutant emissions to water"

Legal development: Switzerland

The **new Swiss Waters Protection Act** (Swiss WPA 814.20 in combination with Water Protection Ordinance 814.201) defined the additional requirements for upgradation of wastewater treatment plants to remove organic micropollutants was issued in 2017 and enters into force in 2021 with the following main aspects:

- **80% removal target for micropollutants** measured for the treatment train of the WWTP from inlet to final outlet on basis of indicator compounds: e.g. diclofenac, carbamazepine, benzotriazole
- **100 out of 759 most relevant WW treatment plants** to be equipped in the next 20 years
- Aim to halve the discharge of TOrC into the receiving waters of Switzerland by 2040
- Candidate technologies: ozonation and activated carbon adsorption
- **Cost coverage through national fund** (75% of the total investment costs) and fees from the wastewater

Source: WPA & WPO, 2016

Conclusions and outlook

1. **Micropollutants and other contaminants of emerging concern have been identified as key risk for safe water supply and the (aquatic) environment**

2. **There are still large knowledge gaps regarding the health and environmental impact of the myriads of compounds and their combinations.**
3. **Scientific based approaches exist and support a targeted and case specific control strategy along the water cycle and main sources of pollution.**

4. **Pollution control should be based on two main principles**
   - **Source control** and pollution prevention
   - Decentralised removal and centralised end-of-pipe **treatment**

5. **Pollution control is crucial for further support of circular water management**

Thank you for your attention !

Christian Kazner, PhD

University of Applied Sciences and Arts
Northwestern Switzerland - FHNW

christian.kazner@fhnw.ch

P: +41 61 228 5456

dialogos.setoriais@planejamento.gov.br
www.sectordialogues.org

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Ministério do
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Ministério das
Relações Exteriores

Ministério da
Ciência, Tecnologia,
Inovações e Comunicações

Brasil
Governo Federal

A overview of the Brazilian Sanitation:
State of Art , Challenges and STI Perspectives

Eng Charles Carneiro, Dr

Water and Sanitation Company of Parana State - SANEPAR

Institute of Business and Economy of Mercosul - ISAE / FGV

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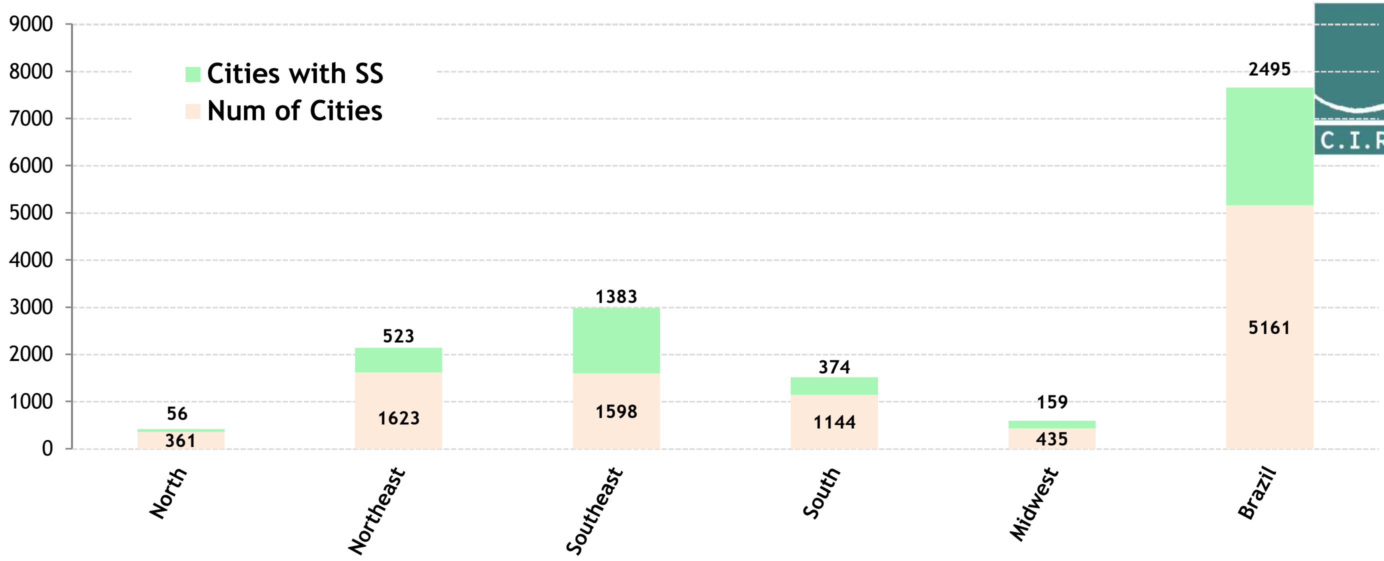
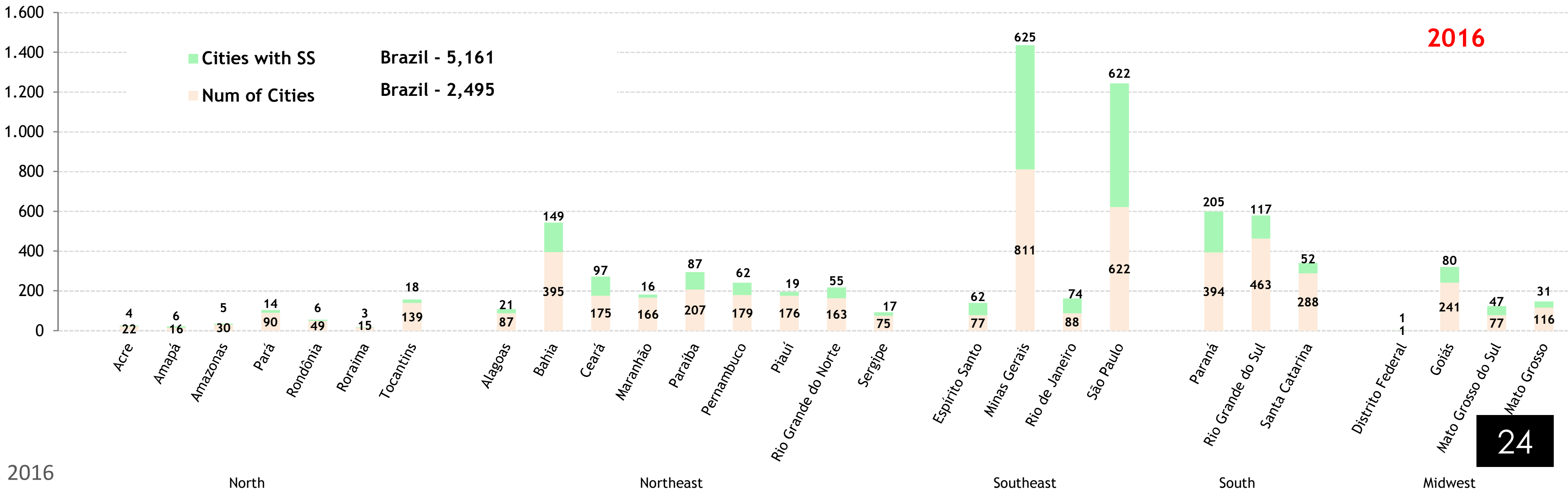
KEY POINTS

1. Introducing – a Brazilian Sanitation Overview
2. Problems and Challenges
3. STI x Sanitation Challenges
4. Looking at the Future

Sewer System

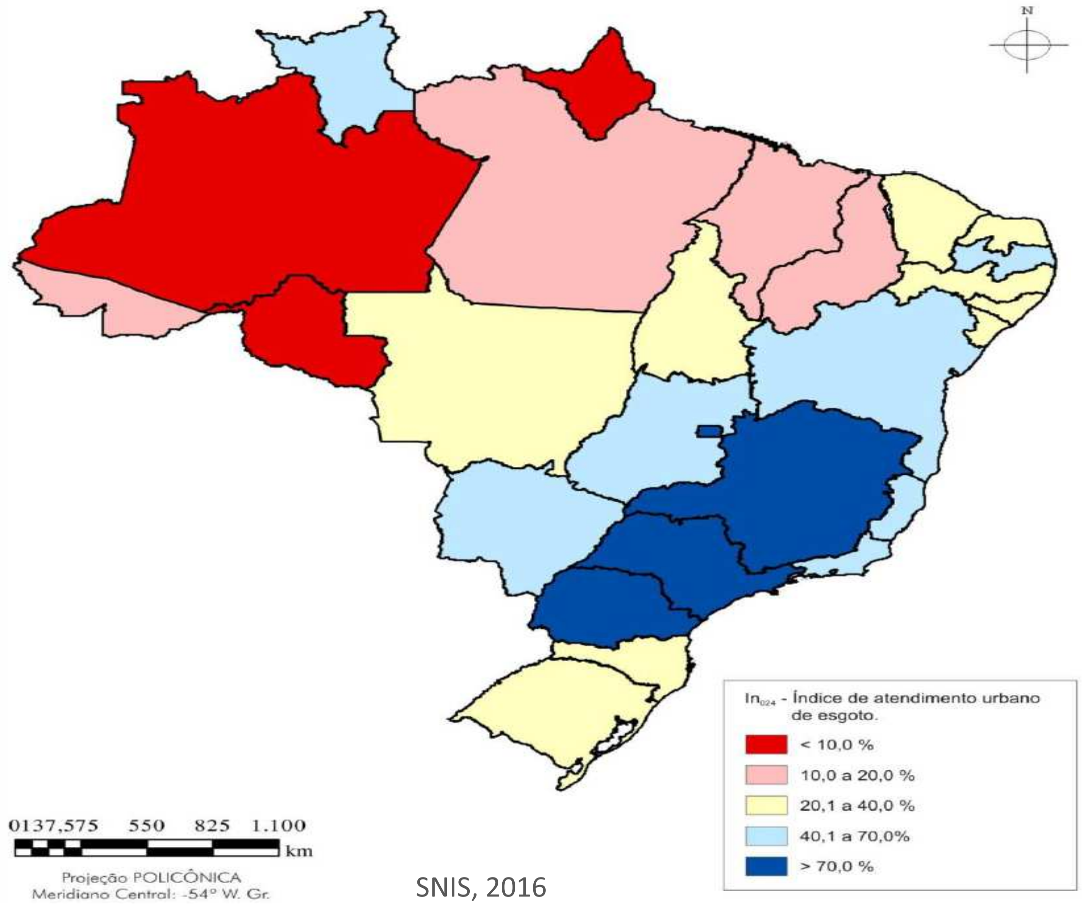
Brazil 2016





SNIS, 2016

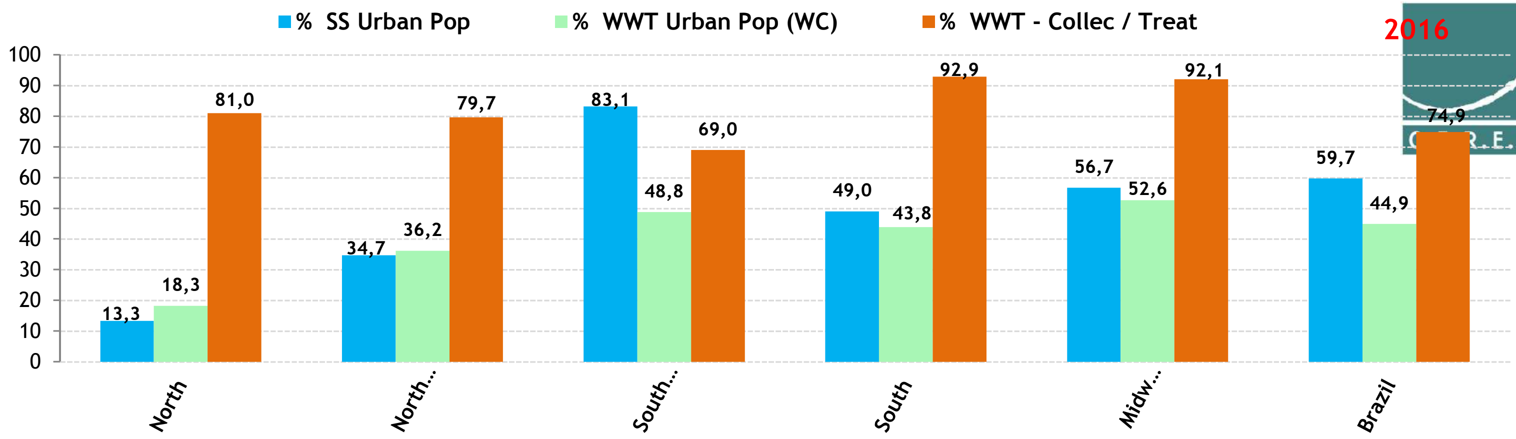
INDEX (%) OF URBAN SEWAGE SYSTEM BY STATE – BRAZIL - 2016

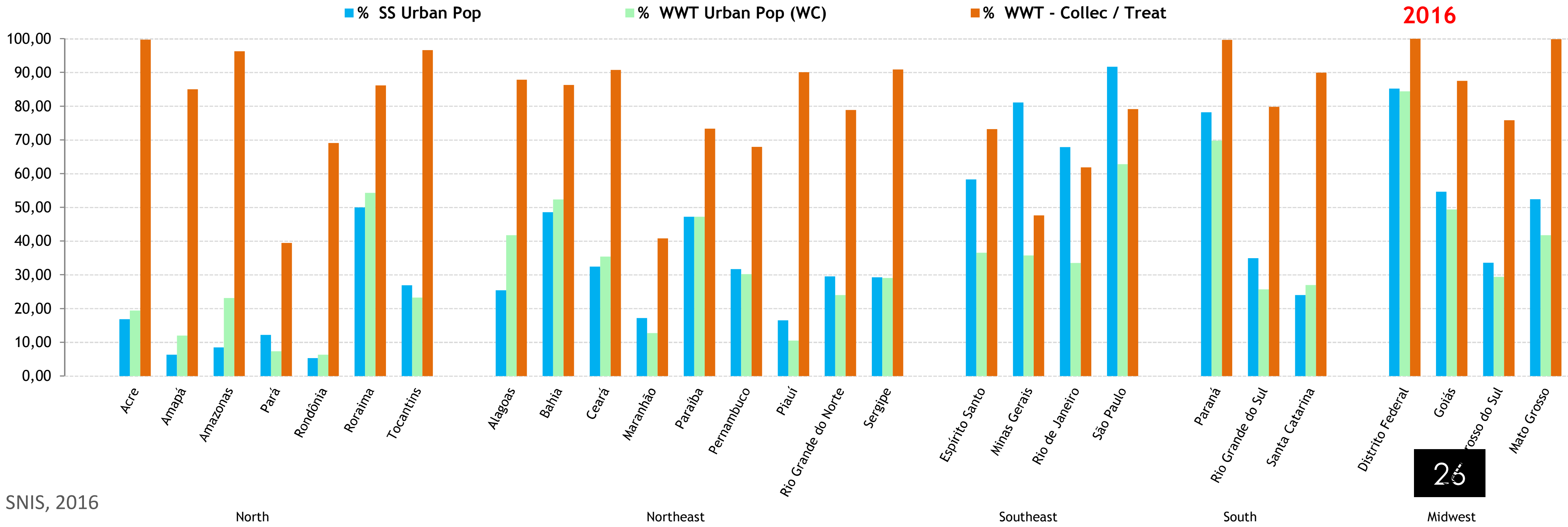


SNIS, 2016

Wastewater Treatment

Brazil 2016



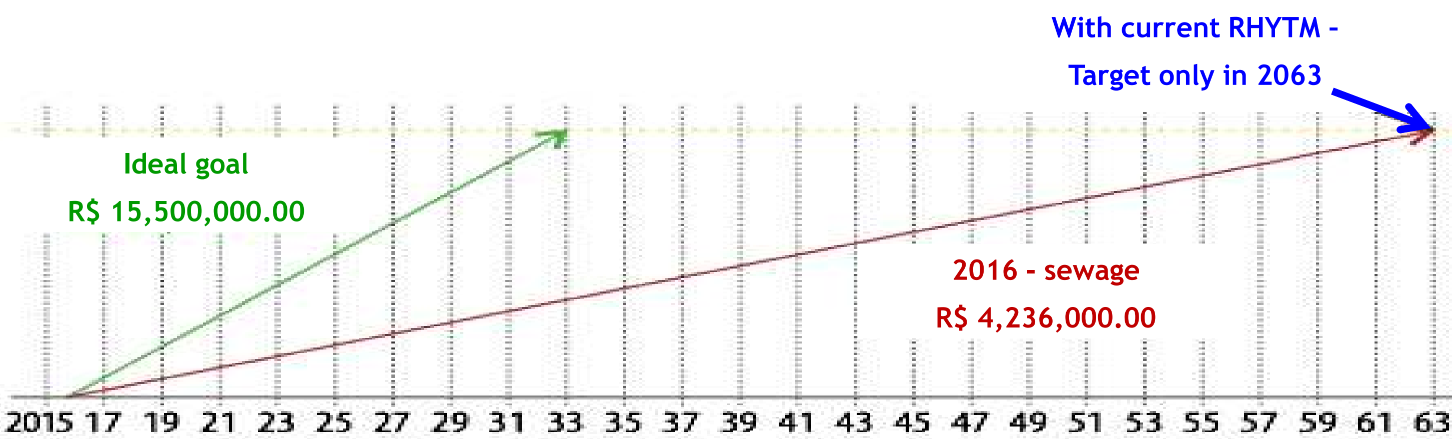


SNIS, 2016

INVESTMENTS (%) IN SANITATION SERVICES BY STATE – BRAZIL - 2016

WATER / SEWAGE – BRAZIL - 2016

Estado	2016	
	(R$ milhões)	(%)
São Paulo	4.505,3	39,14
Rio de Janeiro	875,1	7,60
Minas Gerais	743,8	6,46
Paraná	766,4	6,66
Pernambuco	563,1	4,89
Bahia	513,1	4,46
Goiás	453,1	3,94
Rio Grande do Sul	456,1	3,96
Santa Catarina	479,0	4,16
Espírito Santo	259,9	2,26
Mato Grosso do Sul	258,7	2,25
Mato Grosso	209,8	1,82
Paraíba	183,3	1,59
Distrito Federal	182,5	1,59
Ceará	159,7	1,39
Pará	139,8	1,21
Maranhão	136,3	1,18
Rio Grande do Norte	133,1	1,16
Sergipe	115,1	1,00
Tocantins	114,8	1,00
Alagoas	86,5	0,75
Amazonas	59,6	0,52
Roraima	56,8	0,49
Acre	24,9	0,22
Piauí	22,8	0,20
Rondônia	12,4	0,11
Amapá	0,00	0,00
Brasil	11.511,0	100,00



SNIS, 2016

MAIN RISKS & CHALLENGES to SANITATION PROGRESS

MAIN RISKS & CHALLENGES to SANITATION PROGRESS

- **Loss of revenue**
- **Funding for investments**
- **Feasibility and profitability from investments**
- **Maintenance of concession contracts**
- **Financial imbalance in concession contracts**
- **Improperly strategic planning**
- **Difficulties to carry out the investment planning**
- **Obsolescence of asset base, technologies and facilities**
- **Low attractiveness for invertors**
- **Relationships with others institutions**

MAIN RISKS & CHALLENGES to SANITATION PROGRESS

- Improperly organizational structure
- Political influence
- Failure in quality of customer service
- Improvements in media
- Corporate image and reputation
- Accidents at work
- Comply with environmental legislation
- Balance between environmental requirements x investment capacity
- Failure in identifying risks associated with all process
- Failure in development and training of human resources
- Low performance of employees

PIPES MANAGEMENT CHALLENGES

- **Injuries in sewer system**
- **Irregular connections;**
- **discharge of no municipal sewage;**
- **solid waste at pipe system (*clothes, comdons, diapers, stones, fat, PET, etc...)***
- **Infiltration of rainwater**
- **Overbooking of WWTP**
- **Low capacity of depuration of rivers → requiring of more complex and expensive solutions;**

FENAJ/2128 Mato Grosso - *Sábado, 28 de março de 2015*
"work at night"

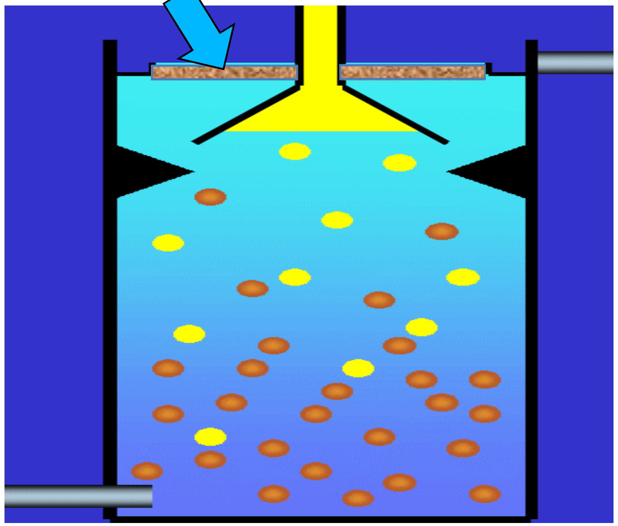
Typical ANAEROBIC Process UASB

Without power input

BIOGAS CONVERTION
gaseous phase

BIOGAS CH_4 H_2S

SCUM



EFFLUENT

POST- TREATMENT

INFLUENT

ORGANIC MATTER
liquid phase

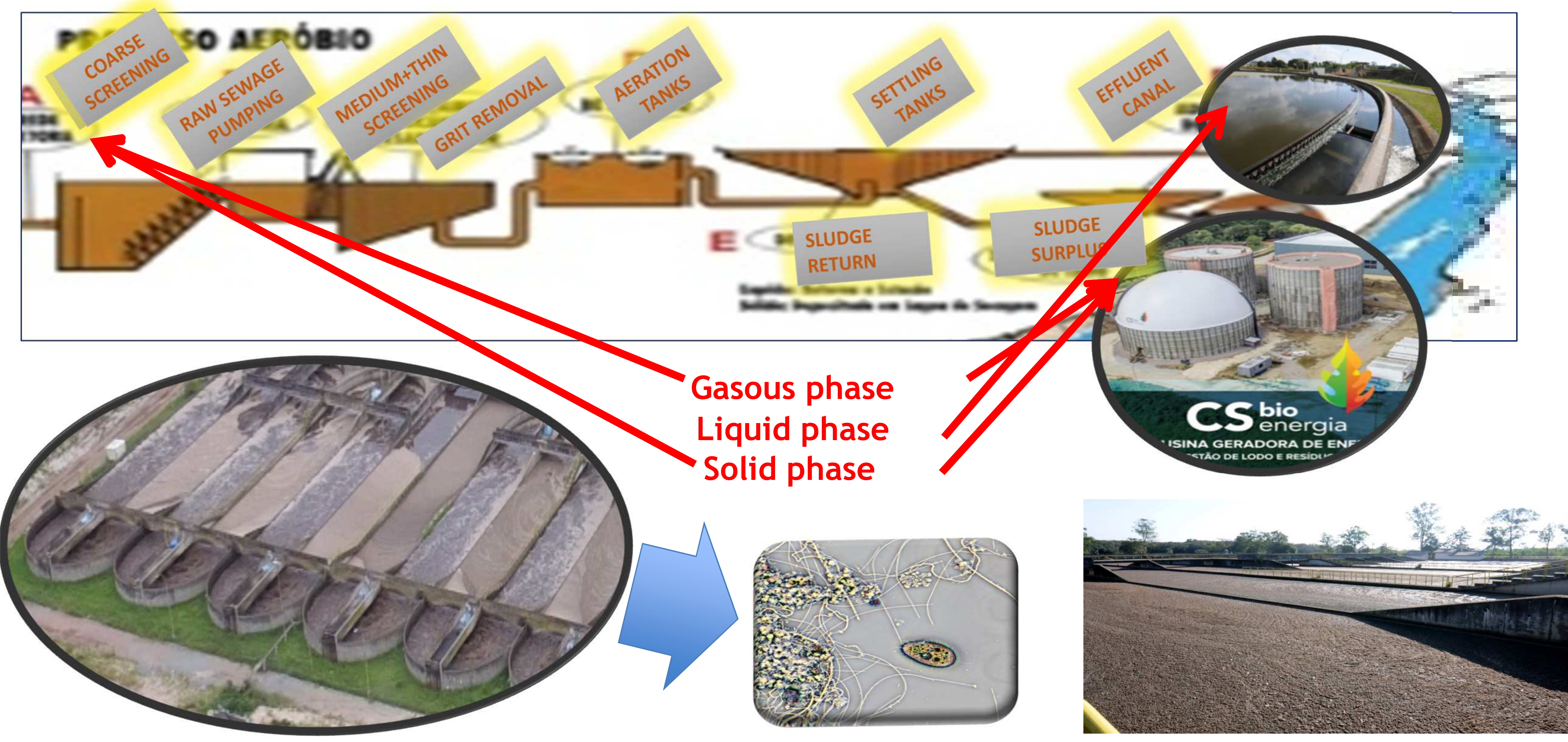
SLUDGE
solid phase

SLUDGE

Typical ANAEROBIC – UASB → *WWTP CIC-Xisto - Curitiba - PR*

490 L/s   79% BOD   300 t sand   340 t waste   3400 t sludge

Typical Aerobic - Activated Sludge → WWTP Belém - Curitiba PR



Typical Aerobic - Activated Sludge → WWTP Belém - Curitiba PR

THE LIQUID PHASE→ EFFLUENT

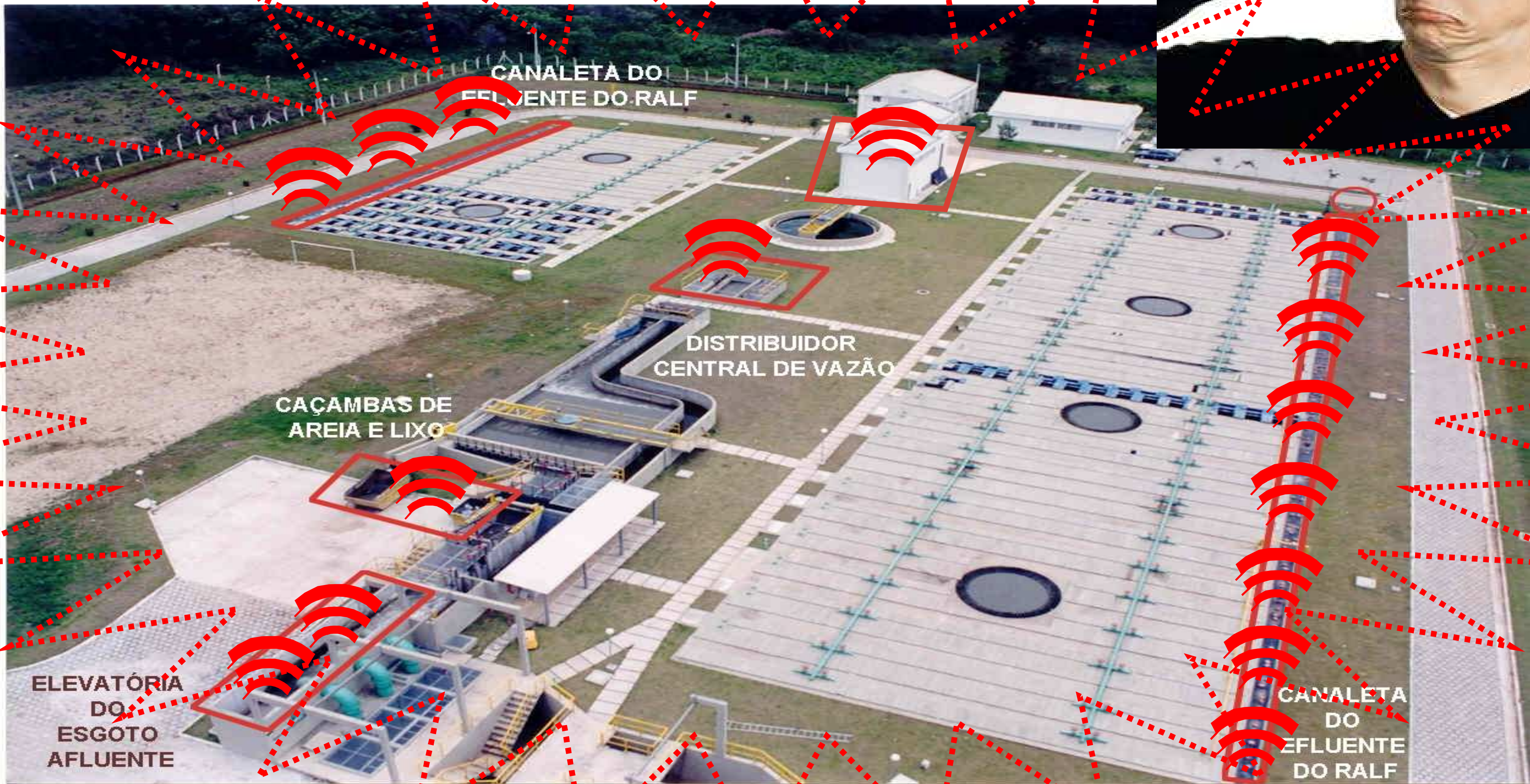
BRAZILIAN LEGISLATION 357/2005

Categoria	Parâmetro	Unidade	Águas doces			
			1	2	3	4
Físicos	Cor	mgPt-Co/l	nível natur.	75	75	-
	Turbidez	UNT	40	100	100	-
	Sólidos dissolvidos totais	mg/l	500	500	500	-
Biológicos	Coliformes totais	org/100ml	1000	5000	20000	-
	Coliformes termotolerantes	org/100ml	200	1000	4000	-
Químicos	DBO_5	mg/l	3	5	10	-
	OD	mg/l	≥6	≥5	≥4	≥2
	pH	-	6,0 a 9,0	6,0 a 9,0	6,0 a 9,0	6 a 9
Subst.pot.prejud.	Amônia não ionizável	$mgNH_3/l$	0,02	0,02	-	-
	Amônia total	mgN/l	-	-	1,0	-
	Nitrato	mgN/l	10	10	10	-
	Nitrito	mgN/l	1,0	1,0	1,0	-
	Fosfato total	mgP/l	0,025	0,025	0,025	-

≅ 90 parameters

THE GASOUS PHASE→ BIOGAS (H_2S + NH_3)

Main emission points



THE SOLID PHASE→ SLUDGE

CHALLENGES

- **Infrastructure**: equipments and utilities
- **Area**: demands large areas to management and storage
- **Odor**: “control” of emissions
- **Monitoring**: labs for quality coontrol
- **Profile**: chemical, biological e physical features for management
- **Legislation**: comply standards and monitoring

THE SOLID PHASE → SCUM

CHALLENGES

- **Removal:** alternative methods and enhancements to removal from reactors UASB
- **Reduction:** dropping of volume for easier disposal (screening, fat interceptors, enzymes)
- **Disposal:** technologies for better recovering (biomass, fuel)

CALORIC VALUES

Sampling	GCV (kJ/kg)	LCV (kJ/kg)
WWTP Atuba Sul	2,470	1,884
WWTP Padilha Sul	2,522	1,700
Pipelines	2,671	2,029

WASTEWATER TREATMENT LEVELS

Preliminary Treatment
Screening and Grit Removal

Coarse Materials and Organic Matter REMOVAL

Primary Treatment
Sedimentation Tanks

Suspended Solids REMOVAL

Secondary Treatment
Activated Sludge
UASB - Ponds
Trickling filters

Organic Matter REMOVAL

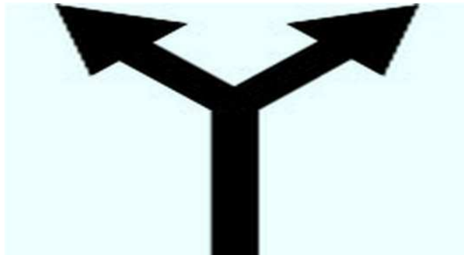
BRAZIL

Tertiary Treatment
Physical
Chemical
Biological

DISINFECTION
Solids and Nutrients REMOVAL

Advanced Treatment
Physical
Chemical

Micropolutants REMOVAL

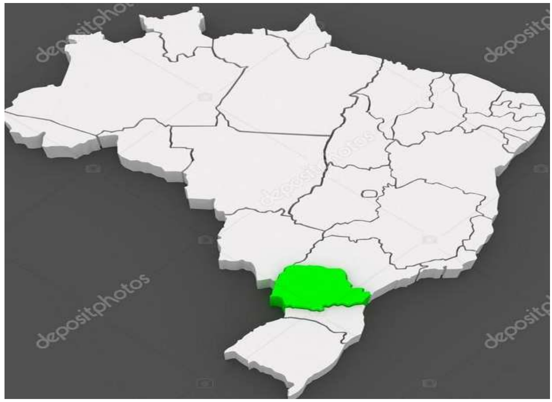


EC

I.R.E.D.

THE ROLE OF SCIENCE, TECHNOLOGY AND INNOVATION IN THE SANITATION CHALLENGES

→ Parana State Experience



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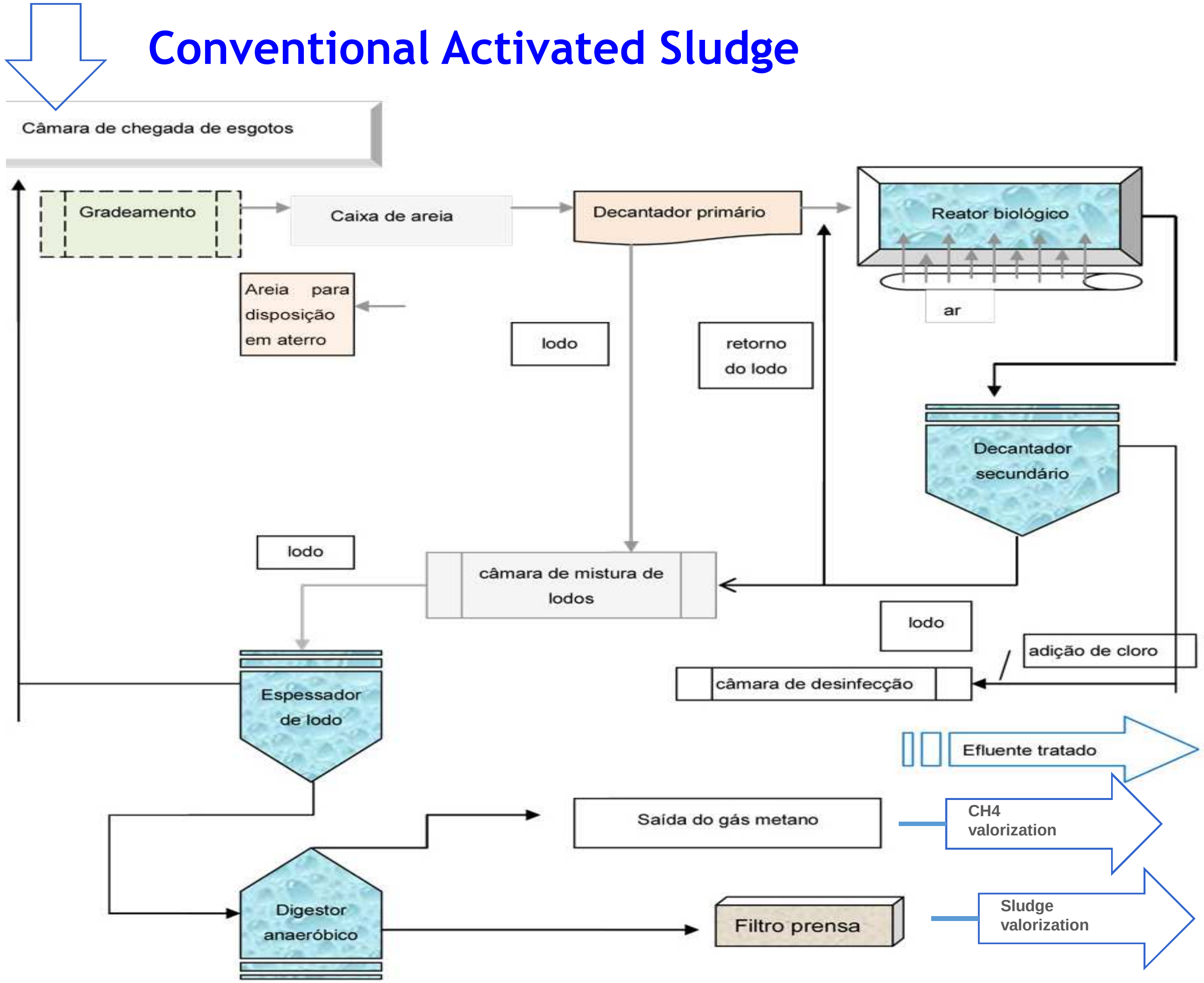
Conventional Activated Sludge



All next big plants in the Parana State will use aerobic way (Master Plan)

→More robustness and efficiency
→Operational safety
→ Less odor

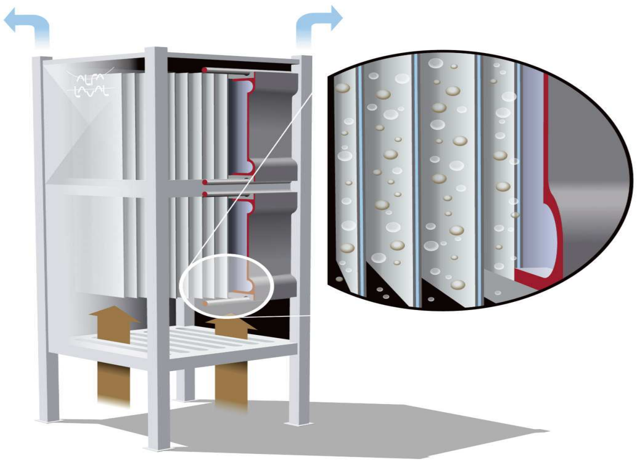
EFFLUENT

Membrane bioreactor (MBR) → post treatment and reuse

The project assess the technical, financial and operational aspects of submerged MBR in anaerobic reactors – UASB as post-treatment.

→ Sewage Reuse and improve effluent quality

Mobile modules



Parede plana – Alfa Laval

Hollow fiber – PAM

Fibra oca – KOCH

Tubular – C-MEM

*** Fellow: UNAM - Mexico University**

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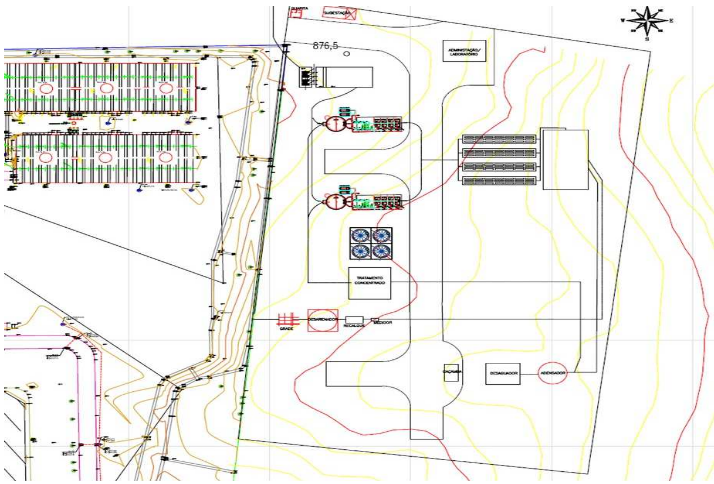
PROJECT OF REUSE
Sustainable solution for supplying of industrial water

Actived sludge + MBR + RO



ODOR

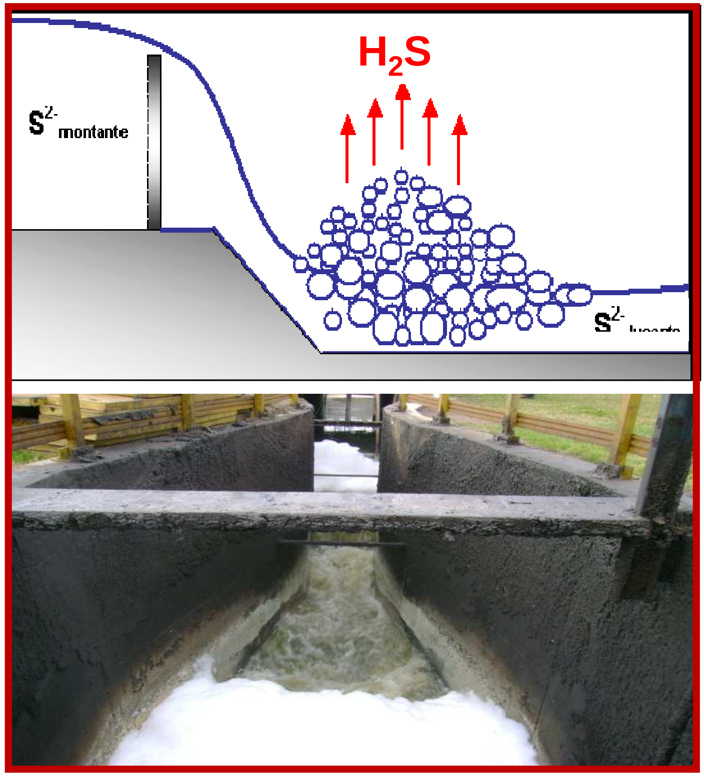
EFFECTS OF SULFUR GAS IN HUMAN BEINGS

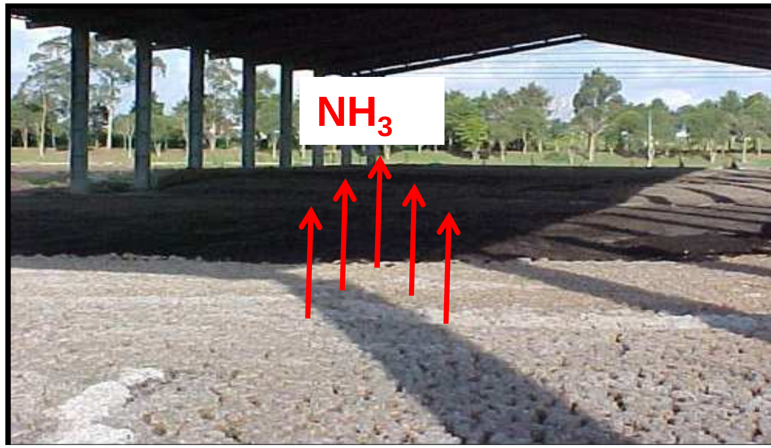
[ ] H_2S (ppm)	EFEITO
0,0005	Pode ser detectável por pessoas
0,001	Detectável por aparelhos de alta precisão
0,3	Detectável pela maioria das pessoas
3 - 5	Odor ofensivo
10 - 20	Olhos e garganta irritados, dor de cabeça, náusea
50 - 100	Danos nos olhos, garganta e pulmões, é possível respirar por alguns minutos
150 - 250	Perda de olfato após 2 a 5 minutos, dificuldade respiratória
530 - 1000	Perda da consciência, possível morte em 30 min a 1 hora
1000 - 2000	Inconsciência instantânea, parada respiratória e morte em minutos

OMS, 1981; Savolainen, 1982

Team ODOR
→ What is it and why?

Special Group with aim of reducing and controling the generation of bad odors in WWTP





EXEMPLE of ACTION PLAN – WWTP ETE CIC XISTO:

USEG - PLANO DE AÇÃO PARA MAUS ODORES - CIC XISTO - atualizado 27/03/2017

Nº	ORIGEM DOS ODORES	SOLUCAO POSSIVEL	Melhorias op. / Obras	Situação	Prazo resultado	Data	Responsável	Co-responsável	VALOR	COMENTÁRIO
1	Efluente anaeróbio na saída da lagoa.	Dosagem de peróxido no efluente	Ajuste Operacional	Concluído	Curto	jan/17	Leni	Eduardo	84.000,00	Provisória, pode não ser necessária caso outros planos de ação resultem em bons resultados. Valor mensal do total aplicado na ETE.
2	Vazamento de gases na caixa de distribuição da lagoa e superfície dos RALF's	Dosagem de peróxido nas canaletas dos RALF's. Revisar os pontos de dosagem.	Ajuste Operacional	Concluído	Curto	jan/17	Leni	Eduardo	110.000,00	Reduz a emissão, mas não de forma completa, pois a reação cessa após S ~ 1-2 mg/L, e nos RALF's ainda sobra a perda nos vertedores
3	Vazamento de gases na caixa de distribuição da lagoa e PV's da saída da lagoa.	Fechamento da caixa de distribuição e reformar e isolar os PV's.	Obra	Orçamentação	Curto	12/17	Cesar	Jeferson	100.000,00	A CDV poderia ser fechada de forma permanente, desde que mantendo um ponto de coleta e desistíssemos da possibilidade de manobras. Caso fosse para manter manobra, teríamos que fazer exaustão e tratamento (e proteção da estrutura). Deixar uma espera em Ino
4	Cananetas abertas na superfície dos reatores	Dimensionar o sistema e orçar o afogamento da linha 1, fechamento das canaletas principais com exaustão e tratamento do gás.	Obra	Indefinido	Médio	06/2017	Eliane Lenz	Cesar	500.000,00	Não seria a solução completa, mas reduziria a emissão de gases pela superfície do reator até termos uma solução para poder realizar o fechamento.
5	Queima ineficiente do biogás	Reforma da linha de gás e queima de alta eficiência	Obra	Em andamento	Médio	12/17	Eliane Lenz	Cesar	700.000,00	
6	Movimentação de lodo caleado	Fechamento para receber o secador de lodo.	Obra	Indefinido	Longo	12/18	Cesar	Eduardo	500.000,00	Avaliar os custo da aeração para realizar esta obra.
7	Movimentação de lodo caleado e queima ineficiente do biogás	Instalação de secador de lodo com aproveitamento do biogás e do lodo seco	Obra	Indefinido	Longo	dez/24	Cesar	Cleverson	Indefinido.	Previsto no projeto de ampliação da ETE.
8	Odor no tratamento preliminar	Instalação de placas de abafamento.	Obra	Indefinido	Médio	03/17	Leni	Eduardo	50.000,00	Menor dos problemas, pode ficar como ultima atividade, mas é até simples, pois não necessita de fechamento hermético. Podem ser somente estruturas de abafamento. Proxima reunião definir responssável.
9	Falha na Cortina Verde	Fiscalizar a manutenção (cuidado na roçada), instalar a sistema de proteção das mudas (garrafa PET ou tub), aplicação de lodo, regar com efluente tratado.	Ajuste Operacional	Em andamento	Longo	12/22	Ana Leticia	Operadores da ETE	Não há	Entre o RALF e o muro de divisa não é possível o desenvolvimento da cortina, estudar uma outra solução.
10	Transporte do Lodo	Limitação do horário, rotas com menos impacto da vizinhança.	Ajuste Operacional	Concluído	Curto	jan/17	Leni	Eduardo	Não há	
11	Ponto de coleta e medição de lodo no reator	Isolar e permitir operação dos pontos	Ajuste Operacional	Indefinido	Curto	03/17	Diego	Eduardo	Não há	Foi realizado um protótipo para aplicar nas outra ETE's.
12	Odor na Lagoa e no efluente.	Aeração da lagoa	Obra	Indefinido	Longo	12/18	Cesar	Carla	9.900.000,00	Aguardando a aprovação de recursos, para a execução desta obra deverá ser retirado o lodo pela USEG.
13	Vazamento de gases na superfície dos reatores	Instalação de cortinas defletoras no RALF05 e 07.	Ajuste Operacional	Concluído	Curto	02/17	Cesar	Caetano	400.000,00	

MEETINGS WITH NEIGHBORHOOD – WWTP ETE CIC XISTO

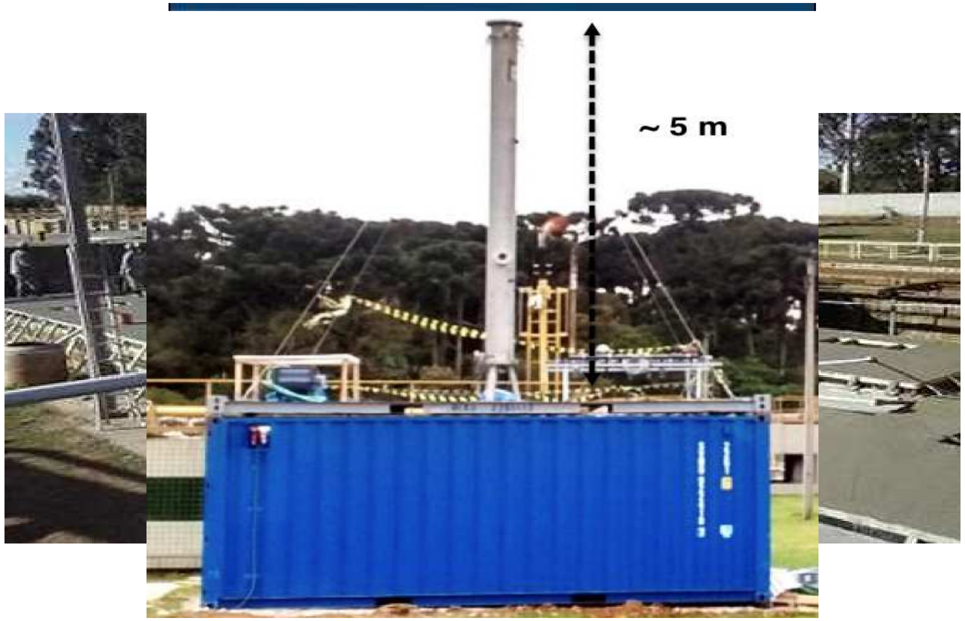
EXTREMELY IMPORTANT !!

→RELATIONSHIP IS A KEY POINT

→NEIGHBOURS HAVE TO KNOW WHAT HAPPEN INSIDE THE WALLS

MORE SOME TECHNOLOGICAL INNOVATIONS …

→ ODOR CONTROL



- **Aeration of ponds → Bio-dome**
- **Dimer → destruction of H_2S**
- **New products (oxismell, geocalcio)**
- **Covering of reactors → hydrostatic removal of scum**
- **Burners with high efficiency**
- **Enhancements in shelterbelts**

Sludge Composition

Source of several Nutrients and Organic Matter

Neutralization of acidity and Hygienization: when CaO is used (50% DM)

N P K Ca Mg S OM

Cl Cu V Co Cr

Fe Mo B Si Al Pb

Mn Zn Ni Cd

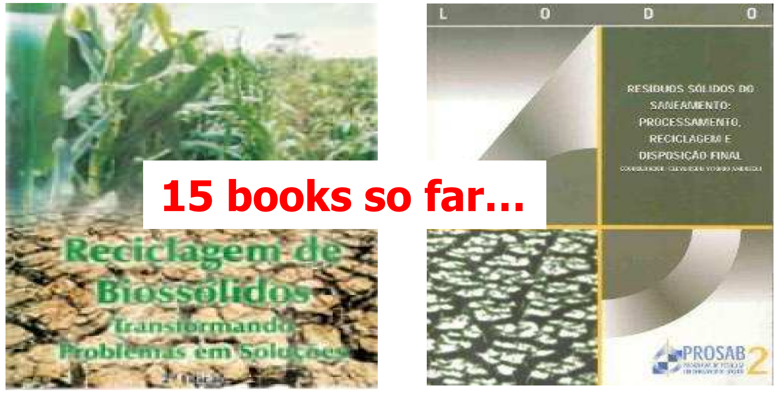
Agriculture Disposal of Sludge in Paraná State - BRAZIL

1990 – Starting – 1º Interdisciplinary Research Program

+ de 200 researchers- 27 Institutions - 10 Brazilian States

1994 – 1º Pilot Scale

1999 - Large Scale



2007 - All main cities in Paraná State

2007 - Award Finep of Technological Innovation

2016 - Publication UN Recommendation as "Good Practicing"

Sewage sludge and scum drying and incineration
→ for large-sized WWTP

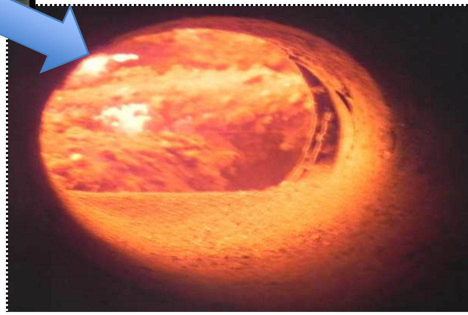
Disposal/Use of sewage sludge, biogas and scum !

BIOGAS
(65-80% CH_4)

100 Kg
WET SLUDGE
(TS ~ 18 %)

DRY SLUDGE
(TS ~ 88 %)

INCINERATION
6-8 Kg ASH
(TS ~ 88 %)



→ UNDER CONSTRUCTION

INDUSTRIAL SITE:

WWTP BELEM +

CSBIOENERGIA

→ Treatment (anaerobic) of sewage sludge + organic waste (1000 t) with power generation (2.8 MW → 3.6 MW)

Final Remarks

C.I.R.E.D.

- Sanitation is expensive (projects and construction)
- Investments are poor than necessity and improperly managed
- Protection of aquatic ecosystems
- High level standards (targets above of real reaching)
- Households are not aware to pay by high level treatment technologies
- Unawareness about collective environmental responsibility

OBRIGADO !

Charles Carneiro

Companhia de Saneamento do Paraná – SANEPAR

Instituto Superior de Economia e Administração – ISAE / FGV

E-mail: charlesc@sanepar.com.br

Panel 2 – Contributions of Science, Technology and Innovation (STI) to cope with water crisis

Contributions of STI to cope with water crisis: the case of Brazil

Prof. Dr. Antonio Eduardo Lanna

Brazilian Water Resources Consultant

Contributions of STI to cope with water crisis / Extreme events: the case of the E.U

Prof. Dr. Olli-Matti Verta

Finnish Ministry of Agriculture and Forestry

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Contributions of STI to cope with water crisis: the case of Brazil

A. Eduardo Lanna
Water resources consultant

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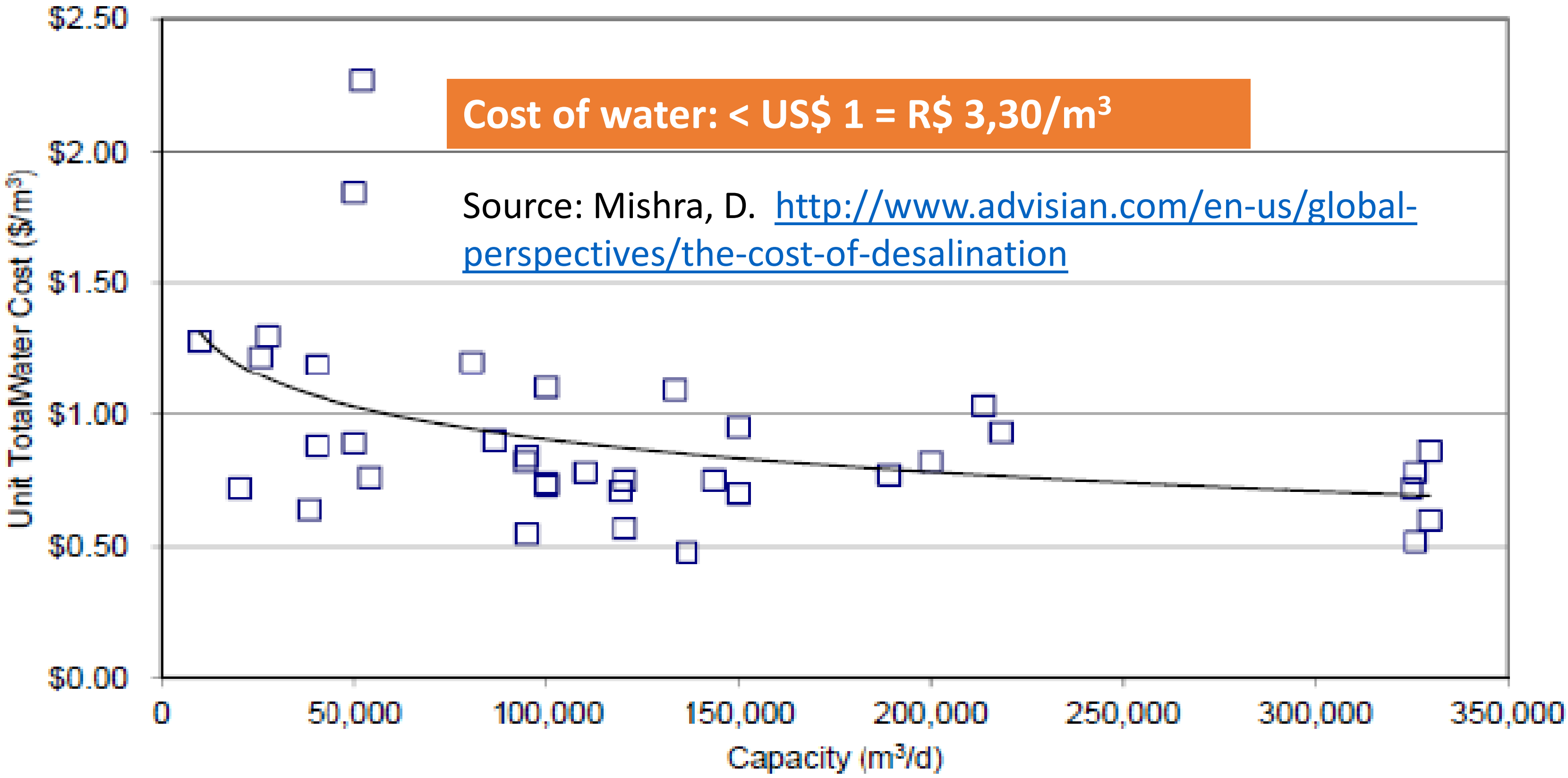
Brazil's water quantity crisis: urban areas

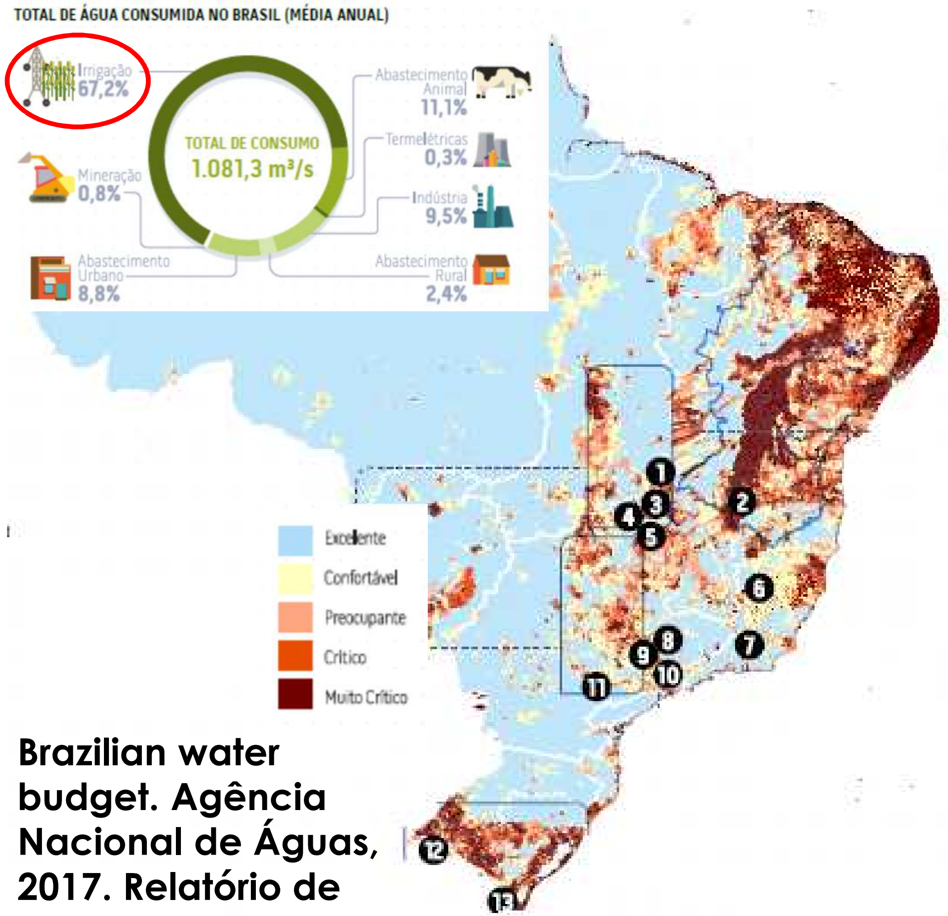
- **Water quantity:**
  1. State Capitals by the Ocean
  2. State Capitals not by the Ocean

- **Contributions of STI:**
  1. Water desalination!
     - STI: develop efficient methods (now, <US$ 1/m^3);
  2. Increase water efficiency!
     - STI: 1) irrigation methods, 2) reduce losses (~40%) in urban distribution systems, 3) reuse of water and 4) use of sewage waters;
  3. Water transfers!

Cost of water in reverse osmosis desalination plant



Brazil's water quantity crisis: urban and rural areas



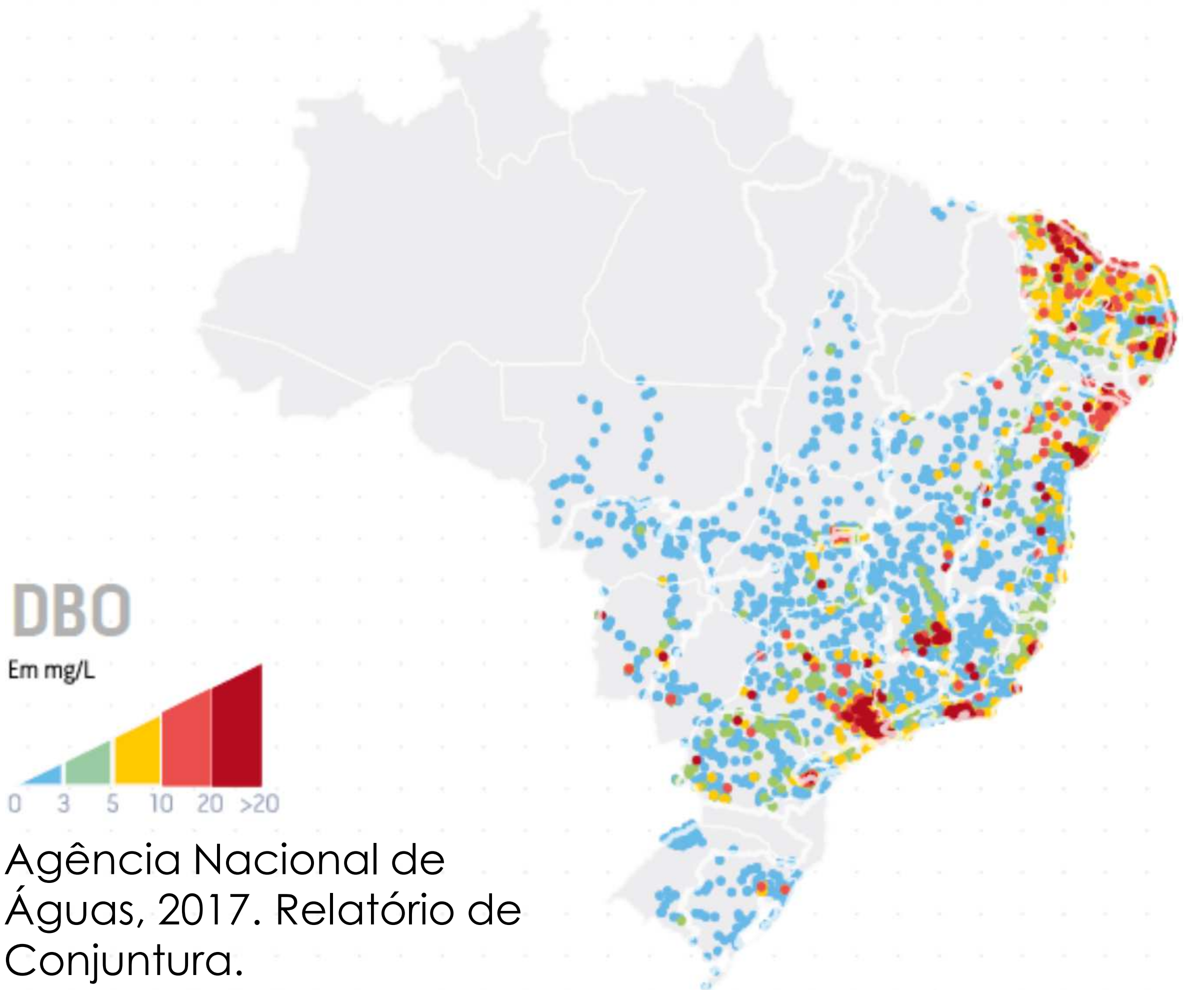
Brazilian water budget. Agência Nacional de Águas, 2017. Relatório de Conjuntura.

Water budget problems due to irrigation in all region, but:

1. Region 10 (Piracicaba, Capivari and Jundiaí basin): urban demand (including São Paulo City) and
2. Northeast region: lack of rain associated with irrigation and urban demands.

- **Contributions of STI:**
  - water efficient irrigations methods – reducing 30% of irrigation water demand > urban + industrial demands;
  - use of treated sewage water for irrigation and industry.

Brazil's water quality crisis: organic pollution



Agência Nacional de Águas, 2017. Relatório de Conjuntura.

- **Water quality:**
  - 3rd Word Pollution: organic pollution due to the lack of collecting and treating urban sewages.
- **Contributions of STI :**
  1. Low cost sewage treatment for small communities;
  2. Advanced drinking water treatment to eliminate dangerous substances, odors and taste.

Brazil’s water quality crisis: accidental minning pollution





- ❑ **Water quality:**
  - ❑3rd Word Accidental Pollution: mining.
- ❑ **Contributions of STI :**
  1. Geophysical and structural methods to evaluate mining tailing dam colapse risks;
  2. Disaster Awareness and Preparedness Strategy for potential affected areas;
  3. Early alert in case of accidents.

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Contributions of STI to cope with Water crisis / Extreme events: the case of the EU

Olli-Matti Verta, Ministerial Adviser

Ministry of Agriculture and Forestry, Finland

Index

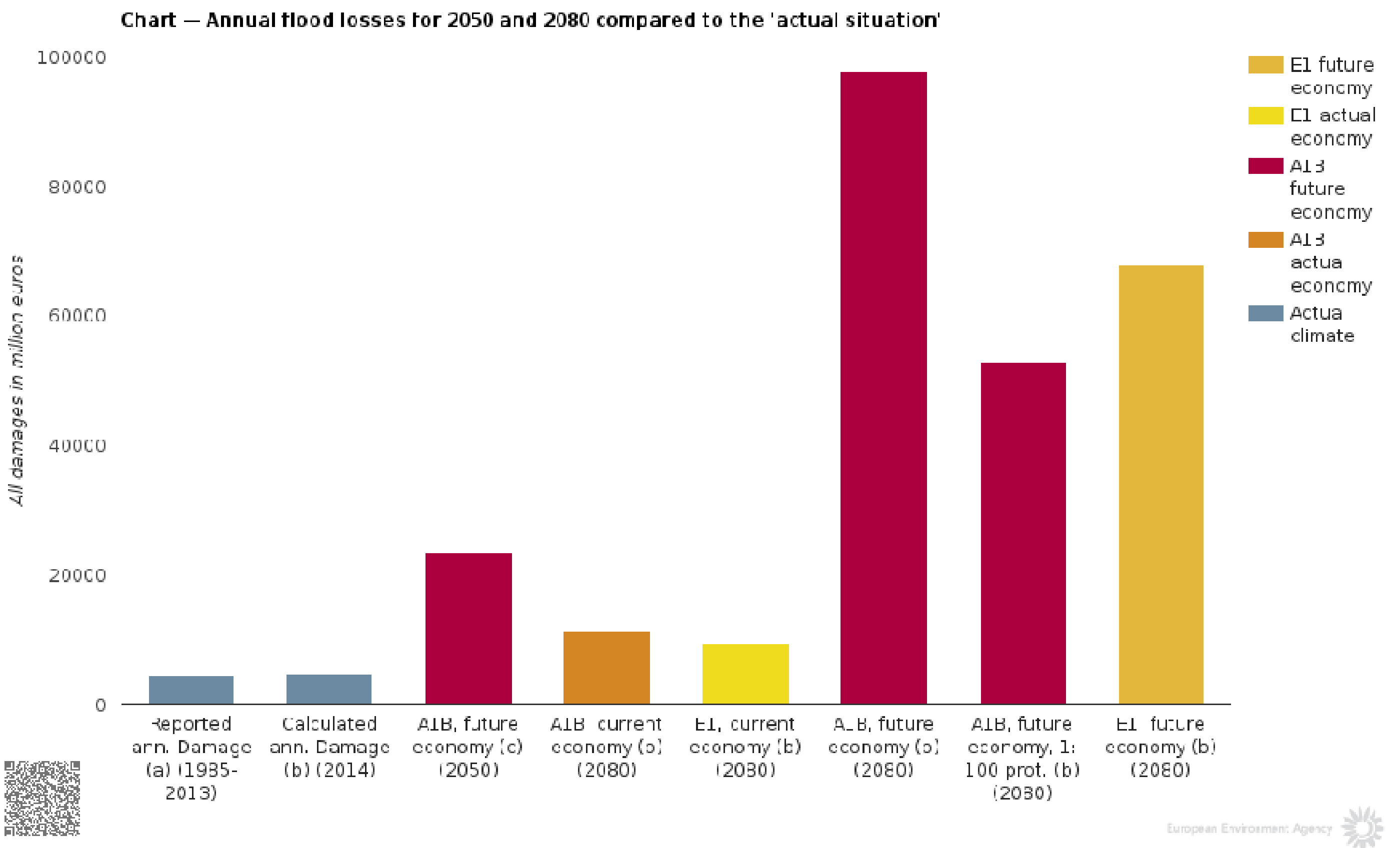
1. **Water Crisis / Extreme Events in EU**
2. **Key Strategies for Research & Innovation in Europe to cope with Water Crisis**

1.Water Crisis / Extreme Events in EU

Water Crisis / Extreme Events in EU

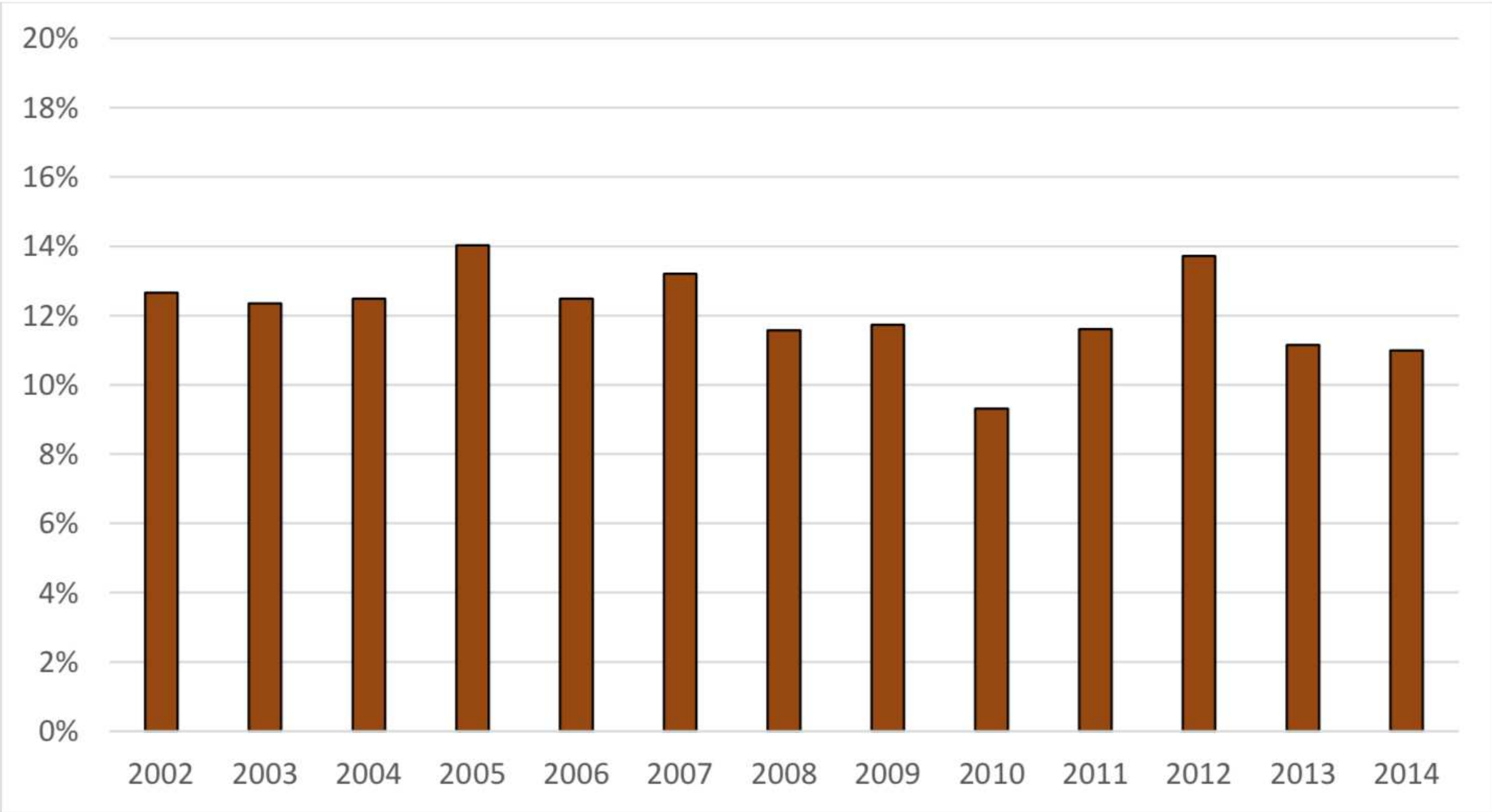
- Increasing Flood Risks
- Water Scarcity
- Droughts
- Loss of Biodiversity and Ecosystem Services
- Climate change is expected to aggravate the problems

Increasing Flood Risks in the EU



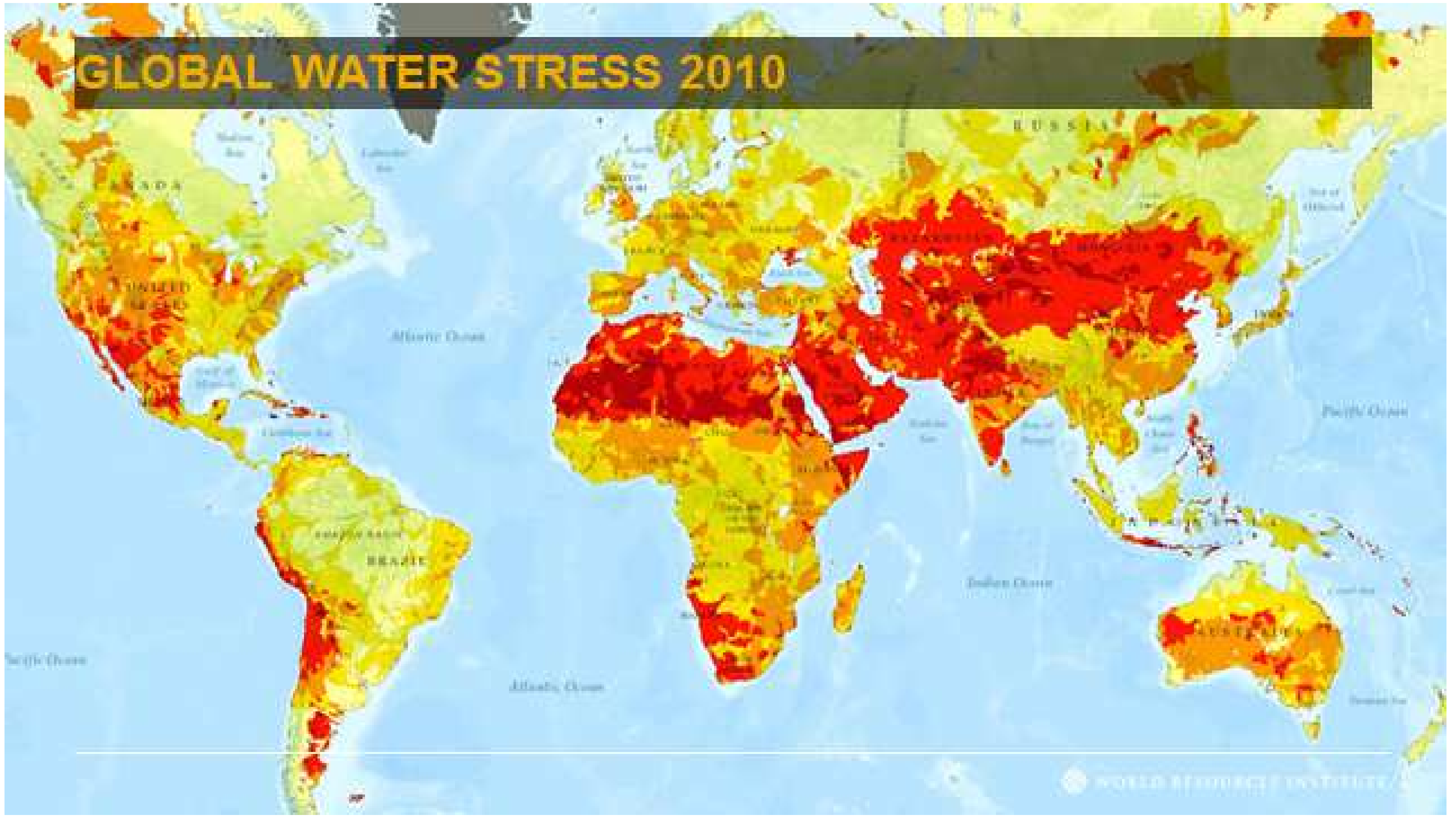
Source: European Environment Agency (EEA)

Water Stressed Area in the EU (WEI+)



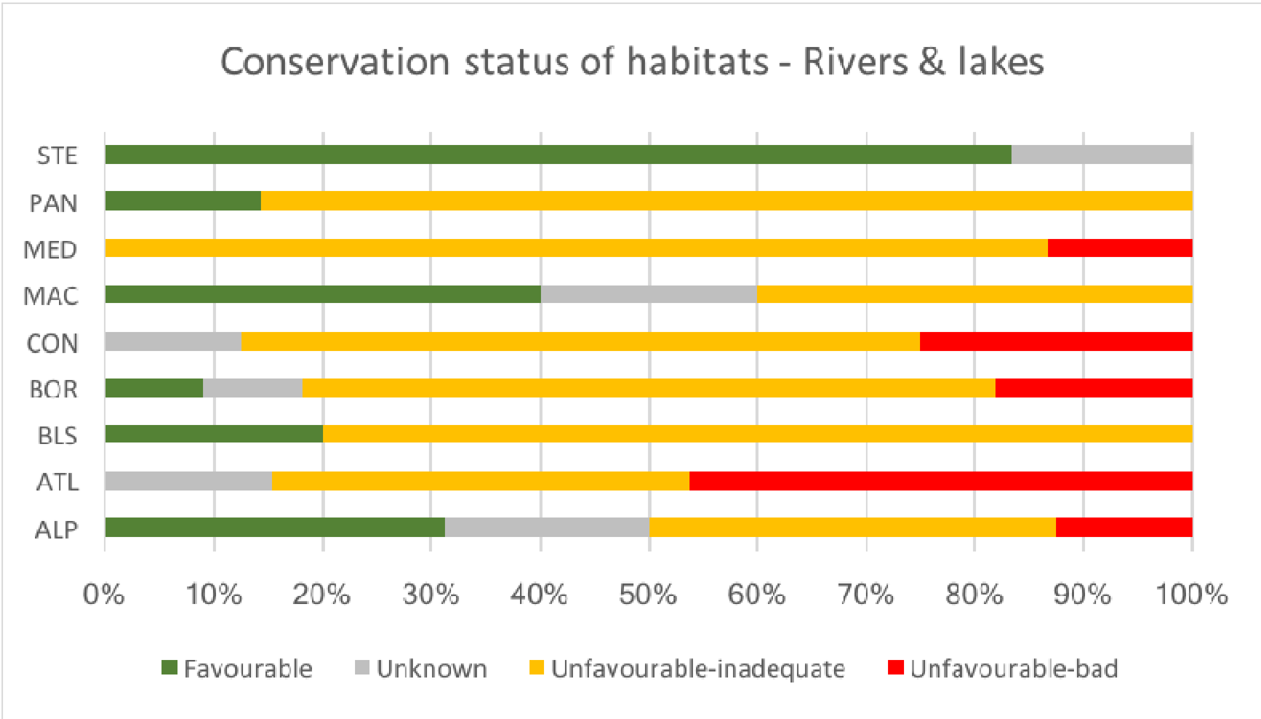
Source: European Environment Agency (EEA)

Global Water Stress



Source: World Resources Institute

River and Lake Habitats in the EU



Source: European Environment Agency (EEA)

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2. Key Strategies for Research & Innovation in Europe to cope with Water Crisis

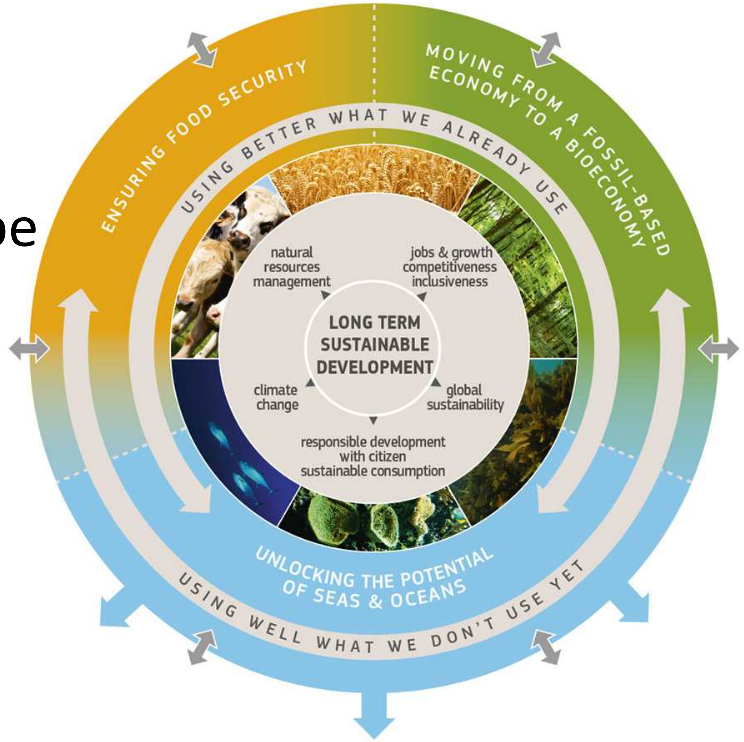
- Europe's Bioeconomy Strategy
- EU Funding Programmes Supporting R&I
- European Investment Bank
- Business & Innovation Organizations

Europe’s Bioeconomy Strategy

- Addresses the production of renewable biological resources and their conversion into vital products and bio-energy (adopted on February 2012)
- It is structured around three pillars:
  - Investments in research, innovation and skills;
  - Reinforced policy interaction and stakeholder engagement;
  - Enhancement of markets and competitiveness.
- The Strategy proposes answers to the challenges Europe

and the world are facing:

  - increasing populations that must be fed
  - depletion of natural resources
  - impacts of ever increasing environmental pressures
  - climate change



Europe’s Bioeconomy Strategy

- Reviewed 2017
  - R&I Investments doubled from FP7 to Horizon2020
  - New policy context highlights the need for a sustainable, *circular bioeconomy*
- Under consultation, to be updated 2018
- Some considerations
  - Freshwater sources should be more recognized as part of the “blue” Bioeconomy
  - More focus should be given to applied research and near-to-market activities – support the development of new technologies and innovations as part of circular bioeconomy

Key EU Funding Programmes Supporting R&I

- Horizon 2020 – the biggest EU R&I programme
- The next EU Framework Programme (after 2020)
- *Water JPI – Water Challenges for a Changing World*

- Environment and Climate action (LIFE) - supporting environmental, nature conservation and climate action projects
- European Structural and Investment Funds
  - European regional development fund (ERDF)
  - European social fund (ESF)
  - Cohesion fund (CF)
  - European agricultural fund for rural development (EAFRD)
  - European maritime and fisheries fund (EMFF)

Horizon 2020

- Horizon 2020 is the biggest EU Research and Innovation programme ever with nearly €80 billion of funding available over 7 years (2014 to 2020)
  - Strong participation of SME's
  - International cooperation is crucial
- Tackling 7 Social Challenges including: Climate Action, Environment, Resource Efficiency and Raw Materials
  - to achieve a resource – and water - efficient and climate change resilient economy and society,
  - the protection and sustainable management of natural resources and ecosystems, and
  - a sustainable supply and use of raw materials

The next EU Framework Programme

- A new, modern Multiannual Financial Framework for a European Union that delivers efficiently on its priorities post-2020

“Two years after the Paris Agreement, the EU also needs to remain firmly in the lead in **fighting climate change** and ensuring a smooth transition towards a **modern, clean and circular economy**. The experience with climate mainstreaming should be taken into account. The EU must also make good on its **commitment to the United Nations Sustainable Development Goals**.”

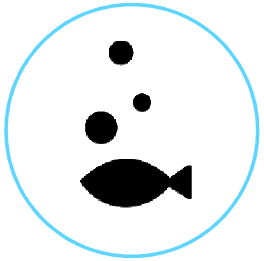
COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE EUROPEAN COUNCIL AND THE COUNCIL 14.2.2018

Water JPI –
Water Challenges for a Changing World

- Grand Challenge: ”Achieving sustainable water systems for a sustainable economy in Europe and abroad”
- Funds ca 500 million €/year - European countries invest 370 million €, the European Commission invests 130 million €
- Strategic Research and Innovation Agenda
  1. Maintaining Ecosystem Sustainability
  2. Developing safe water systems for the citizens
  3. Promoting competitiveness in the water industry
  4. Implementing a water-wise bio-based economy
  5. Closing the water cycle gap

European Investment Bank – Strenghtening water Security

One of the largest lenders to the global water sector to date with more than EUR 64 billion supporting over 1400 projects

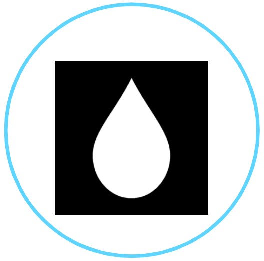


- **Integrated Water Resources Management (IWRM) – priority to nature-based solutions**

  covering e.g. flood risk reduction measures, re-use of treated wastewater, water retention and storage, controlling diffuse pollution, restoring and protecting water-related ecosystems, and water and energy efficiency improvements in the basin

- **Industrial Water Management**

  developing, promoting and implementing cost-effective and resource-efficient methods of sourcing, (re-)using and treating water



- **Water Utilities**

  resource-efficient water supply and wastewater treatment facilities

- **Innovation**

  provides support to investments in R&I as well as for the commercialisation and deployment of novel water technologies

Business & Innovation Organizations

European Innovation Partnership on Water (EIP Water)

- Vision: "To stimulate creative and innovative solutions that contribute significantly to tackling water challenges at the European and global level, while stimulating sustainable economic growth and job creation"
- Aim: Identify, test, scale up, disseminate and stimulate the uptake of innovative solutions by the market and society for 10 major water related challenges.
    - incl. e.g. Flood and drought risk management, Water reuse and recycling

Water Supply and Sanitation Technology Platform (WSSTP)

- In order to make the water-smart society emerge, WssTP proposes to focus research, development and innovation investments in Europe on four key impact parameters:
    1. Reducing the impact of Europe's society on our natural water resources by 50%;
    2. Realising the true value of water for our society, the economy, and the environment;
    3. Boosting the European water market as well as global competitiveness of the European water industries;
    4. Securing long term resilience, stability, sustainability, and security of the society with regard to water.

Concluding remarks

- Regardless of Paris Agreement and climate actions, climate change is here and weather extremes are becoming more frequent and severe
- Preparedness and adaptation is important and societies need to be resilient
- To achieve this we need not only research & innovation, but also investments in novel technology and infrastructure as well as adequate insurance policies


THANK YOU
FOR LISTENING!

Panel 3 – Science, Technology and Innovation (STI) tools in water resources management

STI tools in water resources management – the situation in the European Union

Prof. Dr. Bernard Barraqué

Agro Paris Tech, France

Water use conflicts: water for development and human consumption

Prof Dr. Yvonilde Medeiros

Federal University of Bahia

STI tools in water resources management
- the situation in the European Union

Bernard Barraqué, DR CNRS emeritus

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Index

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1. **WFD Challenges for scientific analysis of water resources**
2. **Economic dimension**
3. **Water related economic impact of climate change**

Scientific Challenge with aquatic environment

- The WFD conludes a decade of debates on the ‘combined approach’
- Before, the Commission and member States limited regulation to controlling discharges in water (emissions) with e.g. BAT or BATNEC
- From now on water policies must derive from the recovery of the aquatic environment (immissions) with an obligation of results
- This implies a preliminary analysis of the status of the aquatic environment; most member States discover a serious knowledge gap leading to wrong programs
- E.g. France overestimated the quality of its groundwater, and adopted an unachievable target of 2/3 water bodies in good status in 2015

WFD : new challenge for modelling

C.I.R.E.D.

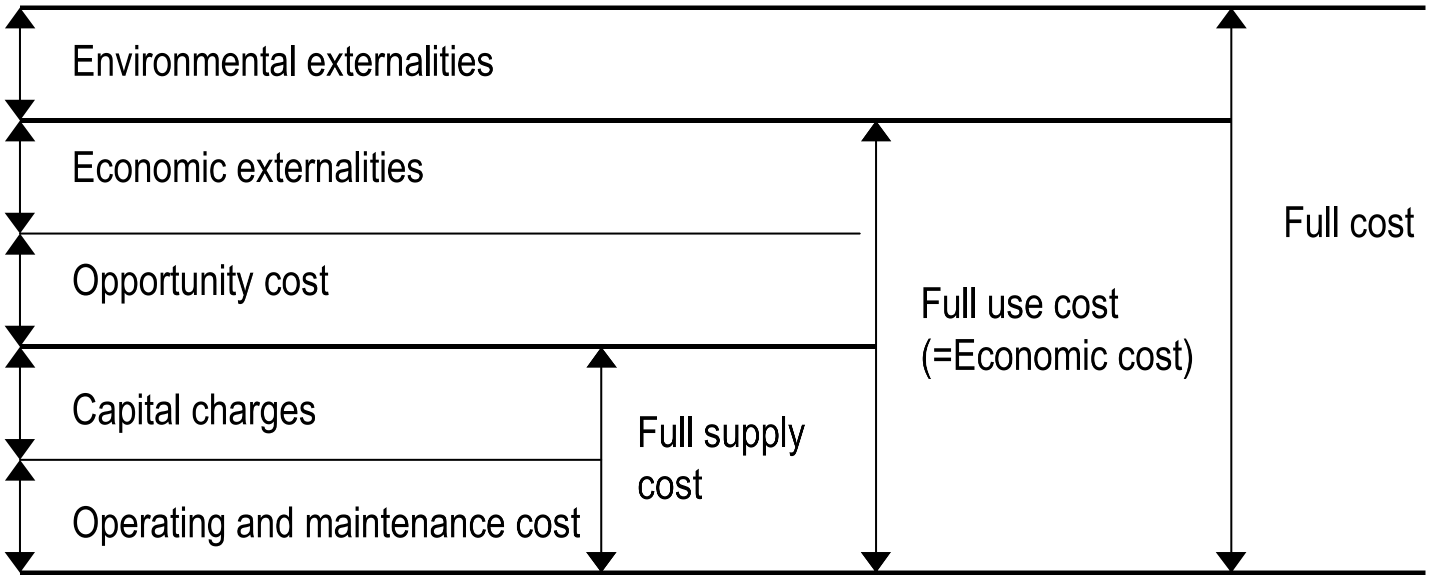
- Scientists and consultants must dramaticlly improve the analysis of water bodies: not only quantitative and qualitative, but also including hydromorphology
- A sensitive problem is to fix the 'state of reference' in a world that has been occupied by mankind for a bimillenium
- They also must dramatically improve the knowledge of the various contributors to the degradation of the environment so as to set them environmental targets
- But they also must present the results in a synthetic and meaningful way for decision makers …

- A lot of books on the back of a donkey don't make a wise ass ! (tribute to Evan Vlachos)

Sustainability and economic analysis

- Article 9 of the EU WFD sets guidelines for establishing water pricing schemes that promote sustainable and efficient water use

- The aim of this is to mainstream a harmonized and functional concept of full cost recovery that internalizes environmental and resource costs (ERC)



(source: Peter Rogers & al, in a GWP-TAC paper, 1998)

Most water users are far from implementing this definition of full cost pricing;
E.g. many utilities still subsidize investments which are then not depreciated.

Efforts made to improve modelling

- At the end of 1990's the Commission's DG Research funded multi-country projects to introduce the economic dimension in the modelling of aquatic environments
- I was involved in Mediterranean side projects like WaterStrategyMan and Aquastress led by my Greek colleague Assimacopoulos
- I remember Panagiotis Balabanis was following these for the commission
- One possibility is to make cost benefit analyses of various solutions after introducing levies according to the Polluter-pays, Abstrator-pays principles
- In France the Agences de l'eau levy a pollution tax , indirectly representing environmental cost ; and an abstraction tax, corresponding to the resource or users' cost

New issue of adaptation to climate change

- In the preparation of COP 21, the World Bank wanted to develop economic evaluations of CC impacts on various issues (cities, transboundary waters allocation, agriculture …)

- A senior water and sanitation specialist asked me and Bruno Tassin (ENPC-LEESU) to draft a review of economic studies made by large cities in the world on:
  - Additional CC economic impacts due to expected water related events (all things equal)
  - Costs of adaptation measures in the water domain, and benefit-cost analyses

- We initially thought there would be few reports, but many studies were drafted in both North and South cities after 2005, and often in the aftermath of an extreme event (typically NYC after Sandy): London, Rotterdam, Copenhagen, Hérault, Barcelona, New York, São Paulo, Mumbai, Kolkata, Bangkok, Manila, Jakarta, Ho Chi Minh, Durban, Jo'burg, Dar-es-Salaam, Mombasa, Alexandria, Tunis, Algiers, Casablanca … wrote reports of various importance

- **Most reports deal with exceptional flooding, eventually on top of sea level rise**

Methodologies and global results

- The worst CC impacts are likely to occur with extreme events taking place in areas affected by long term and insidious water related changes: sea level rise, land subsidence, snowpack decrease
- The first step is to downgrade selected IPCC scenarios at local level and imagine which new events (flash/long term) could occur, and their costs (both direct and indirect)
- An important effort to be developed by the scientific community to reduce the uncertainty of water related climate change predictions, which combines with uncertainty of anthropogenic change
- A 2007 UNFCCC report guestimated the adaptation costs for the sole water supply to urban areas in the world at $11 bn/year until 2030. But this value would come on top of yet existing costs to improve access to water and sanitation in developing countries, which should bring the costs up to $32-40 bn/year.
- Additional cost withadaptation to sea level rise: $12 bn/year (cities and coastal zones in general)

- **The costs appear appalling, i.e. urgency is declared**

Typical content of city studies

C.I.R.E.D.

- After acknowledging the numerous uncertainties, basically the studies cross downgraded CC scenarios at local level with urbanisation prospects plus various adaptation measures. They (ideally) sometimes end with benefit-cost analyses.
- Usually, non structural measures like land use control and early warning systems give the best benefit-cost ratios, but are politically difficult to implement (e.g. relocating people from flood-prone areas)
- Many studies concern cases where CC causes more floods and worst sea surges; almost none in case of droughts (probably because more difficult to assess); in California and Brazil, extreme drought impacts calculations focus on agriculture…
- Only one city has done a drought-related CC impact study with a comparison of adaptation measures: Barcelona

Adaptation to climate change and water resources

- It is more difficult to perform the climate change impact study in the case of droughts than excess water
- For the reason that it is diffcult to assess when a drought has started
- We also must refine the understanding of the phenomena at stake: weaker precipitations with rising droughts are also followed by increased evaporation
- But it is an important challenge: the extreme drought event in São Paulo and Rio de Janeiro area, two of the largest cities in the global south should provide a good case study
- Cities in Europe are concerned too, e.g. Paris …

- Thank you for your attention

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Water use conflicts: water for development and human consumption

Yvonilde Dantas P. Medeiros
Universidade Federal da Bahia – UFBA
Escola Politécnica – Depto de Engenharia Ambiental
yvonilde.medeiros@gmail.com

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Cidade do México, México
Cairo, Egito
Jacarta, Indonésia
Moscou, Rússia
Istambul, Turquia
Londres, Reino Unido
Pequim, China
The biggest cities in the world could be without access to safe drinking water
Tóquio, Japão
Bangalore, Índia
Miami, EUA
São Paulo, Brasil

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Unsustainable development and governmental failures have affected the quality and availabilty of water resources

(UN, 2015)

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Unless the balance between demand and availability is restored, the world will face ever worsening water scarcity

(UN, 2015)

Water scarcity = an excess of water demand over available supply

Physical scarcity

Symptoms are severe environmental degradation, declining groundwater, and water allocations that favour some groups over others (FAO, 2012).

Economic scarcity

Symptoms include scant infrastructure development, so that people have trouble getting enough water for drinking or agriculture (FAO, 2012).

Scarcity is signalled by unsatisfied demand, tensions between users, and insufficient flows to the natural environment (environmental flow).

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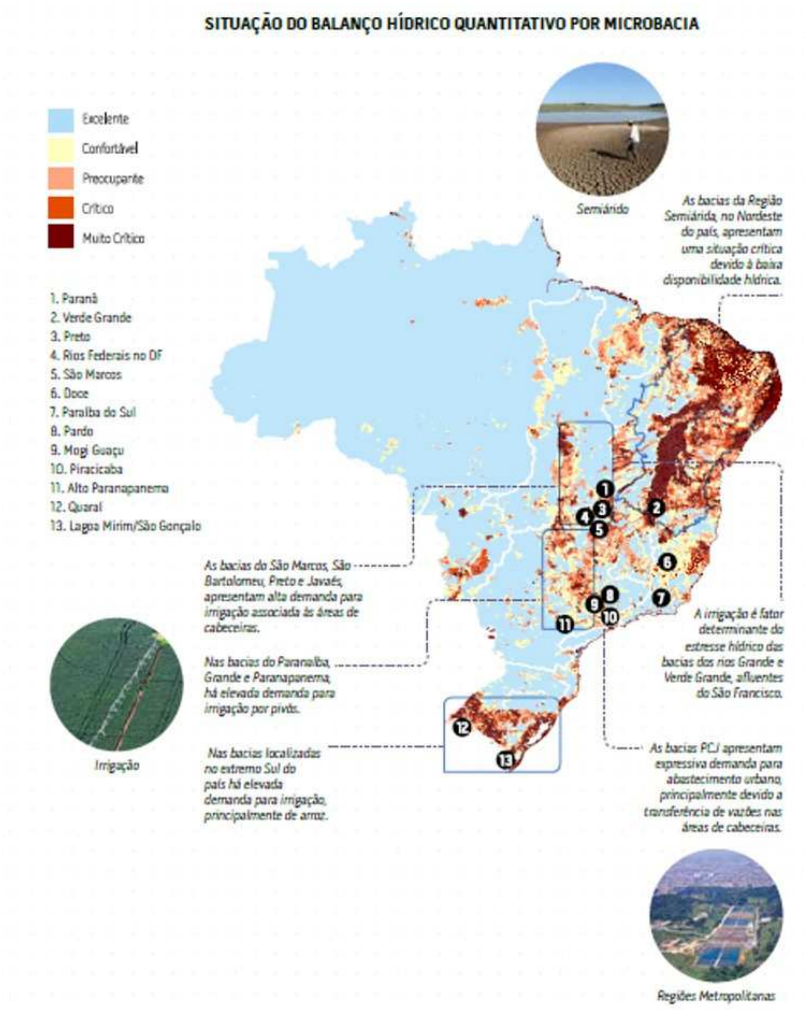
Water use conflicts



Fonte: ANA, 2017

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Droughts observered since 2012 have negatively impacted the supply of water for human consumption and user sectors

Problems associated with low investment in infrastructure have aggravated the situation leading to periods of water crisis due to scarcity

Piancó-Piranhas-Açú River Basin (semi-arid region)

reduced dam volumes (2,9% VU) created risk to public supply, as well as negative economic impacts:

industry ➡ 40% of projected demand not met, accounting for almost half of the economic losses (49%);

livestock watering ➡ 21% of total losses, the second most economically affected use;

irrigation ➡ 20% of demand (the highest of all user sectors) not met, corresponding to 62% of the basin's total water deficit.

Paraíba do Sul River Basin

CHaracterized by conflicts between water users, located between the largest industrial complexes and populations of the country.

In 2014 and 2015 precipitations and flows much lower than average were recorded, significantly reducing the amount of water stored in reservoirs;

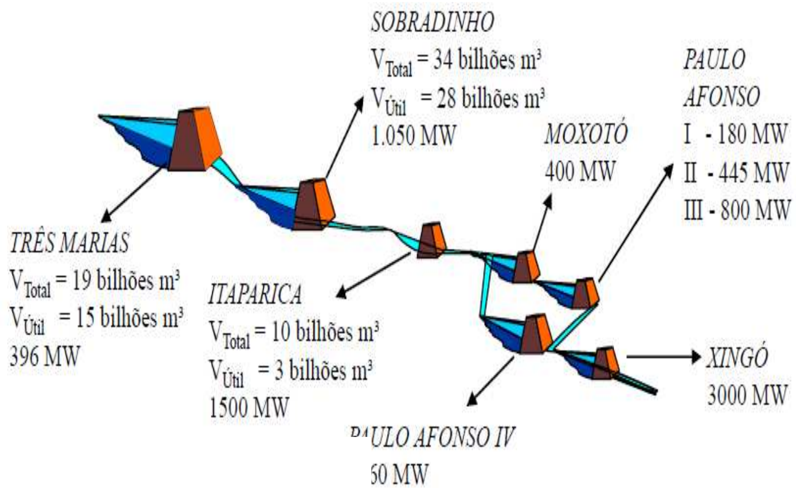
Some reservoirs had to to operate below their minimum operational levels, using **dead storage;**

The "water crisis" impacted the water supply sytems with the highest demand (and the highest GDP) in the region.

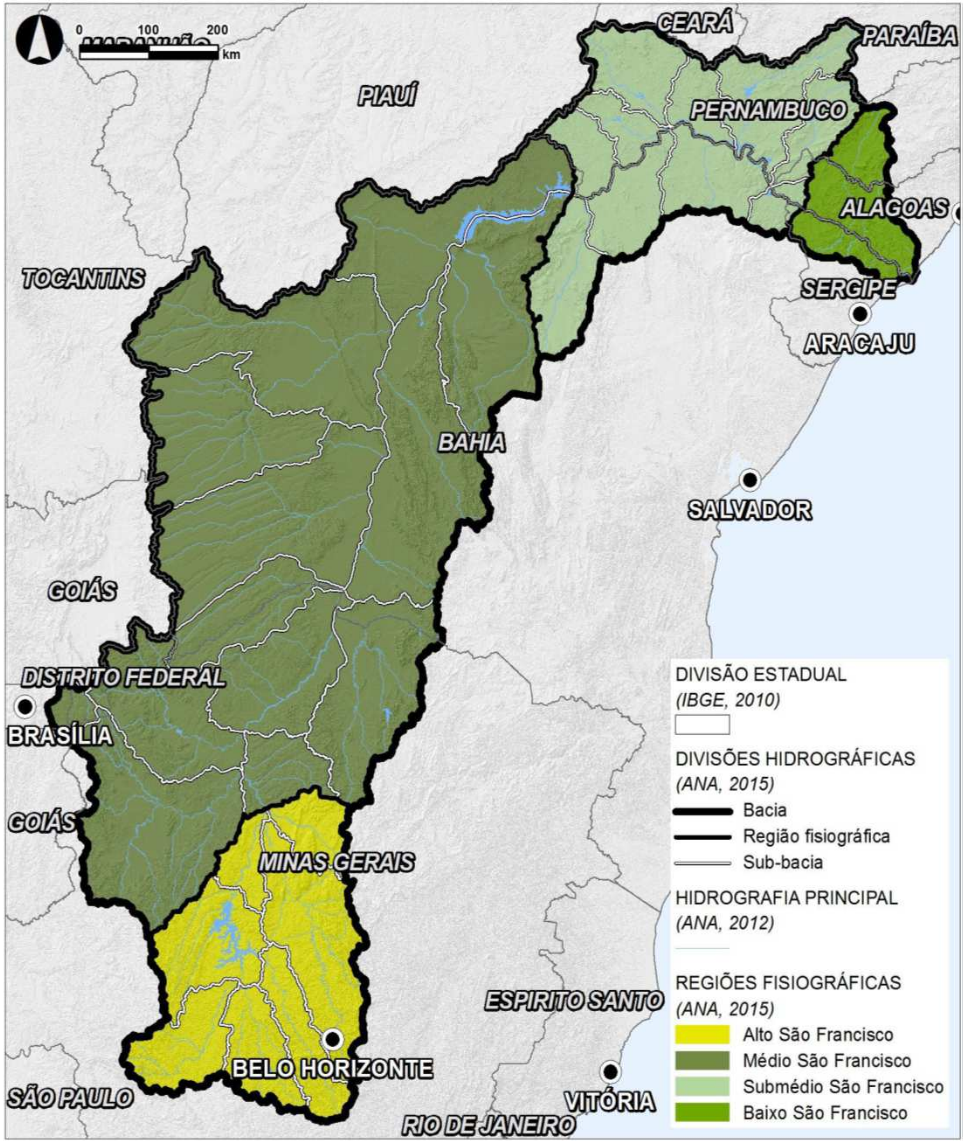
The **São Francisco** River Basin covers an area of 7.5% of Brazilian national territory;

58% of its territory is in the semi-arid region

Cascade of the pricipal reservoirs of the São Francisco river, total volume, usable volume and installed generating power



Fonte: CBHSF (2004).



Fonte: CBHSF (2016).

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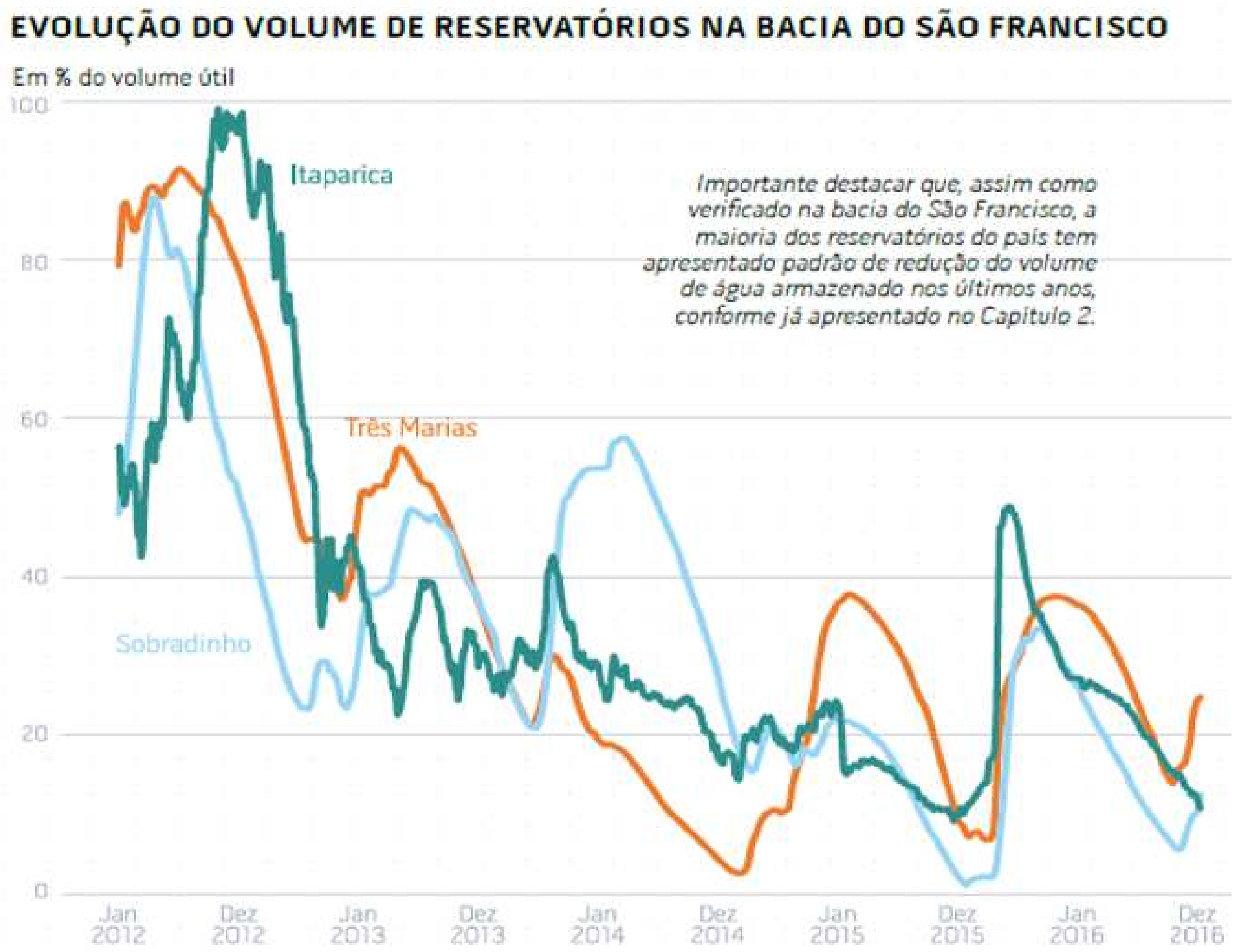
The principal conflicts of the São Francisco River Basin

water demand for consumptive uses for generating electrical energy;

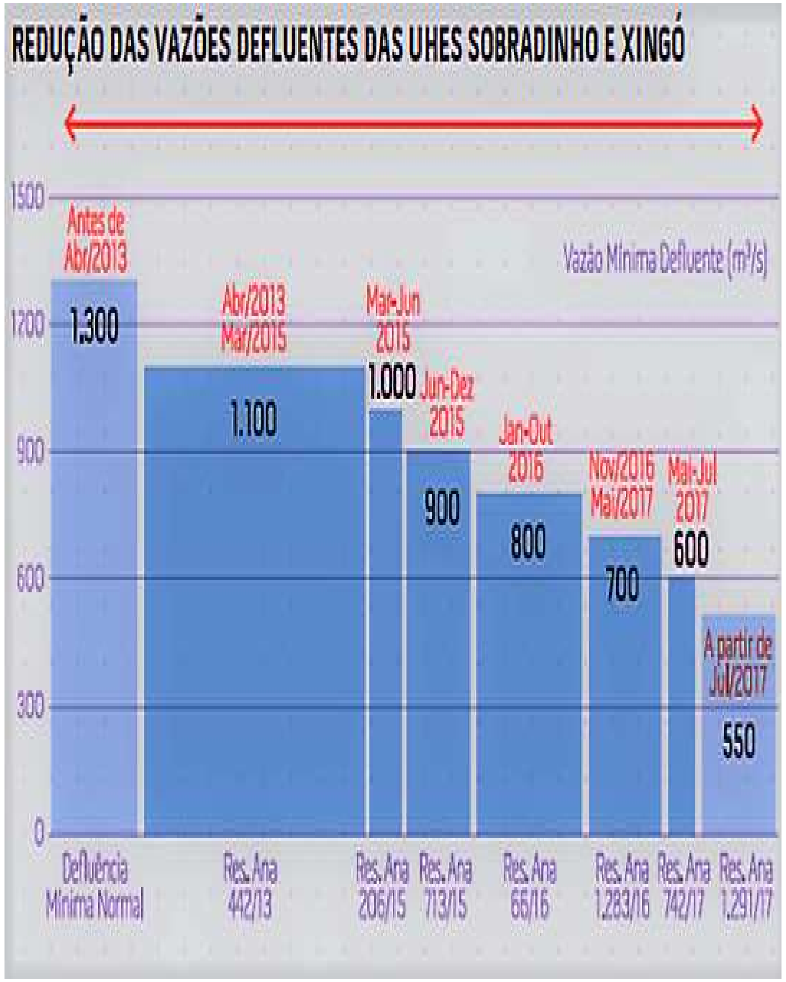
competition for water among diverse consumptive uses, particularly irrigation because of the the volume required;

marked variations in boosted flow, entail problems for aquatic ecosystems and the use of river margins by riverside communities.

Since 2012 the **São Francisco** basin has been facing adverse hydrological conditions, with precipitation and flow below average, with consequences for the levels of storage in its reservoirs.



Fonte: ANA, 2017



Fonte: ANA, 2017

Between 2014 and 2016 the lowest annual average natural flows were registered in the Sobradinho reservoir since 1931;

Operating rules of the reservoirs were defined by specific resolutions aimed to ensure water for diverse uses;

Reductions in released flows from Sobradinho and Xingó reservoirs were authorized progressively from 1300 to 550 m³/s

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Final considerations

According to the UN (2014), these are the principal challenges for sustainable development:

- The institutional capacity building to manage water resources and promote sustainable integration for economic development and poverty reduction;
- The adoption of a model of "management based on ecosystems" is fundamental to guarantee water sustainability in the long term;
- Agriculture has to increase its efficiency in water use;
- The expansion of eolic, solar, photovoltaic and geothermic energy generation will be a determining factor;
- The use of new sources of data as well as better and more powerful models and methods of analysis can help us to respond effectively to conditions of climate change and uncertainty.

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CLOSING WORDS

Dr. Panagiotis Balabanis
Deputy Head of Unit – DG Research

Dr. Joanna Drake
Deputy Director General of DG Environment

Dr. José Galizia Tundisi
Brazilian Expert

CLOSING REMARKS

Dr. Dominique Darmendrail

Water Joint Programming Initiatives / European Commission (JPI Water / EC)

Dr. Sanderson Leitão

Ministery of Science, Technology, Innovation and Communication (MCTIC)

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