MEASURING THE CIRCULAR ECONOMY OF WATER SECTOR IN THE THREE-FOLD LINKAGE OF WATER, ENERGY AND MATERIALS

P. Stanchev, V. Vasilaki, J. Dosta, E. Katsou

5th International Conference on Sustainable Solid Waste Management
21–24 June 2017

ATHENS 2017
Linear vs Circular economy model

Linear model
- Raw materials
- Production
- Distribution
- Consumption
- Waste

Circular model
- Raw materials
- Design
- Remanufacturing
- Production
- Distribution
- Consumption
- Use, reuse, repair
- Recycling
- Collection
- Residual waste

Fundamental characteristics:
- Design out waste
- Build resilience through diversity
- Work towards energy from renewable sources
- Think in systems
- Think in cascades

Source: European Commission
Circular economy in product based systems

- Biological Materials
- Soil Restoration
- Biogas
- Anaerobic Digestion & Composting
- Farming & Collection
- Biochemical Feedstock
- Mining & Materials Manufacturing
- Technical Materials
- Recycle
- Refurbish & Remanufacture
- Reuse & Redistribute
- Maintain
- Collection
- Consumer
- User
- Product Manufacturer
- Materials & Parts Manufacturer
- Collection
- Extraction of Biochemical Feedstock
- Energy Recovery
- Landfill
Natural and man-made water cycle
Water quality balance on catchment level
Historical transition of urban water systems

Cumulative Socio-Political Drivers

- Water supply access & security
- Public health protection
- Flood protection
- Social amenity, environmental protection
- Limits on natural resources
- Intergenerational equity, resilience to climate change

Service Delivery Functions

- Water Supply City
  - Supply hydraulics
- Sewered City
  - Separate sewerage schemes
- Drained City
  - Drainage, channelisation
- Waterways City
  - Point & diffuse source pollution management
- Water Cycle City
  - Diverse, fit-for-purpose sources & conservation, promoting waterway protection
- Water Sensitive City
  - Adaptive, multifunctional infrastructure & urban design reinforcing water sensitive behaviours

Source: Brown et al., 2008
Linear model of the urban water systems
Water as medium of resources

Source: Kenway, S. J. 2013
Circular economy solutions in water sector

1. Water use efficiency
2. Water reuse
3. Alternative water sources

Energy pathway
4. Energy recovery
5. Energy use efficiency
6. Biogas/biogas production

Nutrient / Material pathway
7. Nutrient recovery
8. Material recovery

Water pathway

Water treatment
Water distribution
Industry
Waste water treatment
Waste water collection
Agriculture
Water wise communities
Sea water desalination
Fresh water

Energy recovery

Nutrient recovery

Material recovery
Wastewater treatment in the circular economy

- Water abstraction
- Water treatment
- Water distribution
- Water Use
- Wastewater collection

- Chemical Intermediates (VFA, N, P derivatives)
- Struvite P-rich compost
- Water reuse
- Construction Industry
- Chemical Industry
- Agriculture
- Biogas
- Multipurpose water reuse
- Biocomposites from Cellulose & PHA
- Water-energy nexus
- Biofuel from cellulosic sludge

Supported by the Horizon 2020 Framework Programme of the European Union
Wastewater treatment in the circular economy

- Water source
- Water abstraction
- Water treatment
- Water distribution
- Water use
- Nutrients and materials
- Infiltration
- Biodegradation
- Wastewater collection
- Wastewater treatment

Environmental Impact Breakdown

- Water intake
- Water treatment
- Water distribution
- Domestic water user
- Non-domestic water use
- Wastewater collection
- Wastewater treatment

- Climate Change
- Fossil Fuels Depletion
- Freshwater Resource Depletion
- Eutrophication
- Human Toxicity
- Acidification
- Aquatic Ecotoxicity
- Stratospheric Ozone Depletion
- Terrestrial Ecotoxicity
- Respiratory Inorganics
- Photochemical Ozone Formation
- Mineral Depletion
Closing the CE loops water systems
Measuring the circular economy
Eco-efficiency Assessment

\[ \text{Eco-efficiency} = \frac{\text{Economic output}}{\text{Environmental impact}} \]

Delivering high value product/service
- Less economic costs

Less resources,
- Less emissions to air, soil, and water

Eco-efficiency = Eco-efficiency Assessment
Eco-efficiency vs Eco-effectiveness and relation to the Circular economy

Optimize positive impact

Minimize negative impact

Transition to circular economy
Conclusions

• The application of circular economy to water sector changes fundamentally the perception of the water supply chains – water is seen as medium of valuable resources, while water infrastructures are considered as a part of an inter-sectoral value chain system.

• Straightforward application of circularity approach (focusing on recycling) could shift the environmental impact into other impact categories and even increase the net environmental impact.

• The fragments of circular approaches on water resources management have yet to be translated into systematic methods and standardized metrics to evaluate different circular models.

• A methodological framework needs to be developed considering all three pathways to water circularity (energy, materials, water).
Thank you for your attention!