Co-funded by the 7th Framework Programme of the EU:

In the framework of:

Innovative technologies for resource efficient cities
Reucity

demEAUmed final conference

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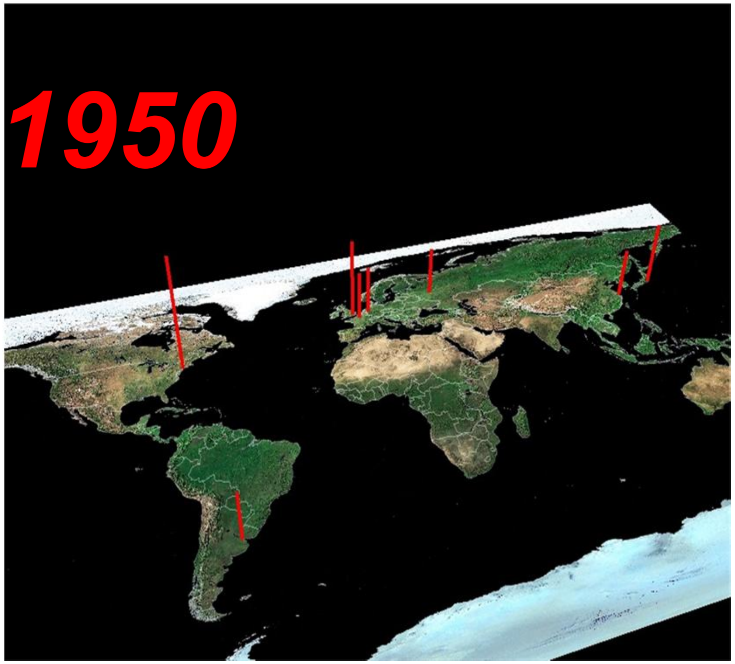
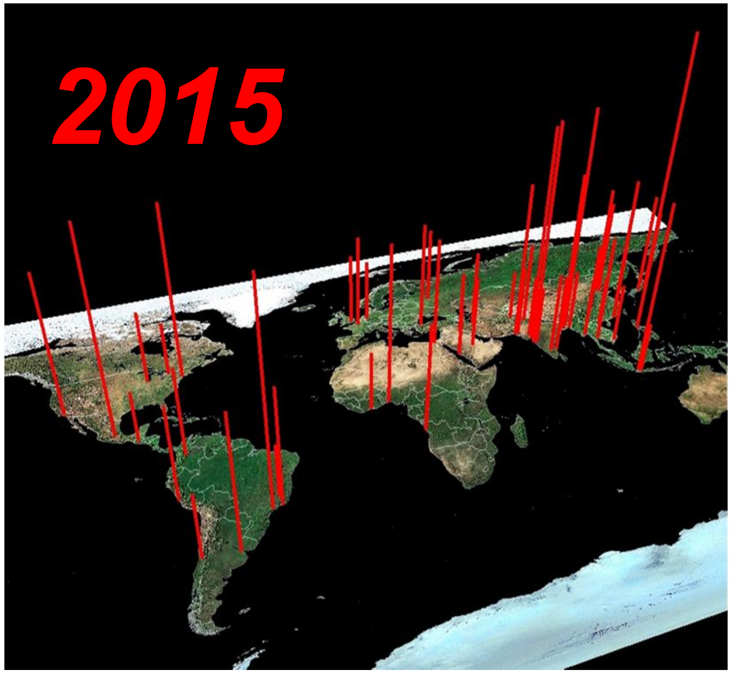
Natasa Atanasova
natasa.atanasova@udg.edu

Why cities?

World Cities exceeding 5 million residents





Major DEMAND for resources comes from cities. Resources are supplied unsustainably, which causes global problems. Thus changing the way resources are supplied and managed in cities can be the key to sustainable world.

The water and food issue

Three crucial questions for water:

- How much fresh potable water do we actually need and how much is supplied? Why?
- What is wastewater; what are we actually flushing away and treating and how do we do that?
- Where do we dispose the wastewater and what are the consequences?

Three crucial questions for food:

- Where do the food comes from?
- How do we produce the food: where the fertilizers come from?
- What are the impacts to the environment: GHG, agrochemicals, soil loss.

ALL THESE ISSUES ARE RELATED TO ENERGY DEMAND

Alternative 1: optimize existing systems

Reduction in unsustainable fertilizers production. Theoretically we can talk about partially ‘closing the loops’.

However:

- Similar agri-practices remain
- Reclaimed water in the city need additional infrastructure.
- Still ‘flushing toilets with potable water’.
- Treating symptoms and not the source of the problem

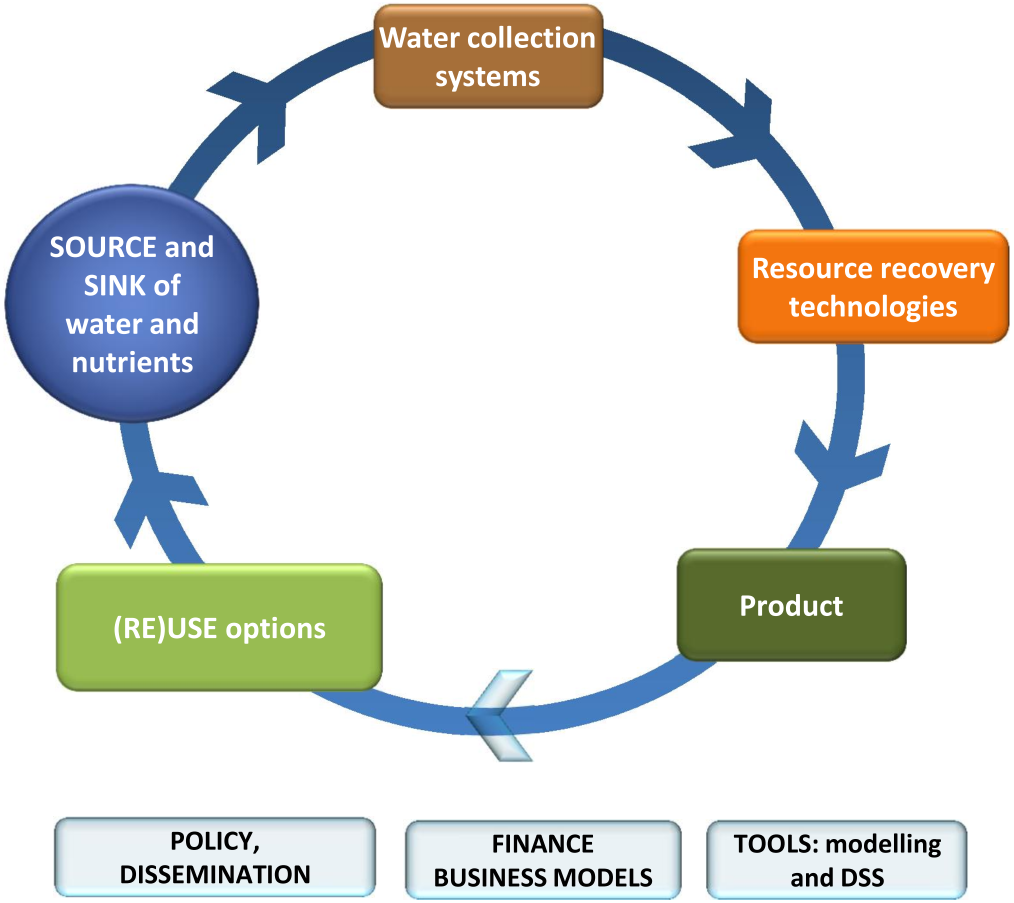
Iglesias Esteban, R., & Ortega de Miguel, E. (2008). Present and future of wastewater reuse in Spain. Desalination, 218(1–3), 105–119.

Papa, M., Foladori, P., Guglielmi, L., Bertanza, G. How far are we from closing the loop of sewage resource recovery? A real picture of municipal wastewater treatment plants in Italy, Journal of Environmental Management, Volume 198, Part 1, 1 August 2017, Pages 9-15, ISSN 0301-4797

Alternative 2: systemic change

If our habitats are SINKS and SOURCES, we need to start thinking from:

- What and how do we consume
- How do we collect our ‘waste’
- Based on the collection system we select appropriate resource recovery technologies
- If we selected properly in the previous steps we can safely use products



Is it feasible?

- Legislation
  - UWW Directive: ‘treated wastewater shall be reused whenever appropriate’, where *appropriate* is left to each member state.
- Present infrastructure, little experience with real-scale systems
- **Fear of pathogens and hazardous substances**
  - What are we eating currently?
  - Micropollutants are deeply embedded in our way of living; they pass by WWTPs and eventually end up in the biota and consequently to our food.
- It is feasible
  - Better source control of pollutants
  - Do we have a better choice?

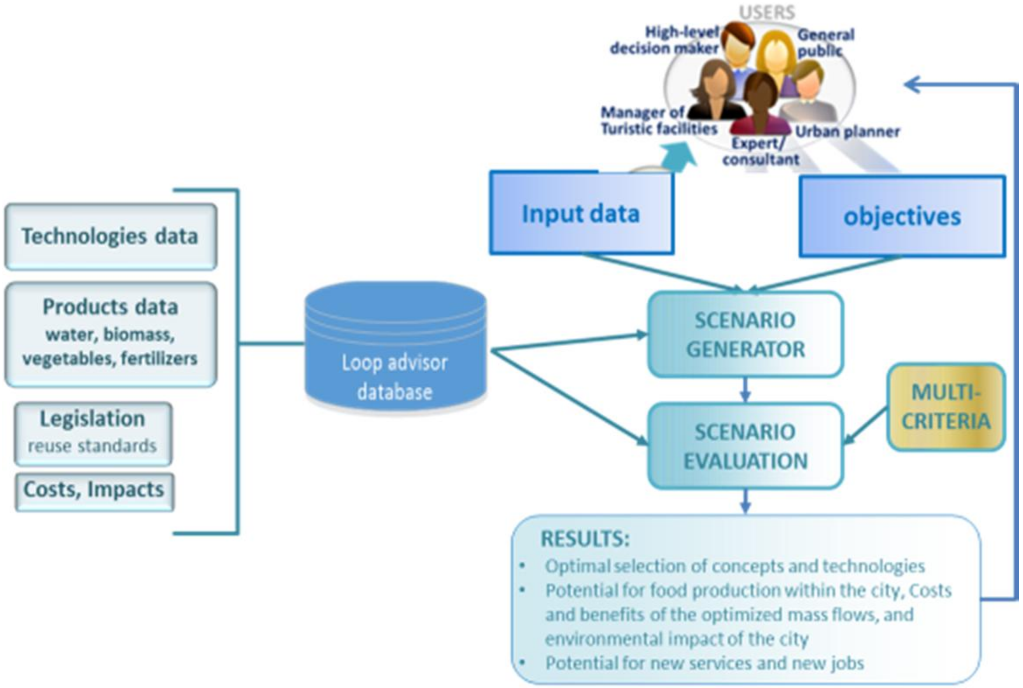
Circular concepts: evaluation

LoopAdvisor DSS

Decision support system

Supports the implementation of circular concepts

How does it work: overview



Example: closing the loop at hotel Samba

Input:
Urban setting: one building, hotel
Space availability: medium
No. inhabitants: 300 rooms, av. 300 PE
Electricity price: 0.18 EUR/kWh
Water price: 2.1 EUR
Average vegetables price: 1.5 EUR/kg
Average biomass price: 0.5 EUR/kg

Waste flows: WW, GW, BW

	WW	GW	BW
Volume, m3/day	45	31.5	13.5

Loads [kg/day]			
	WW	GW	BW
COD	27	6.93	12.15
BOD5	15.75	4.725	5.4
N-tot	3.15	0.315	2.16
NH4	2.7	0.126	1.89
Ptot	0.45	0.016	0.54
K	0.45	0.016	0.54

Select objectives:
O1. Resources recovery:
water and nutrient recovery from 45 m3/day waste flow, the peaks go to existing sewer

O2. Products:
Food
Plant biomass
Water

O3. All ranking priorities will be analysed

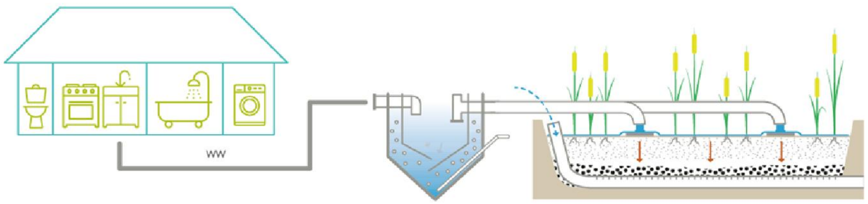
Proposed concepts based on the expert knowledge in the Loop advisor:
Concept 1. Treatment and reuse of mixed WW
Concept 2. Complete separation and treatment of GW and BW

Scenarios generator

Scenarios (1)

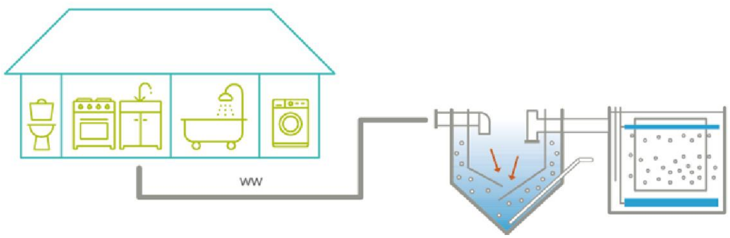
concept 1: mixed WW

Scenario 1.1



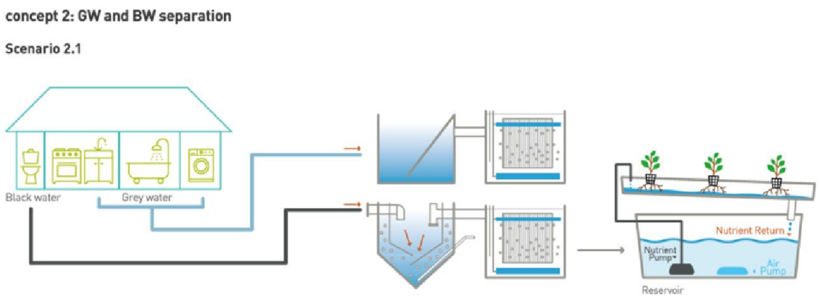
Mixed domestic WW (45 m^3/day) is treated mechanically in an Imhoff tank, followed by a constructed wetland. Products: plant biomass and 22 m^3/day water.

Scenario 1.2

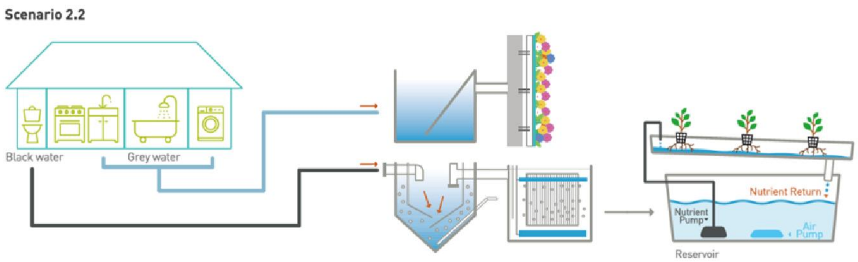


Mixed domestic WW is treated mechanically in an Imhoff tank, followed by a membrane bioreactor. Product: 45 m3/day water and dissolved nutrients.

Scenarios (2)

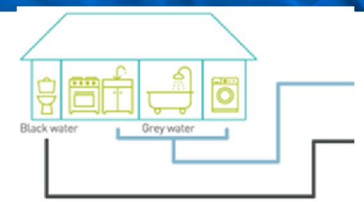


Separated GW (31 m^3/day) is treated by mesh screen and then by MBR. The BW (13 m^3/day) is taken to imhoff tank followed by MBR. Treated effluent from the MBR is used as liquid fertilizer in a hydroponic system. Products are: 31 m^3/day of high quality water for urban uses 11 tonnes of vegetables/year.



Same as scenario 2.1, except the GW line is treated by a green wall. Products are 23 m3/day water for urban uses, plant biomass, and approx. 11 tonnes of vegetables/year.

Evaluation of scenarios



			concept 1: WW		concept 2: GW+BW	
			1.1, CW	1.2, MBR	2.1; MBRs	2.2; MBR, CW
SPACE		m2	757	14	655	878
COSTS	CAPEX	EUR	**51,720**	**88,751**	**90,049**	**65,585**
	OPEX	EUR/year	**14,751**	**24,585**	**20,631**	**20,003**
products: amounts	water	m3/day	23	45	32	24
	energy	kWh/year	0	0		
	food	kg/year	0	0	11,970	11,970
	fertilizer		0	0		
	plant biomass	kg/year	3,750	0		1,181
Environmental benefits	monetary	value of products, EUR/year	**20,175**	**32,850**	**41,541**	**35,201**
		return period of investment [years]	7	11	4	4
	non-monetary	kg N not released /year	785	460	1,150	1,150
		kg P not released /year	90	16	159	159
		Avoided agricultural land [m2]	0	0	2,993	2,993
		Avoided N_min fertilizer [kg/year]	0	0	922	922
		Avoided energy to produce N_min [MJ/year]	0	0	36,868	36,868

Conclusion

- Urban water is a valuable resource and we can and should use it more wisely than we presently do (use-treat-dispose).

- Circular water management can trigger a change in the management of the closely related food and energy systems.

- Food production systems can be a core part of the urban water management. This requires a shift towards a cross-sector, ‘resources management’.

- Shifting towards circular urban resources (water-food-energy) management is a way to introduce high quality urban lifestyle and more importantly, to significantly improve the living conditions in many parts of the world, without compromising the ecosystems and their services to humans of today and tomorrow.

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THANK YOU

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