Universidade Federal do Espírito Santo

HMW Brasil : Towards Sustainable Communities

Water Quality and Greywater Reuse

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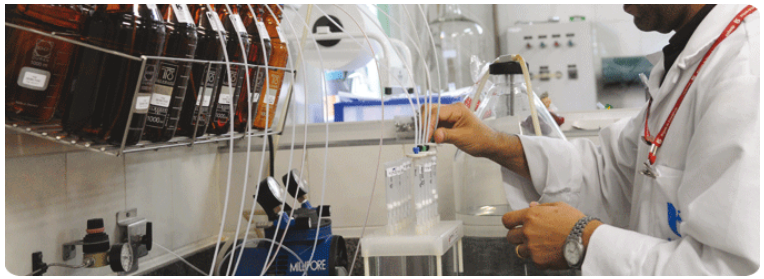
Water Quality

- Physico-Chemical
- Microbiology
- Aesthetic



Water Quality

Potability, Aquaculture, Irrigation, Bathing, Gardening, T.Flushing, Cooling, ***Effluents***.

→ Defined by Standards or Legislation

→ Alternatives to water demands.

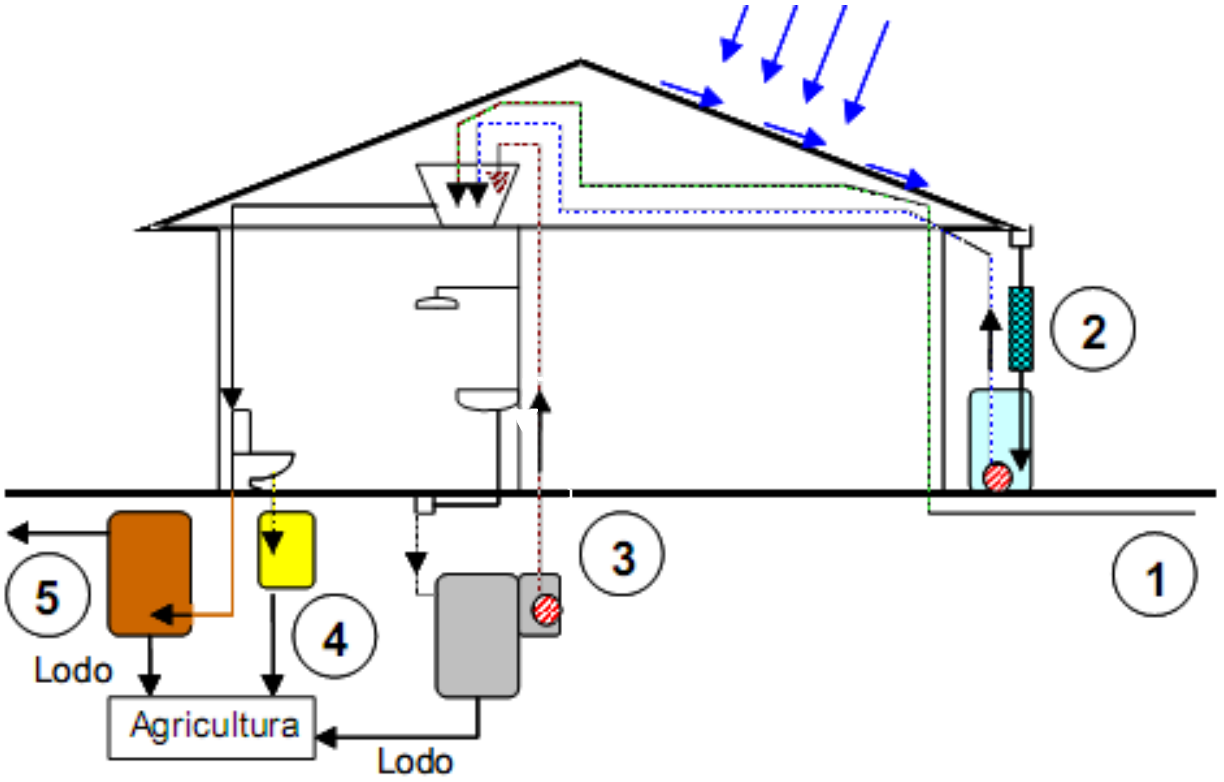
“Color of the Waters” Edification

Rainwater (Blue)

Greywater

Urine Collection

Black Waters

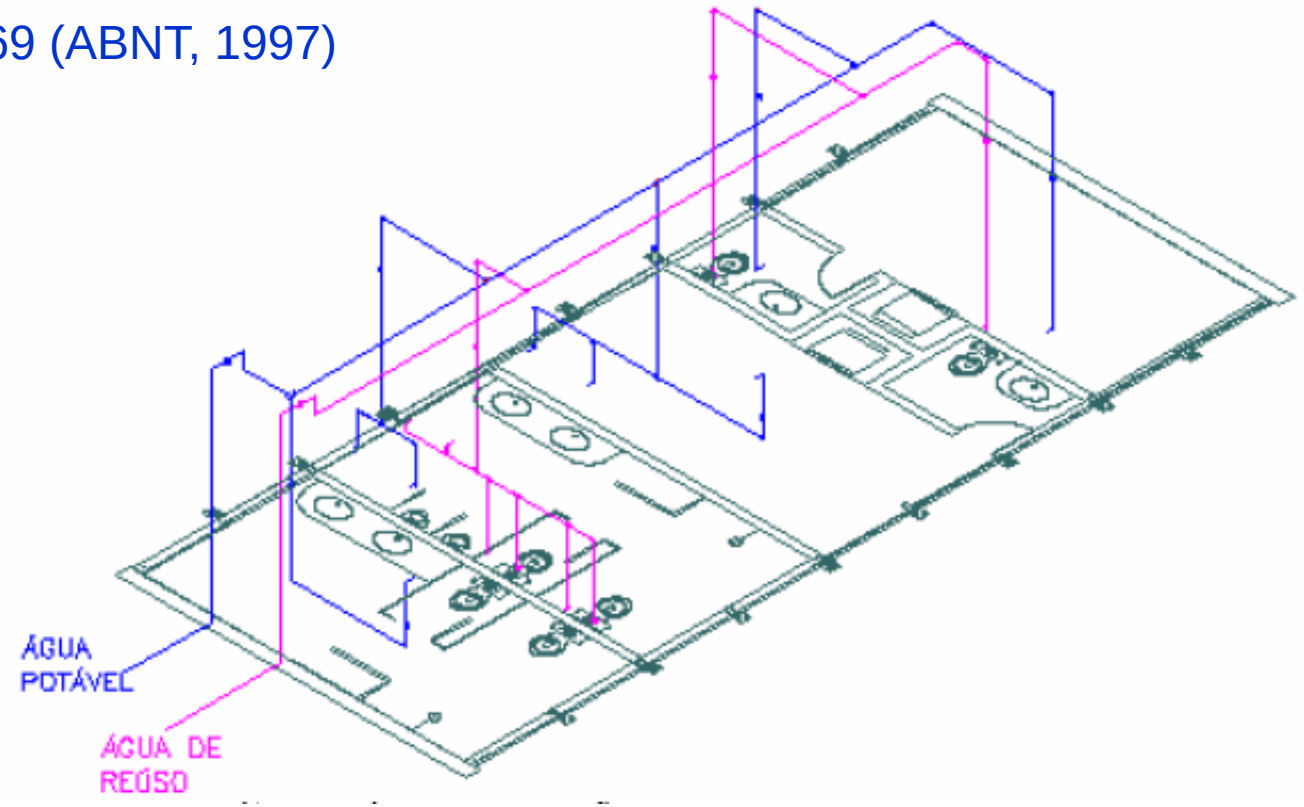


Fonte: OTTERPOHL, 2001

Hydro Sanitary Planning with segregation of water colors

Segregated Waste Water in Edifications

NBR 13969 (ABNT, 1997)



Isometric for potable and reuse water in UFES Edification as proposed byGonçalves, 2004.

Greywater Treatment For reuse

UFES Research Group (Nucleo Agua) has a strong background on Wastewater Treatment. Through the PROSAB (Brazilian Research Network on Basic Sanitation) there was several studies focusing on Greywater Treatment and Resuse in Edifications.

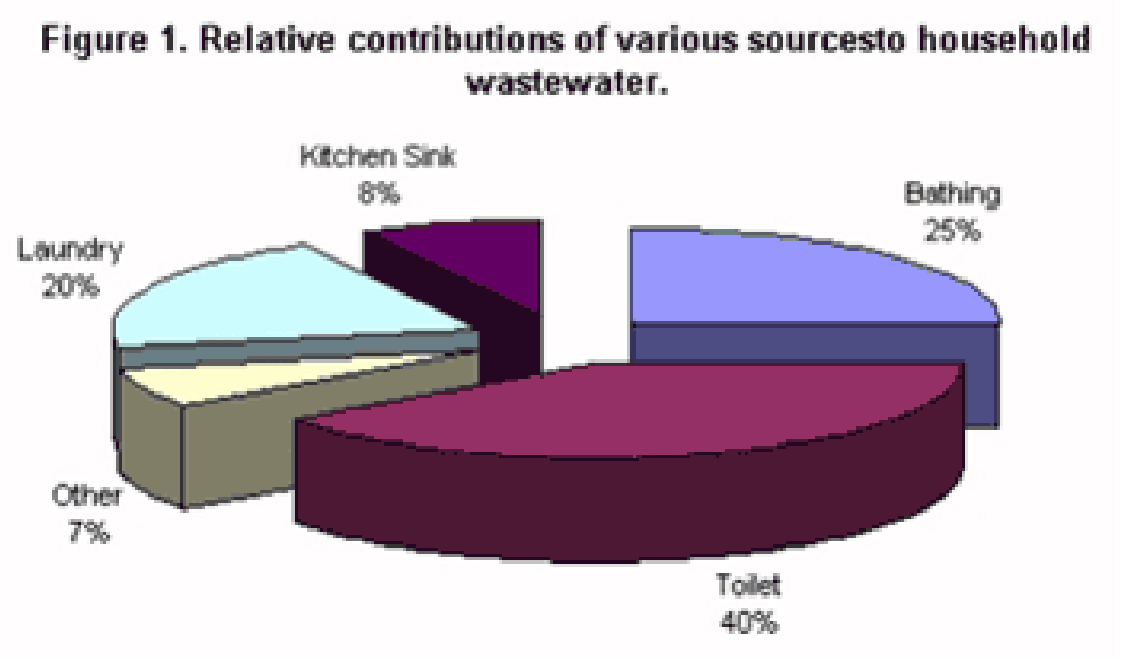
Bazzarella 2002., Gonçalves, 2006

What are in a Greywater?

Water-quality characteristics of selected domestic wastewater.

Water Source	Characteristics
Automatic Clothes Washer	Bleach, Foam, High pH, Hot water, Nitrate, Oil and Grease, Oxygen demand, Phosphate, Salinity, Soaps, Sodium, Suspended solids, and Turbidity
Automatic Dish Washer	Bacteria, Foam, Food particles, High pH, Hot water, Odor, Oil and grease, Organic matter, Oxygen demand, Salinity, Soaps, Suspended solids, and Turbidity
Bath tub and shower	Bacteria, Hair, Hot water, Odor, Oil and grease, Oxygen demand, Soaps, Suspended solids, and Turbidity
Evaporative Cooler	Salinity
Sinks, including kitchen	*Bacteria, Food particles, Hot water, Odor, Oil and grease, Organic matter, Oxygen demand, Soaps, Suspended solids, and Turbidity*
Swimming Pool	Chlorine, and Salinity

Greywater: where it comes from



Grey water x Black Water:-

- Lower BOD, 140 to 160 mg/L.
- Low Suspended solids:, 50 – 150 mg/L.
- Low Nitrogen 5 – 10 mg/L.
- Low Phosphorus 0.4 to 2mg/L.

> SO_4 as high as 0,02 mg L

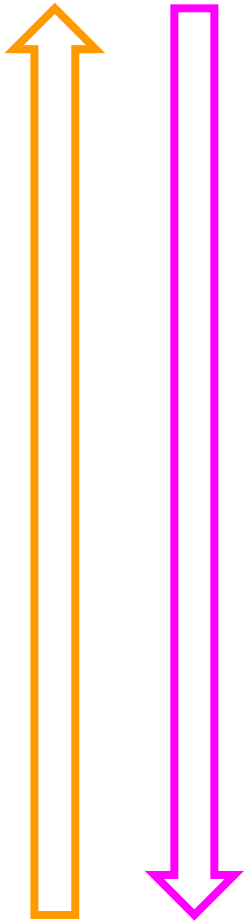
- Alkaline is high.
- Salt content is high.

Still have higher coliforms:
> 10^3 to 10^4 / 100 ml

What are the Risks for Greywater Reuse?

What is the Risk if.....

Water Treatment Costs x Water Quality



Excellent	10000
Good	1000
Fair	100
Reasonable	10
Low (Poorest)	1

Risks for Greywater use:

- For Irrigation
- Gardening
- Washing machines
- Toilet flushing
- Cooling water
- Concrete water
- Fire sprinklers

Microbial Risk Assessment

Hazard Identification; identification of pathogens in a system that can cause infection or disease.

Exposure Assessment; how many people are likely to be exposed to the pathogen and in what doses?

Dose – Response establishment; what rate of infection is the likely outcome from a certain dose of a pathogen?

Risk Characterisation; The result, expressed for example as number of infections per year, system lifetime or 1000 exposed.

MRA Components

Source water

⇩

Treatment Efficiency (Inactivation /Reduction)

⇩

Dose

⇩

Dose response Models

⇩

= Risk of Infection

Exposure Scenarios

Ottoson & Axel (2003)

1. Accidental ingestion to treated greywater (1mL).
2. Drinking recharged groundwater (10 times dilution, 3 m unsaturated zone, 60 days retention time in aquifer. Yearly risk).
3. Swimming in polluted recipients (1,000 times dilution).
4. Eating unprocessed crops (10 mL ingested, 1 week between irrigation and harvest).

Brazilian Standards for Greywater Reuse

Parameter	FIESP 2005	German Guideline
pH	06 to 10	6 to 9
Color	10	
Turbidity	2	1 to 2
O&G mg/L	1	
BOD mg/L	10	20
N-NH3 mg/L	20	
Ptotal mg/L	0,1	
TSS mg/L	5	30
TDS mg/L	500	
Coliforms (Th) MPN/100 mL	ND	100

Greywater Characterization

Parâmetro	N	Média	Mediana	Máx	Min	DP	Variância
pH	8	**6,84**	6,87	7,12	6,46	0,20	0,04
Alcalinidade (mg/L $CaCO_3$)	8	62,01	58,50	94,25	49,20	13,89	192,82
Turbidez (NTU)	8	89,82	74,56	189,00	55,00	45,84	2101,48
Cor (uc)	6	62,19	58,74	145,11	13,82	44,78	2005,54
SST (mg/L)	8	69,25	57,00	181,00	23,00	48,41	2343,64
SSD (mg/L)	8	0,60	0,40	2,00	0,30	0,58	0,33
DQO (mg/L)	8	216,96	207,69	315,30	149,11	48,56	2357,73
DBO (mg/L)	6	130,83	132,50	155,00	105,00	18,55	344,17
NTK (mg/L)	6	7,06	6,38	12,10	4,70	2,65	7,00
N-NH_3 (mg/L)	6	1,06	1,01	2,35	0,00	0,81	0,65
N-NO_3 (mg/L)	7	0,07	0,06	0,16	0,00	0,05	0,00
N-NO_2 (mg/L)	6	0,01	0,00	0,03	0,00	0,01	0,00
Pt (mg/L)	6	2,53	2,25	4,26	1,80	0,91	0,83
ortofosfato (mg/L)	6	0,97	0,81	1,95	0,03	0,68	0,46

Greywater Characterization

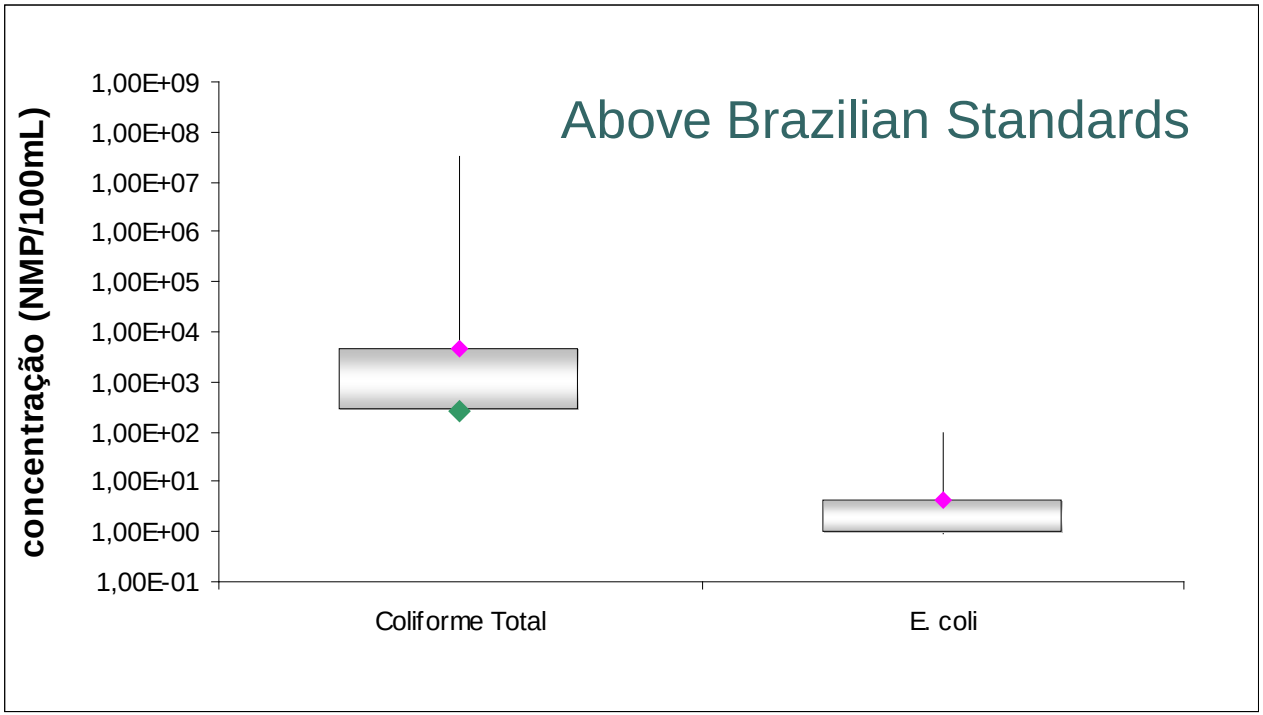
Referência	Parâmetros			
	Turbidez(NTU)	SST (mg/L)	DQO (mg/L)	DBO_5 (mg/L)
Jeppersen & Solley (1994)	100	115	*	160
Cristova - Boal apud Santos				
Zabrocki (2001)	60-240	*	*	76-200
Santos Zabrocki (2001)	37,3	*	*	96,5
Guy R. et al. (2004)[a]	23	29,8	170	78
Bazzarella(2005)[b]	166	134	857	170
Essa pesquisa	89,8	69,2	216,9	130,8

a: chuveiro, lavanderia e lavatório b: chuveiro, lavanderia, lavatórios e cozinha

Parâmetro	Esgoto forte	Esgoto médio	Esgoto Fraco
SST (mg/L)	360	230	100
DQO (mg/L)	800	400	200
DBO_5 (mg/L)	400	200	100
NTK (mg/L)	85	40	20
$N\text{-}NO_3$ (mg/L)	0,4	0,2	0,1
$N\text{-}NO_2$ (mg/L)	0,1	0,05	0
P total (mg/L)	20	10	5

Jordão e Pessoa, 2005

Greywater Microbiology



Média: 4,36 x 10^3 NMP/100mL

DP: 1,15 x 10^7

Média: 5,21x10^0 NMP/100mL

DP: 3,52 x 10^1

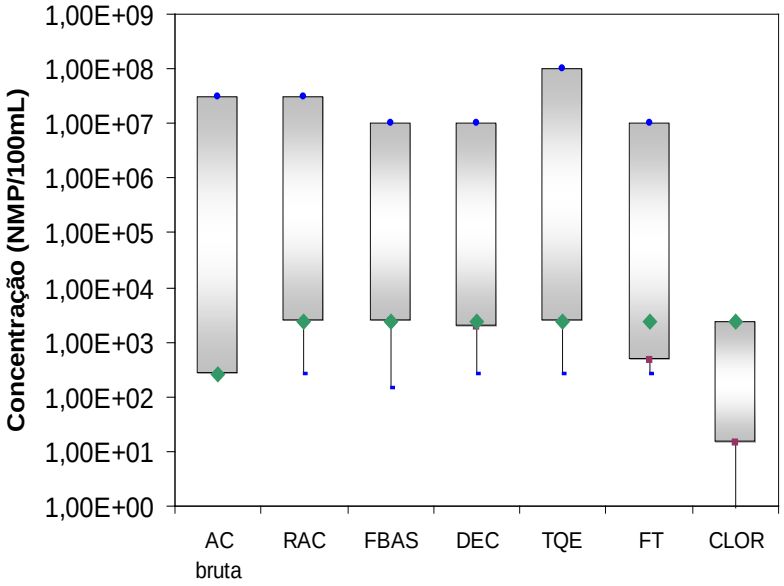
Não foram detectados *Salmonella spp.*, ovos de helmintos, *Cryptosporidium sp* e *Giardia spp*.

Greywater ETAC Microbiology

Tratamentos	Parâmetros		Referências
	Coliformes totais (NMP/100mL)	E.coli (NMP/100mL)	
RAC+FBAS+FT+cloração	$5,4 \times 10^{2}$	$3,17 \times 10^{1}$	Bazzarella (2005)
Filtro biológico aerado	$3,0 \times 10^{3}$	$5,1 \times 10^{0}$	Birks et al. (2004)
Biorretato de fluxo vertical		1×10^{-1}	Gross et al.(2007)
Esta pesquisa	$3,3 \times 10^{2}$	<1	

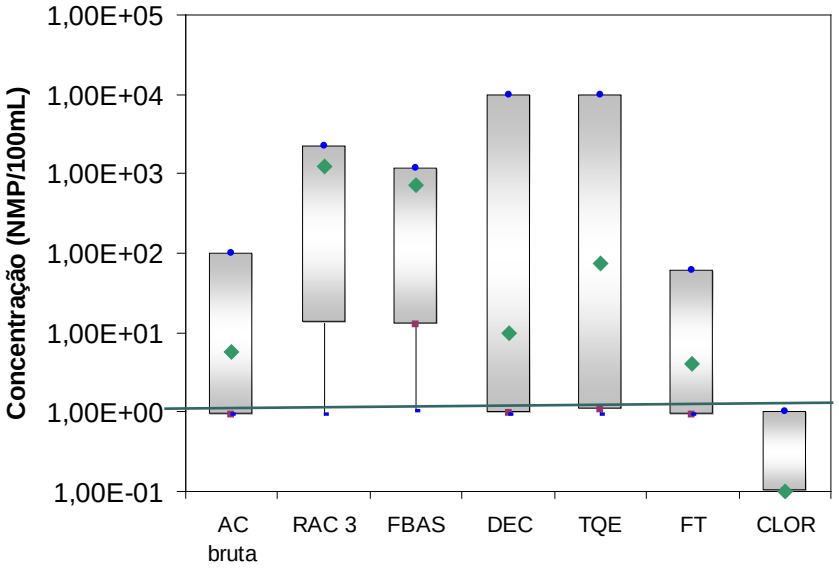
Greywater ETAC Microbiology

Coliforme Total



Padrão Alemão: <1000 ufc/100mL
WHO: 200-1000 ufc/100mL

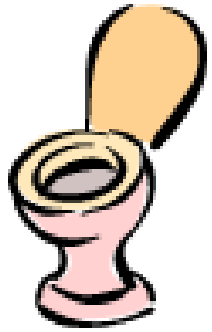
E. coli

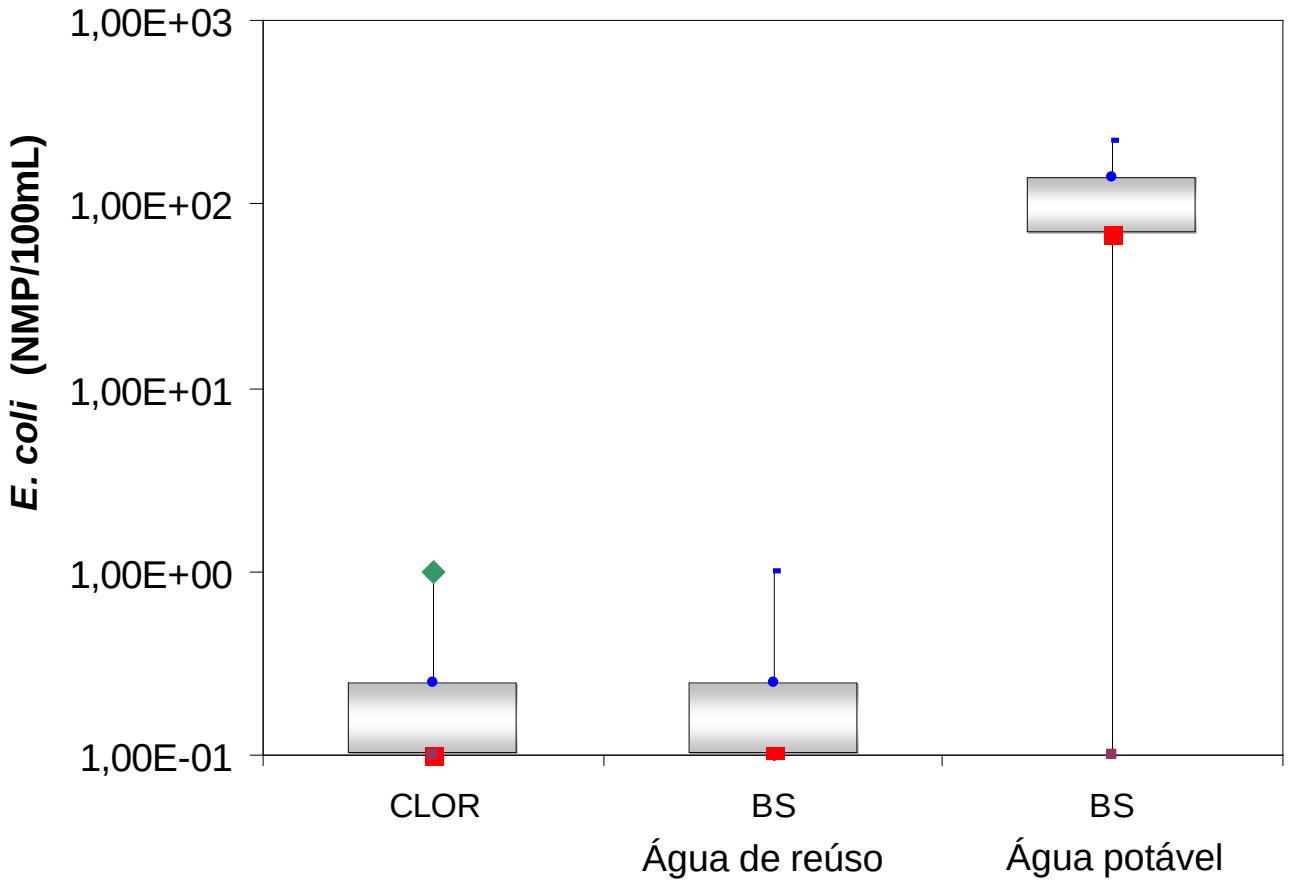


Inglaterra/ Flória/ Arizona: ND
Japão: 10UFC/100mL

NBR 13.969/97: <500 ufc/100mL

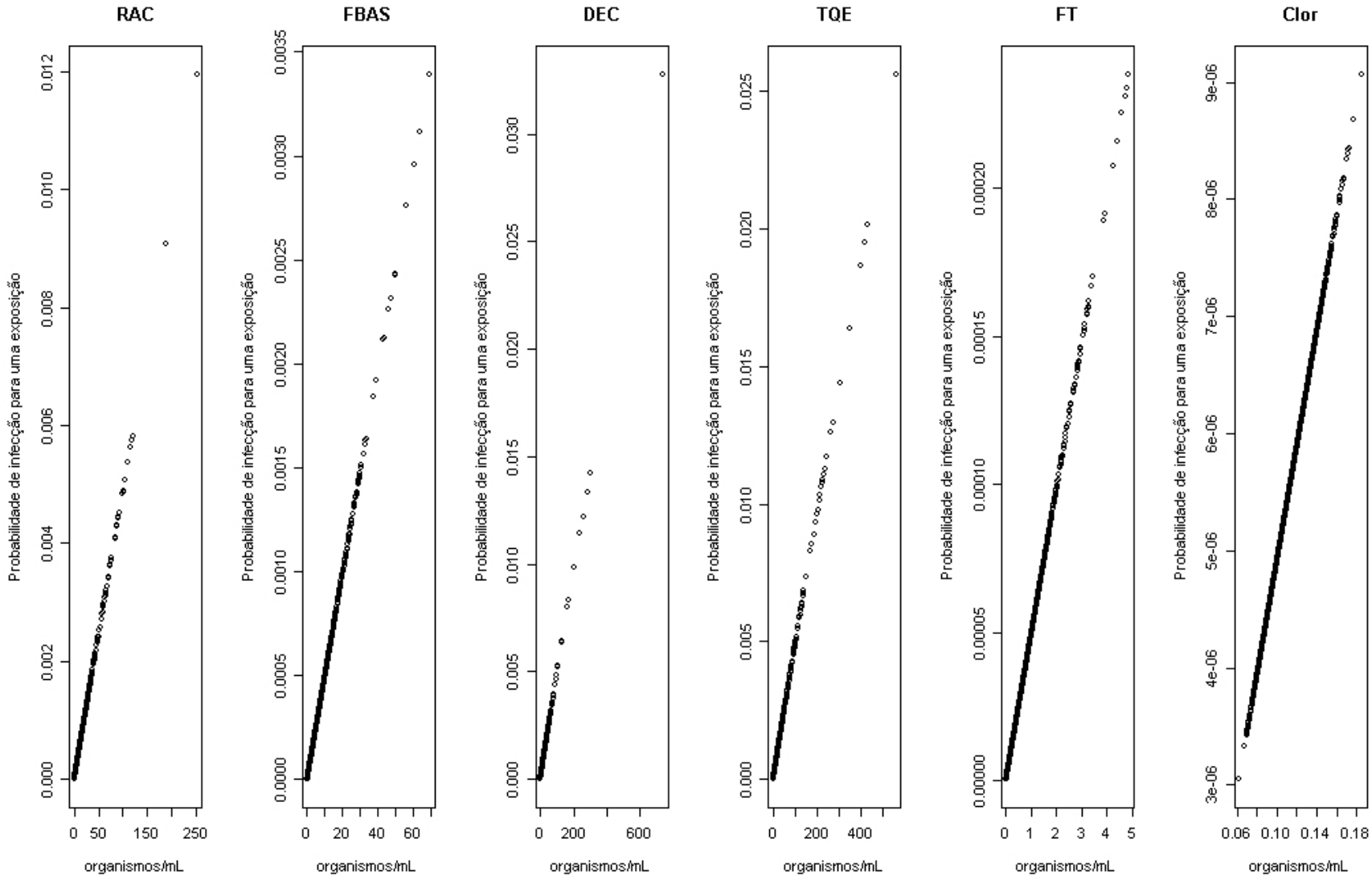
Selo hídrico com X Sem reúso





Ornellas (2004)= 10^3 NMP E.coli/100ml

Probabilidade de infecção para uma exposição -PI(d)



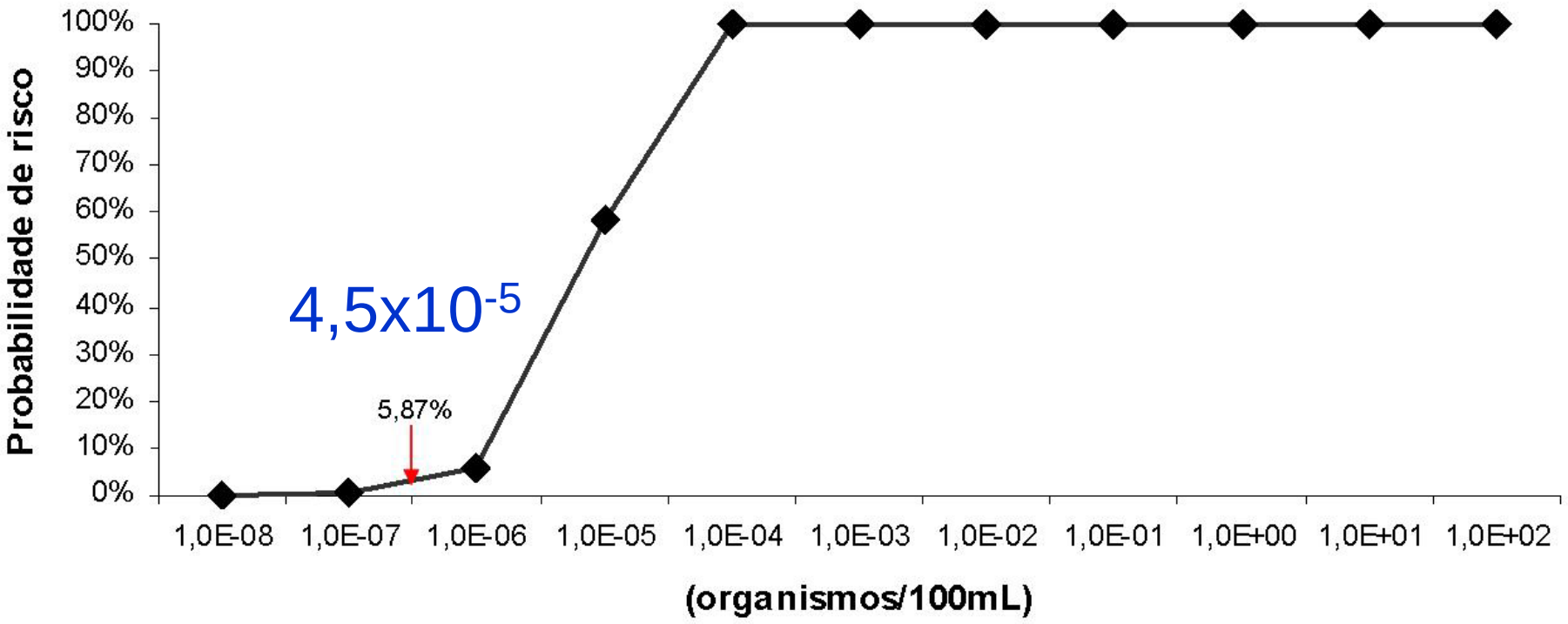
Simulação de risco para rotavírus

Mara et al.:10^5 *E.coli* → 0,1 a 1rotavírus →

Água de reúso:

1 x 10^{-6} rotavírus/100mL

Simulação: 10^{-8}-10^2 rotavírus/100mL



Conclusions

- Greywater is similar to weak sewage
- Brazilian Legislation for GW reuse is too stringent and demands a high cost equipment.
- Greywater is a low Risk management water for reuse.
- Treatment for Greywater can be integrated in Edifications as a part of water rationalization program.