Poster presented at

COST Action CA17133 Circular City

Implementing nature-based solutions for creating a resourceful circular city

Final event

18+19 September 2022

VIA University College
Campus Aarhus C
Ceresbyen 24, 8000 Aarhus
Denmark

ID CARD – COST Action Circular City

COST Action CA17133 Circular City

Implementing nature based solutions for creating a resourceful circular city

Guenter Langergraber
BOKU

Project contact: Guenter Langergraber
E-mail: guenter.langergraber@boku.ac.at
Affiliation: University of Natural Resources and Life Sciences, Vienna (BOKU), Department of Water, Atmosphere and Environment, Institute of Sanitary Engineering and Water Pollution Control, Muthgasse 18, A-1190 Vienna, Austria

Framework

Cities worldwide are facing a number of challenges including resource depletion, climate change and degradation of ecosystems. If cities do not adapt their current infrastructure and resource management, they will not be able to cope with these challenges. Nature-Based Solutions (NBS) are one element that can help to achieve this transition.

Objectives

The main aim and objective of the COST Action Circular City is to build an interdisciplinary platform for connecting city planners, architects, system designers, economists, engineers and researchers from social and natural sciences

- that develop nature based solutions in the urban landscape that
- facilitate circular economies based on the 3Rs (Reduce, Reuse and Recover) and
- allow cities to cope with future challenges.

Main result

A framework for addressing Urban Circularity Challenges with NBS that includes

- a catalogue of NBS units/interventions for providing/recovering resources, and
- the analysis of the required input and output resource streams.

Main outputs

- Animation video with subtitles in > 30 languages (https://www.youtube.com/watch?v=R3NXLb-W1pg)
- On-line course @ Cap-Net platform (https://cap-net.org/circularcities/)
- Course materials for training city planners and administrators to overcome barriers for implementing NBS *
- Guidance on how NBS con be used create Circular Cities *

* still under development

Main publications

- Special Issue "*Towards Circular Cities*" in the IWA Publishing Open Access journal *Blue-Green Systems* (6 papers, > 100 authors from 35 countries), https://iwaponline.com/bgs/pages/towards_circular_cities_special_issue
- Special issue "*Water and Circular Cities*" in the MDPI Open Access journal *Water* (6 papers, > 80 authors from 28 countries), https://www.mdpi.com/journal/water/special_issues/water_circular_cities

Duration: 22/10/2018 – 21/04/2023
Programme: COST Action
Website: https://circular-city.eu/

Circular City
circular-city.eu

cost
EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY
Funded by the European Union

Circular City
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EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY
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www.cost.eu

COST Action CA17133 Circular City

Implementing nature based solutions for creating a resourceful circular city

Duration: 22 Oct 2018 – 21 Apr 2023

Objective

- Mainstreaming the use of Nature-Based Solutions (NBS) for the enhancement of resource management in urban environments.

Main result

- A framework for addressing Urban Circularity Challenges with NBS that includes
  - a catalogue of NBS units/interventions for providing/recovering resources, and
  - the analysis of the required input and output resource streams.

Outputs

- Animation video with subtitles in > 30 languages
  https://www.youtube.com/watch?v=R3NXLb-W1pg
- On-line course @ Cap-Net platform
  https://cap-net.org/circularcities/
- Main publications
  - Special Issue **"*Towards Circular Cities*"** in the IWA Publishing Open Access journal ***Blue-Green Systems*** (6 papers, > 100 authors from 35 countries)
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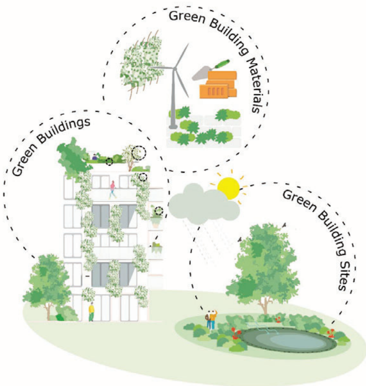
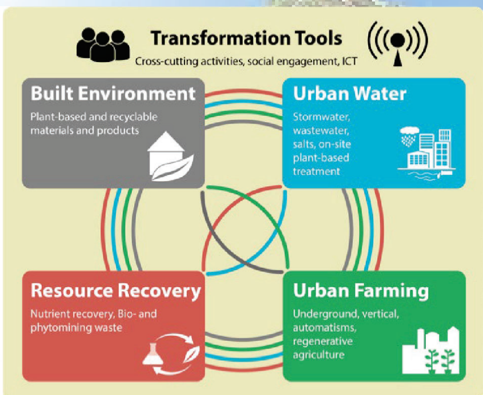
  - Special issue **"*Water and Circular Cities*"** in the MDPI Open Access journal ***Water*** (6 papers, > 80 authors from 28 countries)
    https://www.mdpi.com/journal/water/special_issues/water_circular_cities

Summary

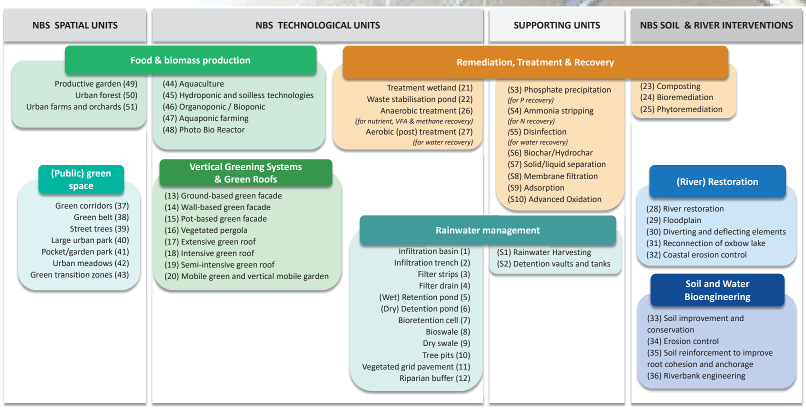
- Cities have to transform to become more resilient towards existing challenges such as resource depletion, climate change and degradation of ecosystems.
- Nature-based solutions (NBS) provide a range of ecosystem services beneficial for the urban biosphere.
- By adopting the concept of circular economy, benefits of NBS for urban areas can be increased.
- Water is a key element when using NBS in the urban environment.
- A circular flow system using NBS for managing nutrients and resources within the urban biosphere facilitates the transformation towards a more resilient, sustainable and healthy urban environment.
- The COST Action Circular City is currently investigating potential ways how these transformations can take place.



Scales of NBS implementation in the built environment (Pearlmutter et al., 2020).

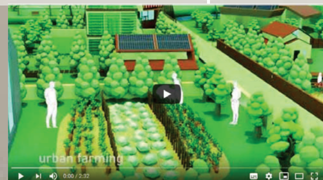


Working Groups of the COST Action Circular City.



NBS units, NBS interventions and Supporting units clustered into sub-categories related to the main application goal according to Langergraber et al. (2021).

Example of activities: Meeting in Iceland (left), Training school in Austria (top), and Training school in Malta (bottom)



Circular City animation video (top) and Circular City on-line course (bottom)

References:
Pearlmutter et al., 2020, *Blue-Green Systems* 2(1), 46-72; https://doi.org/10.2166/bgs.2019.928.
Langergraber et al., 2021, *Water* 13, 2355; https://doi.org/10.3390/w13172355.

Dr. Guenter Langergraber
Chair, COST Actin Circular City
University of Natural Resources and Life Sciences, Vienna (BOKU)
Email: guenter.langergraber@boku.ac.at

BOKU 150 JAHRE NACHHALTIG VORAUSSCHAUEN 1872 – 2022
UNIVERSITÄT FÜR BODENKULTUR WIEN

ID CARD – "AutoSCM"

UL FGG

Title: AUTOMATED MODELLING AND DESIGN OF URBAN STORMWATER CONTROL MEASURES

Project contact: Matej Radinja
E-mail: matej.radinja@fgg.uni-lj.si
Affiliation: University of Ljubljana, Faculty of Civil and Geodetic Engineering

Framework

Stormwater control measures (SCMs) are technical elements that are designed to prevent and mitigate the negative effects of uncontrolled stormwater flow. As opposed to the conventional approach that controls the stormwater in a centralized way (using grey infrastructure), decentralized SCMs aim to control the rainfall at the source. Models are being used to design SCMs and predict their performance for different design and weather scenarios. To investigate the impact of SCMs at different spatial scales, SCM models need to be integrated into or coupled with catchments rainfall-runoff (RR) models. Moreover, approaches that include auto-calibration of the RR model and objective-driven automated SCM design can be of great assistance.

Objectives

The overall project aim is to apply automated modelling (AM) to the field of urban drainage and optimal SCM design. The specific research objectives are as follows:

1. To develop and construct a domain knowledge library for urban drainage modelling, including SCMs, fit for use with the Process-based Modelling Toll for AM.
2. To develop a new methodology for AM of urban drainage processes and optimal selection of SCMs.
3. To test, validate and demonstrate the above new methodology on a real case study in Ljubljana.

Outcomes

The proposed modelling approach (i.e., using ProBMoT) enables effective automation of two complex calibration tasks in the field of urban drainage, i.e., the calibration of rainfall-runoff models and single-objective optimization/design of SCMs. The proposed framework establishes a transparent connection between the designed SCM parameter values and the multi-criteria evaluation of SCMs.

Given the local conditions of the analysed experimental urban catchment and considering additional criteria, the landscape-integrated SCMs (i.e., detention pond, infiltration trench, rain garden, bio-retention cell) were evaluated as more favourable measures as compared to the building-integrated SCMs (i.e., green roof, rainwater-harvesting storage tank), while at the same time providing similar hydrological performance (i.e., reduction of urban catchment outflow). The lowest score was achieved by the underground storage tank, representing grey infrastructure or centralized SCMs.

The developed knowledge library and conceptual models can be reused and reformulated according to a new task specification. This enables transferability of the proposed modelling approach to any urban catchment, which can be described well with the encoded domain knowledge.

Urban Circular Challenges

The following urban circularity challenges (UCC) for shifting to circular management of resources can be addressed with NBS (source: https://doi.org/10.1007/s43615-021-00024-1): Restoring and maintaining the water cycle (by rainwater management).

Duration: 1. 10. 2017 – 31. 9. 2021

Programme: Slovenian Research Agency, funding no. P2-0180.

University of Ljubljana
Faculty of Civil and Geodetic Engineering

DEPARTMENT OF KNOWLEDGE TECHNOLOGIES
Jožef Stefan Institute

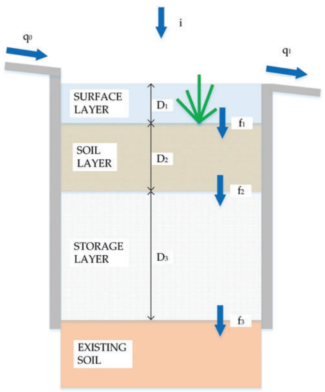
AUTOMATED MODELLING AND DESIGN OF URBAN STORMWATER CONTROL MEASURES

Matej Radinja[1,*], Mateja Škerjanec[1], Sašo Džeroski[2], Ljupčo Todorovski[2,3], Nataša Atanasova[1]

[1]Faculty of Civil and Geodetic Engineering, University of Ljubljana, Slovenia; [2]Department of Knowledge Technologies, Jožef Stefan Institute, Slovenia; [3]Faculty of Mathematics and Physics, University of Ljubljana, Slovenia; *Correspondence: matej.radinja@fgg.uni-lj.si;

1. Introduction

- **Stormwater control measures (SCMs)** are technical elements that are designed to prevent and mitigate the negative effects of uncontrolled stormwater flow.
- To investigate the impact of SCMs at different spatial scales, SCM models need to be integrated into catchments rainfall-runoff (RR) models.
- Approaches that include auto-calibration of the RR model and objective-driven automated SCM design can be of great assistance.



A conceptual model of a typical bio-retention cell.

2. Objectives

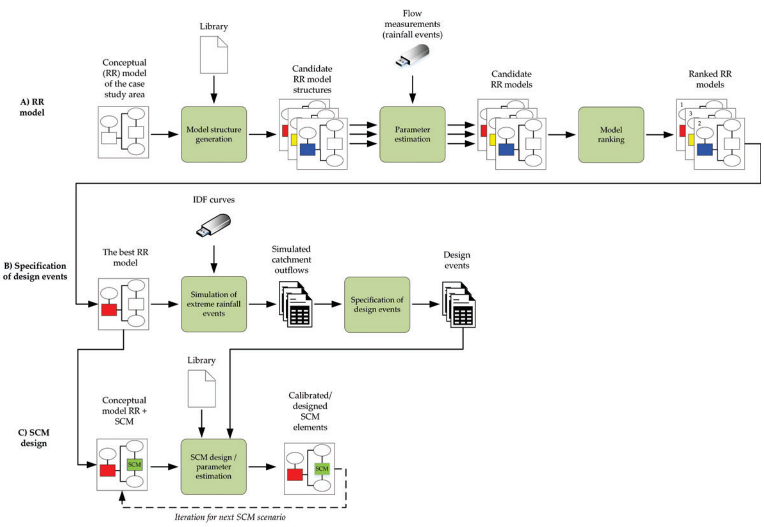
Overall project aim: to apply automated modelling (AM) to the field of urban drainage and optimal SCM design.

The specific research objectives:

1. To develop and construct a domain knowledge library for urban drainage modelling, including SCMs, fit for use with the **Process-based Modelling Toll (ProBMoT)** [1] for AM.
2. To develop a new methodology for AM of urban drainage processes and optimal selection of SCMs.
3. To test, validate and demonstrate the above new methodology on a real case study in Ljubljana.

3. Methods

- To use ProBMoT within the presented case study of RR modelling and SCM design, the steps presented in figure below were taken.



A schematic workflow for the rainfall-runoff (RR) model discovery and stormwater control measure (SCM) design using the automated modelling tool ProBMoT.

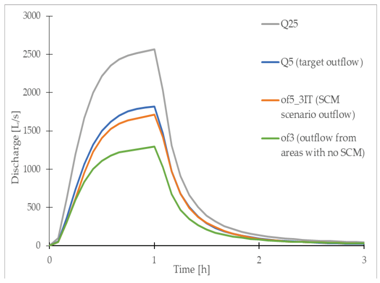
- A multi-criteria decision analysis (MCDA), which enables the assessment of the automaticaly designed SCMs with additional criteria (e.g., capital expenditure (CAPEX), operating expenses (OPEX), plant space …) was developed.

4. Results

The developed methodology was applied to an experimental urban catchment located in Ljubljana, Slovenia.
Catchment characteristics:

- Area: 30 ha;
- Land use: family houses with gardens;
- Mixed sewer system (lenght of 5.4 km).

Experimental urban catchment in Ljubljana, Slovenia.



The results of the 3IT scenario, which includes three types of an infiltration trench, for DE_Q5_P25.

SCMs were designed to retain the difference between outflows from the catchment provided by precipitation with 25 years return period (Q25) and 5 years return period (Q5, or the target outflow).

Considering additional criteria, the landscape-integrated SCMs (i.e., detention pond, rain garden, infiltration trench, bio-retention cell) were evaluated as more favourable measures as compared to the building-integrated SCMs (i.e., rainwater-harvesting storage tank, green roof), while at the same time providing similar hydrological performance (i.e., reduction of urban catchment outflow). The lowest score was achieved by the underground storage tank, representing grey infrastructure.

Performance of stormwater control measure (SCM) scenarios evaluated with additional criteria.

SCM Scenario	Criteria						MCDA (lower score – more favourable)
	Economics and land take			Co-benefits			
	CAPEX [€]	OPEX [€]	Land take [m²]	Retained water - water reuse [m³]	Detained water - water cycle [m³]	Plant space [%]	
3DP	330,012.29 €	16,448.93 €	1687	0	3765	10	1.44
3RG	775,704.87 €	29,169.53 €	4806	0	3271	20	1.83
3IT	703,671.26 €	1,421.59 €	2347	0	3314	0	1.89
3BRC	1,368,431.32 €	39,448.29 €	6500	0	3382	20	2.44
3RWH-ST	1,178,101.23 €	96,617.57 €	1500	3300	0	0	2.57
3GR	8,448,316.37 €	38,636.78 €	0	0	0	20	2.73
3UST	3,465,287.91 €	114,527.50 €	0	0	0	0	3.48

5. Conclusions

- The proposed modelling approach enables effective automation of two complex calibration tasks in the field of urban drainage, i.e., the calibration of rainfall-runoff models [2] and single-objective optimization/design of SCMs [3].
- The proposed framework establishes a transparent connection between the designed SCM parameter values and the multi-criteria evaluation of SCMs.
- The project presents an advance towards more comprehensive design and selection of SCMs, to provide as many co-benefits as possible and secure their full potential for urban areas.

References

[1] Džeroski, S.; Todorovski, L.; Čerepnalkoski, D.; Tanevski, J.; Simidjievski, N. Process-based modelling tool (ProBMoT) Available online: http://probmot.ijs.si/
[2] Radinja, M., Škerjanec, M., Šraj, M., Džeroski, S., Todorovski, L., Atanasova, N. 2021. Automated Modelling of Urban Runoff Based on Domain Knowledge and Equation Discovery. Journal of Hydrology. https://doi.org/10.1016/j.jhydrol.2021.127077
[3] Radinja, M., Škerjanec, M., Džeroski, S., Todorovski, L., Atanasova, N. 2021. Design and Simulation of Stormwater Control Measures Using Automated Modeling. Water. https://doi.org/10.3390/w13162268

Acknowledgements

This work was supported by the Slovenian Research Agency through research core funding no. P2-0180.

ID CARD – “Biochar for City Trees”

Title: Biochar in City Tree Substrates

Andreas Schönborn
ZHAW

Project contact: Andreas Schönborn
E-mail: andreas.schoenborn@zhaw.ch
Affiliation: Zurich University of Applied Science, Switzerland

Framework

In view of climate change and global urbanization, trees are increasingly becoming a central element of urban greenery. However, due to extreme site conditions in street spaces, many trees can no longer meet the demands placed on them. Urban trees increasingly suffer from stressors such as tree pits that are too small and restrict root growth, soil compaction in the root zone, pollutants in seepage water or the air, or a lack of nutrient salts such as potassium or phosphorus. Tree vitality is declining in urban areas due to a significant deterioration in growing conditions. Today's urban trees only achieve 50% of their life expectancy, and trees on street only achieve 25% due to site specific problems that affect their vitality.

In this study we tested the hypothesis, that structurally stable substrate (leading to much less soil compaction) combined with fecal-matter-based biochar (acting as additional water storage and nutrient supply) will lead to better growing conditions for city trees (1-year old birch seedlings). The biochar was produced at 550 ˚C from horse manure, plant residues and human feces. It was added to a novel, structurally stable tree substrate, based on 90% crushed granite gravel, 5% expanded shale (2–50 μm) and 5% sand (2–50 μm). Apart from the composition of the produced biochar, the leachate from the substrates and the health and growth rate of the birch seedlings were observed over a period of 322 days.

Objectives

- Technical feasibility of a novel, structurally stable and compactable tree substrate
- Use of nutrient-rich biochar as nutrient carrier and storage medium in this substrate
- Use of biochar produced from fecal material, hygienized and stabilized by a pyrolysis process at 550°C
- Demonstration of a possible model of the circular economy that improves the conditions for trees in cities

Outcomes

- Biochar-amended and structurally stable tree substrates can improve the conditions of city trees
- The main factor is the increased water retention capacity provided by the biochar
- Fresh, biochar-amended, structurally stable tree substrates leach easily soluble ions in the first 3–4 months
- Biochar from fecal matter may be a valuable option as nutrient source in structurally stable tree substrates
- The two fecal-based biochars complied with the European Biochar Certificate (EBC) guidelines
- The presence of the biochar in the substrates enhanced the survival rate of the birch trees

Urban Circular Challenges

The project addresses these circular challenges:

- Restoring and maintaining the water cycle (by rainwater management)
- Nutrient recovery and reuse

Duration: 2018-2021

Programme: Swiss Federal Office for the Environment (FOEN), UTF 570.28.17

Website: https://doi.org/10.1016/j.scitotenv.2022.156236

Life Sciences and Facility Management
Institute of Natural Resource Sciences

Biochar for City Trees

How to create good conditions for trees in future cities?

Contact:
Andreas Schönborn, Andrea Gion Saluz, Mira Bleuler
Zurich University of Applied Science, PO Box, CH-8820 Waedenswil, Contact: andreas.schoenborn@zhaw.ch

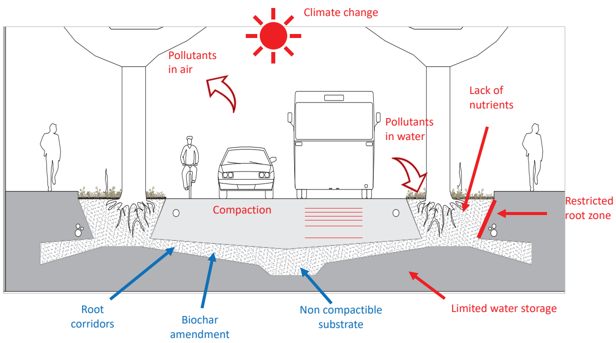
Zurich University of Applied Sciences
zh aw Life Sciences and Facility Management
Institute of Natural Resource Sciences
www.zhaw.ch/iunr

Funded by:
Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra
Bundesamt für Umwelt BAFU
Grant: UTF 570.28.17

Challenge

How to tackle these problems:

- Reduced life span, due to pollutants in air and water
- Restricted root zone, soil compaction,
- limited water storage, lack of nutrients….



Methods

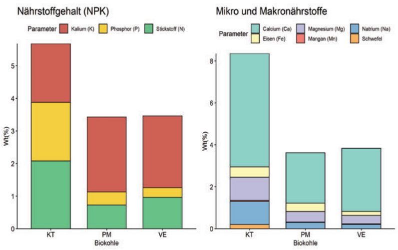
- structurally stable, non-compactable tree substrate
- + nutrient-rich biochar as nutrient carrier and storage medium…
- … from composting toilet substrate (KT) & horse manure (PM)
- … by slow pyrolysis at 550°C / 20 minutes
- 1 yr. old birch seedlings in 20-liter pots (5 replicates)
- watered manually, experiment in foil tunnel, over 322 days
- 19 parameters measured at different frequency

Parameter	Method	Frequency
pH, EC	Manual probes	every 2nd week
Na, NO3-, NH4, PO43-, K	Ion chromatography	4 x in 322 days
Cl, SO4, Mg,	Ion chromatography	5 x in 322 days
Non-purgeable organic C	TOC-L	At beginning and after 2 months
Total N	CHN analyzer	At beginning and after 2 months
Heavy metals	ICP-OES	1 x at beginning
PAK, PCB, PCDD/F (char)	External lab	1 x at beginning

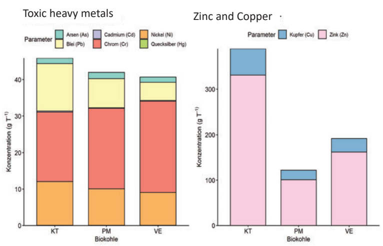
Parameter	Method	Frequence
Height	Maximum height (with meter)	Months 0, 6, end
Chlorophyll	Dualex Force A	At end of experiment
Root length	Maximum length (with meter)	At end of experiment
Root volume	Average 2 widths x length	At end of experiment
Stem shoots	Visual assessment	At end of experiment

Findings

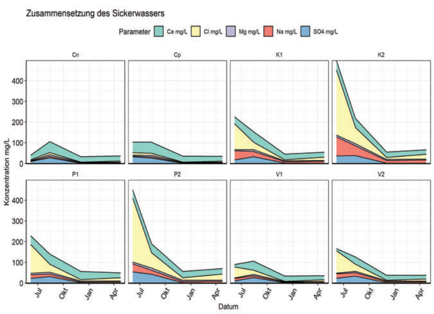
1 Composting toilet biochar: highest nutrient content



2 Heavy metals: Trace amounts (Cu + Zn are also nutrients)

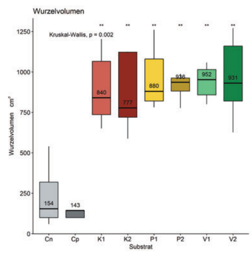


3 Leaching of ions in first three months, depending of BC content



4
- Seedlings survived and were healthier in presence of biochar
- No clear differences between the different biochar setups
- Roots of birch seedlings significantly larger in pots with biochar

Negative control — With horse manure biochar (5%) — Composting toilet biochar (5%) — Commercial wood chip biochar, loaded (5%)



Outlook

- Biochar presence improves survival rate of birch seedlings in structurally stable, non-compactable tree substrate
- Initial leaching will be an issue on large scale
- Promising approach to improve living conditions of city trees

Reference: https://www.sciencedirect.com/science/article/pii/S0048969722033332 (Saluz et al., 2022))

ID CARD – "ECOBUILT"

Title: Eco-friendly Built Environment

Jelena Ristic Trajkovic
University of Belgrade
Serbia

Project contact: Dr. Jelena Ristić Trajković
E-mail: jelena.ristic@arh.bg.ac.rs
Affiliation: University of Belgrade – Faculty of Architecture, RS

Framework

The ECOBUILT project responds to an increasing national and Europe-wide demand for professionals with a focus on sustainability who can manage the complexities of the planning process in various fields and at different scales.
The project involves three universities from various European regions and thus introduces the transnational dimension: Riga Technical University (coordinator), University of Genoa (Italy) and University of Belgrade (Serbia).

Objectives

- To design an integrated joint Master's programme in Eco-friendly Built Environment. The programme will be designed in cooperation with associate partners and will be practice-oriented on the one hand and flexible in terms of individualized learning paths, while on the other hand being adaptive in terms of inclusiveness;
- To develop common integrated regulations and rules concerning admission, selection, student performance, and degree awarding;
- To ensure QA of the programme with regard to current European Standards of QA;
- To develop a promotion strategy to recruit talented students from around the world.

Outcomes

The concept of the project is to develop an integrated Master's programme in Eco-friendly Built Environment aimed at training highly qualified professionals who will be able to design and restore buildings and landscapes in urban and rural settings with minimal impact on human well-being and the environment. The graduates, while having acquired basic/comprehensive knowledge and competences in Ecofriendly built environment (engineering module, circular economy module, sustainability module) will gain more specific skills in one of the programme concentration tracks: green architecture, urban design, landscape design, and renovation design.

Urban Circular Challenges

Select and select here the circular challenges addressed by the project, under the COST ACTION circular cities framework:
The following urban circularity challenges (UCC) for shifting to circular management of resources can be addressed with NBS (source: : https://doi.org/10.1007/s43615-021-00024-1):
.Restoring and maintaining the water cycle (by rainwater management)
.Water and waste treatment, recovery and reuse
. Nutrient recovery and reuse
.Material recovery and reuse
.Food and biomass production
.Energy efficiency and recovery
.Building system recovery

Duration: 1. Februar 2022 – 30. April 2023
Programme: Erasmus+ Programme (ERASMUS)
Website: under construction

Co-funded by the Erasmus+ Programme of the European Union

ecoBUILT

Enhancing Socially Responsible action and Approach to Nature-Based Solutions in Architectural Education within the framework of the Project:

Eco-friendly Built Environment

PROJECT TEAM FROM UNIVERSITY OF BELGRADE - FACULTY OF ARCHITECTURE:

project team member participating in Aarhus COST Event:
Dr. Jelena Ristić Trajković

other team members:
Dr. Ana Nikezić, Dr. Budimir Sudimac, Dr. Vladan Đokić, Aleksandra Milovanović, Dr. Aleksandra Đorđević, Dr. Mladen Pešić

Green architecture

Landscape design

Urban design

Renovation desing

The ECOBUILT highlights four conectration tracks: Green architecture, Landscape design, Urban design and Renovation design.

Framework

The ECOBUILT project responds to an increasing national and Europe-wide demand for professionals with a focus on sustainability who can manage the complexities of the planning process in various fields and at different scales.
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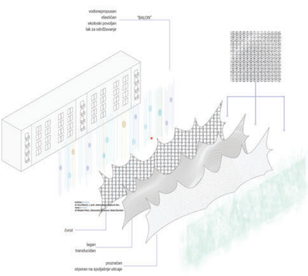
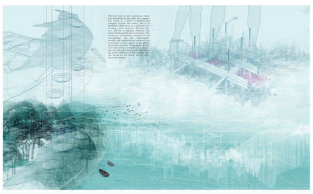
Examples of good practice at UB-FA



Extracurricular activity for architectural students of bachelor and master level / Student Workshop "Challenges of COVID-19: Architecture of Pandemic"

Extracurricular activity motivated by the COVID 19 crisis and which is based on the recognition of the importance of proactive approach and the effective search for appropriate reactions in a state of emergency as one of the leading challenges in light of the COVID-19 pandemic that the global population is facing.



Integrated single-cycle-5-year studies in architecture (IASA) / Design Studio Architecture and Nature

Compulsory studio design aimed at understanding the complexity and layering of the mutual influence of man and the environment, and reflecting on the potential of the relationship between man and nature through the disciplinary framework of architecture and especially the design process.

Educational initiative / "MY FIRST GARDEN - educational and didactic kit"

Implemented as a synergetic connection in-between two elective courses - cooperation between artistic and scientific disciplines: (1) course Urban Oasis in the field of Architectural Technologies (led by prof. B. Sudimac) and (2) course Art forms in the field of Visual Arts (led by prof. Br. Pavic).
"MY FIRST GARDEN - educational and didactic kit" is a set of collapsible elements for assembling a mobile garden according to the "do it yourself" principle.

Consortium members
■ Lead, ▲ ● Partners

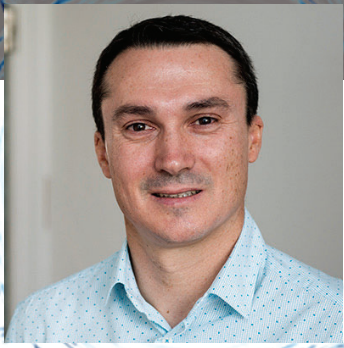
■	Riga	Riga Technical University, Latvia
●	Genova	Università degli Studi di Genova, Italy
▲	Belgrade	University of Belgrade – Faculty of Architecture, Serbia

The Project is funded by the European Union

ID CARD – "EOCRbyCW"

Emerging Organic Contaminants Removal by Constructed Wetlands: Comprehensive Meta-analysis and Development of Decision Support Tools

Huma Ilyas[1,2], Eric D. van Hullebusch[1]
[1]Université Paris Cité, Institut de physique du globe de Paris, CNRS, F-75005 Paris, France
E-mail: vanhullebusch@ipgp.fr
[2]Water Treatment and Management Consultancy, B.V., 2289 ED Rijswijk, The Netherlands
E-mail: hi.wtmconsult@gmail.com



Eric van Hullebusch
Institut de physique du globe de Paris

Framework

This research is based on the analysis of secondary data and a critical review of the published literature. Three global databases were compiled containing information of a large number of constructed wetlands (CWs) that were reported in several peer-reviewed journal publications with case studies from different countries, which are used for this research. The environmental risk posed by the examined types of emerging organic contaminants (EOCs) (pharmaceuticals, personal care products and steroidal hormones) was estimated as a risk quotient. The statistical comparison among different types of CWs for the removal efficiency of EOCs was done with one-way ANOVA and z-Test for comparison of means. Principle component, correlation and multiple linear regression analyses were carried out in the process of developing predictive models for the removal efficiency of EOCs based on their physicochemical properties, and design and operational parameters of CWs.

Objectives

(1) to analyze the effect of CWs design and governing factors on the removal of EOCs; (2) to investigate the prevalence of EOCs in the wastewater, and their fate and removal in CWs; (3) to develop predictive models for simulating the removal efficiency of different categories of EOCs based on their physicochemical properties; (4) to develop predictive models for simulating the removal efficiency of different categories of EOCs based on design and operational parameters of CWs; (5) to develop Decision Support Tools (DSTs) for the application of predictive models formulated based on physicochemical properties of EOCs, and design and operational parameters of CWs; and (6) to develop a decision tree framework to support design and operation of CWs for the removal of different categories of EOCs; and to develop a DST to generate data and information for the application of the proposed decision tree framework.

Outcomes

Four novel DSTs are developed: (1) REOCW-PCP for the potential application of predictive models formulated based on physicochemical properties of EOCs; (2) REOCW-DOP for the potential application of predictive models formulated based on design and operational parameters of CWs; (3) Decision tree framework, which is a very useful tool to improve the knowledge and applications for the removal of EOCs by different types of CWs; and (4) DTFT-CW to generate data and information for the application of the proposed decision tree framework.

Urban Circular Challenges

This PhD project addressed the following urban circularity challenge (UCC): **Water and waste treatment, recovery and reuse**

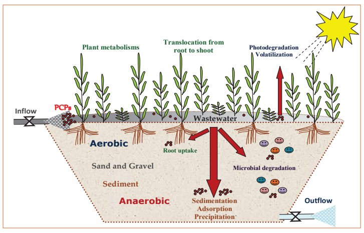
Duration: 2018-2021
Programme: PhD Research (the work presented in the poster is part of this PhD research)
Website: https://ed560.ed.univ-paris-diderot.fr/

The removal of personal care products by different types of constructed wetlands[a]

Authors: Huma Ilyas[1,2*], Eric D. van Hullebusch[1]
[1]Université Paris Cité, Institut de physique du globe de Paris, CNRS, F-75005 Paris, France
[2]Water Treatment and Management Consultancy, B.V., 2289 ED Rijswijk, The Netherlands
*Corresponding author email: hi.wtmconsult@gmail.com

Introduction

- **Sources of personal care products (PCPs) in water resources and environment**: domestic and industrial wastewaters, landfill leachates, and effluent discharge from wastewater treatment plants (WWTPs)
- **Concentration of PhCs in water resources:** from ng L^{-1} to µg L^{-1}, however, their continuous discharge to environment and water resources could pose risk for human as well as aquatic and terrestrial life
- **Constructed wetlands (CWs) for wastewater treatment:** low cost, environmentally friendly, and nature-based treatment technologies that have been extensively investigated for the removal of PCPs from the wastewater
- **Types of investigated CWs:** free water surface CW (FWSCW), horizontal flow CW (HFCW), vertical flow CW (VFCW) and hybrid CW (HCW)



A schematic representation of the removal mechanisms of PCPs in SSFCW

Research gaps filled by this study

- The detailed statistical analysis (e.g. meta-analysis) of available studies is lacking to ascertain significant differences in the performance of different types of CWs
- The environmental risk posed by PCPs and contribution of CWs in risk reduction was assessed by limited number of studies and also of a few PCPs

Main Objectives

1. **To assess the environmental risks posed by PCPs and the contribution of CWs in risk reduction**
2. **To conduct a comparative assessment of four types of CWs for the removal of PCPs**
3. **To analyze the effect of artificial aeration (AA) on the removal of PCPs in different types of CWs**

Methodology

Literature Review and data collection

- This research is based on the analysis of secondary data and a critical review of the published literature
- A global database was compiled containing information of 137 CWs that were reported in 39 peer-reviewed journal publications with case studies from 13 countries
- This database contains influent and effluent concentrations, removal efficiencies, and removal rates of 20 PCPs grouped to seven categories according to their uses

Statistical Analysis

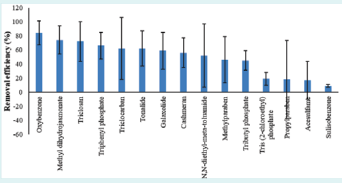
- The treatment performance of four types of CWs (FWSCW, HFCW, VFCW and HCW) was evaluated
- In some CWs, statistical comparison was done in two or three types of CWs (wherever sufficient data was available)
- Statistical analysis to estimate mean and standard deviation of the selected studied variables
- The comparison among CWs with one-way ANOVA for the significance or non-significance of observed differences and z-Test for comparison of means between two types of CWs

Results and Discussion

Effect of AA on the removal of PCPs by CWs

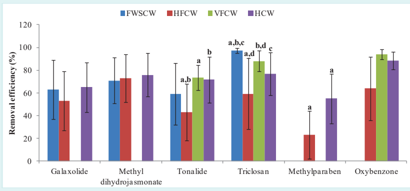
Removal efficiency of PCPs in different types of aerated (AA) and non-aerated (NA) CWs.

Removal of widely studied PCPs by CWs



Removal efficiency (mean and standard deviation) of 15 widely studied PCPs.

Statistical comparison of different types of CWs for PCPs removal



Removal efficiency of six selected PCPs with different types of CWs.

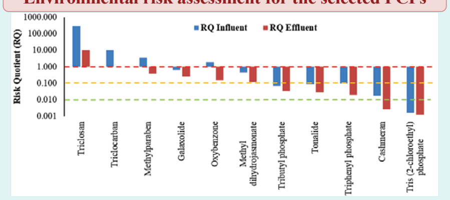
Note: Tonalide: 'a' shows that HFCW exhibits a significant difference from VFCW; 'b' shows that HFCW and HCW are significantly different from each other; Triclosan: 'a' shows that FWSCW exhibits a significant difference from HFCW; 'b' shows that FWSCW and VFCW are significantly different from each other; 'c' shows that FWSCW exhibits a significant difference from HCW; 'd' shows that HFCW and VFCW are significantly different from each other; Methylparaben: 'a' shows that HFCW exhibits a significant difference from HCW at α = 0.05 ($P < 0.05$).

Removal mechanisms of PCPs in CWs: In most of the examined PCPs, adsorption and/or sorption is the most dominant removal mechanism (eight out of 15 widely studied PCPs) followed by biodegradation (aerobic and/or anaerobic) (five out of 15 widely studied PCPs) and plant uptake (planted CWs) (two out of 15 widely studied PCPs).

Conclusions

1. CWs could effectively remove a large number of PCPs from the wastewater, and all of the 15 widely studied PCPs show a positive removal efficiency ranged from 9.0% to 84%.
2. In most of the examined PCPs, adsorption and/or sorption is the most dominant removal mechanism followed by biodegradation (aerobic and anaerobic) and plant uptake (planted CWs).
3. The six selected PCPs, which were studied by more than two types of CWs, demonstrate a moderate to high potential for successful treatment. Among the studied CWs, the HCW performed better for most of the examined PCPs followed by VFCW, HFCW, and FWSCW.
4. The improvement in dissolved oxygen (DO) due to redox manipulation with AA, enhances the removal efficiency of PCPs. This is evident by the enhanced removal efficiency in the case of AA-CWs compared with their corresponding NA-CWs.
5. The CWs contributed considerably in reducing the environmental risks posed by PCPs. Although the risk is not fully abolished by CWs, it is significantly reduced in most of the cases. The high risk PCP (triclosan) is recommended to be considered for regulatory monitoring, water quality standard formulation, and control purposes.

Environmental risk assessment for the selected PCPs



Risk quotient (RQ) of 11 selected PCPs based on the influent and effluent concentration in CWs.
Note: Risk is categorized into four levels: high risk (RQ > 1.0; above red line), medium risk (0.1 ≤ RQ ≤ 1.0; between red and orange line), low risk (0.01 ≤ RQ ≤ 0.1; between orange and green line), and no risk (RQ < 0.01; below green line).

Based on the effluent concentrations:

- Cashmeran and tris (2-chloroethyl) phosphate are classified as no risk PCPs
- Triclosan is assessed as high risk PCP, despite considerable risk reduction after the treatment
- Triclocarban, methylparaben, galaxolide, oxybenzone, and methyl dihydrojasmonate are classified under medium risk category
- Tributyl phosphate, tonalide, and triphenyl phosphate pose low risk

[a]**Ilyas, H.**, van Hullebusch, E.D., 2020. Performance comparison of different constructed wetlands designs for the removal of personal care products. *International Journal of Environmental Research and Public Health.* 17 (9), 3091, 1-26. DOI: https://doi.org/10.3390/ijerph17093091

ID CARD – "Chlorine2Biodiversity"




• **Contact persons:** Mónica López-Martínez[1,*]; Rocío Pineda-Martos[2]; Enriqueta Martín-Consuegra[1,3]; Bárbara Martínez-Escrich[1,*]

• **Institutions:** [1]IMGEMA – Royal Botanical Garden of Córdoba, Spain; [2]University of Seville, School of Agricultural Engineering (ETSIA-US), Spain; [3]University of Córdoba, School of Agricultural and Forestry Engineering (ETSIAM-UCO), Spain

Title: From Chlorine to Biodiversity – Transforming Urban Ponds

Project contacts: Mónica López-Martínez and Bárbara Martínez-Escrich
E-mails: herb.mlopez@jardinbotanicodecordoba.com; edu.bmartinez@jardinbotanicodecordoba.com
Affiliation: IMGEMA – Royal Botanical Garden of Córdoba, Spain

Framework

The project from Chlorine to Biodiversity aims to the naturalization of urban ponds, removing chlorinated water, and introducing aquatic species and algae in order to created a hot spot of biodiversity, imitating the typical ecosystems of Mediterranean ponds. In this way, it is not only possible to eliminate chemical compounds harmful to the environment and reduce water consumption, but also ecological restoration points are created in cities and small towns.

One of the greatest strengths of this Project is that the species used are autochthonous aquatic macrophytes and algae. This practice makes it possible to deal with the proliferation of invasive exotic plants.

The growing pollution of cities, the scarcity of water, and climate change can be tackled through urban policies and management strategies that consider green structures as backbones of the design of cities and villages.

Furthermore, naturalized ponds have been revealed as a novel and attractive instrument to explain the complex concept of Biodiversity.

Objectives

- Ecological objectives:
  - To create ecological restoration points in the city that provide ecosystem services;
  - To enhance water saving and eliminate chlorinated products from some water ponds;
  - To control the presence of haematophagous Diptera (mosquitoes) and green waters;
  - To identify promising native species to be used in urban gardening.
- Educational objectives:
  - To develop an educational programme to raise awareness and inform citizens.
- Social objectives:
  - To improve social welfare and generate new educational resources.

Outcomes

1. Naturalized ponds increase urban BIODIVERSITY exponentially, and control mosquito larvae proliferation. During the three years of the From Chlorine to Biodiversity project development, a total of 14 ponds have been naturalized.
2. Improvement of ECOSYSTEM SERVICES (Supply, Regulation/Maintenance and Cultural) in the city.
3. Impact on urban WATER MANAGEMENT: water savings and elimination of chlorinated products.
4. Improvement of social welfare and generation of new EDUCATIONAL resources. More than 2'000 children from schools have participated in the educational program; and many workshops have been held in schools and numerous scientific meetings, scientific and outreach talks.

Urban Circularity Challenges

The following urban circularity challenges (UCC) for shifting to circular management of resources can be addressed with NBS (source: https://doi.org/10.1007/s43615-021-00024-1):

UCC1 – Restoring and maintaining the water cycle (by rainwater management)
UCC2 – Water and waste treatment, recovery and reuse
UCC3 – Nutrient recovery and reuse
UCC5 – Food and biomass production

Duration: 2018-____
Programme: IMGEMA – Royal Botanical Garden of Córdoba, ES
Website: www.jardinbotanicodecordoba.com

AYUNTAMIENTO DE CÓRDOBA
IMGEMA INSTITUTO MUNICIPAL DE GESTIÓN MEDIOAMBIENTAL
DEL CLORO A LA BIODIVERSIDAD

FROM CHLORINE TO BIODIVERSITY: TRANSFORMING URBAN PONDS

Mónica López-Martínez[1,*], Rocío Pineda-Martos[2], Enriqueta Martín-Consuegra[1,3], Bárbara Martínez-Escrich[1,*]

[1,*]IMGEMA - Royal Botanical Garden of Córdoba, Herbario COA, Spain herb.mlopez@jardinbotanicodecordoba.com
[2]University of Seville, School of Agricultural Engineering (ETSIA-US), Spain rpineda@us.es
[3]University of Córdoba, School of Agricultural and Forestry Engineering (ETSIAM-UCO), Spain cr1mafee@uco.es
[1,*]IMGEMA - Royal Botanical Garden of Córdoba, Education Department, Spain edu.bmartinez@jardinbotanicodecordoba.com

FRAMEWORK

The main objective of this initiative is the naturalization of urban ponds, removing chlorinated water and introducing autochthonous aquatic species and algae in order to create a hot spot of biodiversity, imitating the typical ecosystems of Mediterranean ponds. In this way, it is not only possible to eliminate chemical compounds harmful to the environment and reduce water consumption, but also ecological restoration points are created in cities and small towns.

One of the greatest strengths of this project is that the species used are autochthonous aquatic macrophytes and algae. This practice makes possible to deal with the proliferation of invasive exotic plants.

The growing pollution of cities, the scarcity of water and climate change can be tackled through urban policies and management strategies that considers green structures as backbones of the design of cities and villages.

Furthermore, naturalized ponds have been revealed as a novel and attractive instrument to explain the complex concept of Biodiversity.

OBJECTIVES

Ecological objectives

- To create ecological restoration points in the city that provide ecosystem services.
- To enhance water savings and eliminate chlorinated products from some water ponds.
- To control the presence of haematophagous Diptera (mosquitoes) and green waters.
- To identify promising native species to be used in urban gardening.

Educational objectives

- To develop an educational programme to raise awareness and inform citizens.

Social objectives

- To improve social welfare and generate new educational resources .

METHODOLOGY

STEP 1

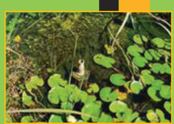
- Emptying of the fountains
- Chlorine removal

STEP 2

Benthos formation:
- 10 cm fertile soil
- 20 cm of washed river sand
- Dry planted of marsh species

STEP 3

- Slow filling of well water
- Planting of floating rooter



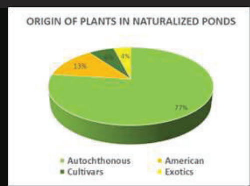
STEP 4

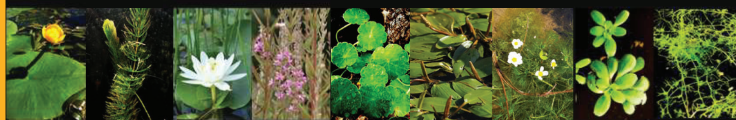
- Planting of meadows of strict hydrophytes and carophytes
- Maintenance: mechanically remove the filamentous algae and pose of marshes

FLORA

We are currently working with 60 Iberian species, some of which are of special interest as they are on red lists or are protected species as *Nymphaea alba* and *Utricularia asutralis*.

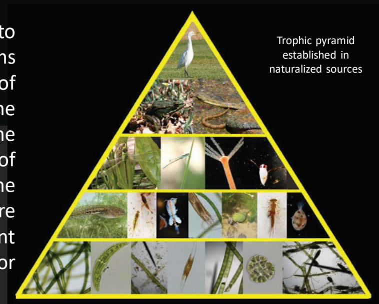
One problem could be the proliferation of filamentous algae belonging to the genera *Spyrogina* and *Phytophora*.





FAUNA

In a few months we were able to identify more than 50 micro-organisms (rotifers, ostracods, copepods) all of them responsible for maintaining the crystallinity of the water. The soundscape created by the croaking of frogs and, also the reproduction of the water snake *Natrix maura* are particularly noteworthy. An important food resource has also been created for the birds.



OUTCOMES

1. Naturalized ponds increase urban BIODIVERSITY exponentially and control mosquito larvae proliferation. In the three years project development, a total of 14 ponds have been naturalized.
2. Improvement of ECOSYSTEM SERVICES (Supply, Regulation/Maintenance and Cultural) in the city.
3. Impact on urban WATER MANAGEMENT: water savings and elimination of chlorinated products.
4. Improvement of social welfare and generation of new EDUCATIONAL resources. More than 2'000 schoolchilds have participated in the educational programme, many workshops have been held in schools, and numerous scientific meetings, science and outreach talks.

Change experienced in a pond after being naturalized

Different moments of an educational activity

URBAN CIRCULARITY CHALLENGES

(Atanasova *et al.*, 2021)

- UCC1 – Restoring and maintaining the water cycle (by rainwater management)
- UCC2 – Water and waste treatment, recovery, and reuse
- UCC3 – Nutrient recovery and reuse
- UCC5 – Food and biomass production

Atanasova, N., Castellar, J.A., Pineda-Martos, R. *et al.* Nature-Based Solutions and Circularity in Cities. *Circ. Econ. Sust.* **1**, 319–332 (2021). https://doi.org/10.1007/s43615-021-00024-1

Coast to Coast Climate Challenge
COST EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY
Circular City circular-city.eu
Implementing nature-based solutions for creating a resourceful circular city
COST Action CA17133 Circular City workshop
Coast to Coast Climate Challenge & The European Science Network "Circular City"
DONE. WHAT'S NEXT?
18 – 19 September 2022, Aarhus, Denmark
DEL CLORO A LA BIODIVERSIDAD
IMGEMA INSTITUTO MUNICIPAL DE GESTIÓN MEDIOAMBIENTAL

M. López-Martínez, R. Pineda-Martos, E. Martín-Consuegra, B. Martínez-Escrich

ID CARD – HOUSEFUL

Title: HOUSEFUL - Innovative circular solutions and services for new business opportunities in the EU housing sector

Gaetano Bertino . alchemia-nova

Project contact: Gaetano Bertino
E-mail: gaetano.bertino@alchemia-nova.net
Affiliation: alchemia-nova GmbH

Framework

At EU level, the housing sector is responsible for 9% of GDP, but it also uses 50% of the extracted materials, 40% and 30% of available energy and water respectively, aside from causing 30% of total waste and 35% of green-house gas emissions. The HOUSEFUL project targets the uptake of circular buildings in the housing sector by designing innovative interventions for efficient management of materials, waste, water and energy along the entire housing value chain. This will be done by demonstrating the feasibility of an integrated systemic service composed of 11 circular solutions, to be demonstrated in four different buildings located in Vienna and nearby Barcelona.

Objectives

HOUSEFUL's main objectives are:

- To develop a methodology to quantify the degree of building circularity at different stages along their life cycle;
- To demonstrate and validate the project's methodology at lab scale and, in 4 selected buildings, at large scale;
- To assess the potential environmental and socioeconomic impacts of the demonstrated circular strategies;
- To ensure the marketability of HOUSEFUL's circular solutions as an integrated systemic service and the development of a Software as a Service for replication of services in the housing sector;
- To deliver policy recommendations at local, regional, national and EU scale to foster circularity in housing;
- To raise awareness and acceptance of HOUSEFUL services among the public and relevant stakeholders to foster their replication.

Outcomes

HOUSEFUL's interventions are expected to have the following impacts:

- Reduction in the use of resources (materials, energy and water) in the housing sector;
- Reduction of waste destined to landfills (from current 40% to 10% in 10 years);
- Recovery of >95% of food waste at home level;
- Recycling of >90% of rainwater, greywater and blackwater for production of reclaimed water and biogas;
- Production of high-quality biogas (>90% conversion yield) as renewable heat and/or power at home level;
- High quality compost production from digestate (approx. 0.55 kg compost/kg digestate);
- Reduction of non-renewable primary energy consumption of buildings up to 50%;
- Reduction of up to 60% of CO_2 emissions.

Urban Circular Challenges

- Building system recovery
- Water and waste treatment, recovery and reuse
- Nutrient recovery and reuse
- Material recovery and reuse
- Energy efficiency and recovery

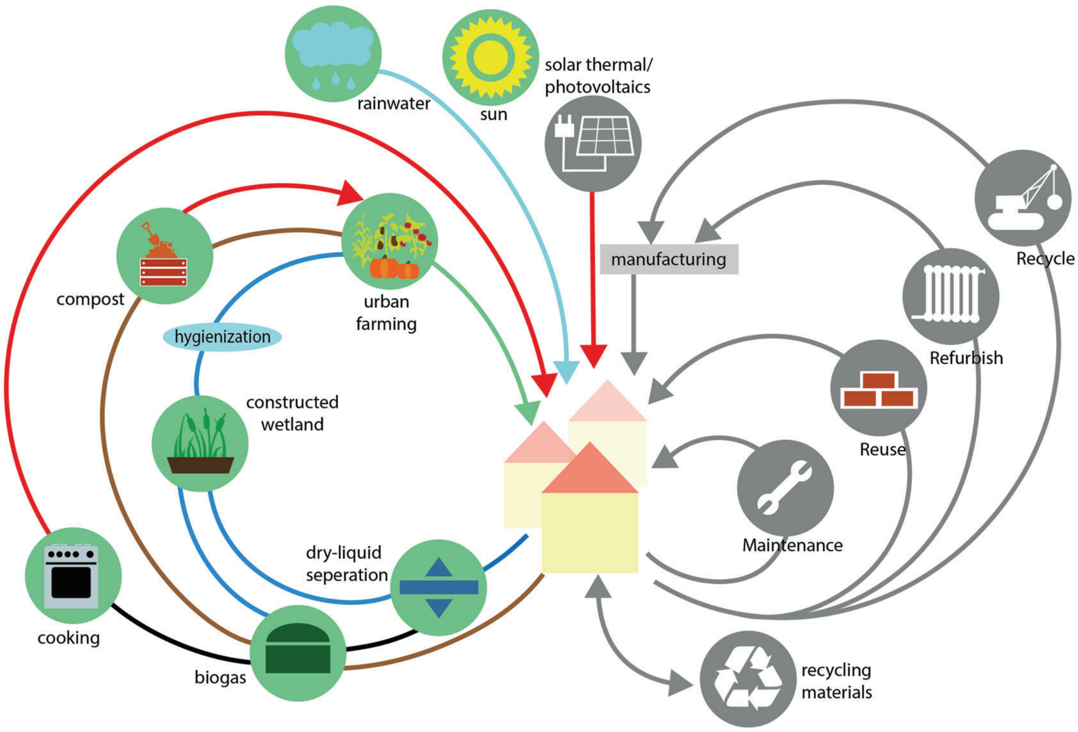
Duration: 2018-2023
Programme: H2020 GA N°776708
Website: www.houseful.eu

HOUSEFUL

alchemia nova

H2020 Project HOUSEFUL

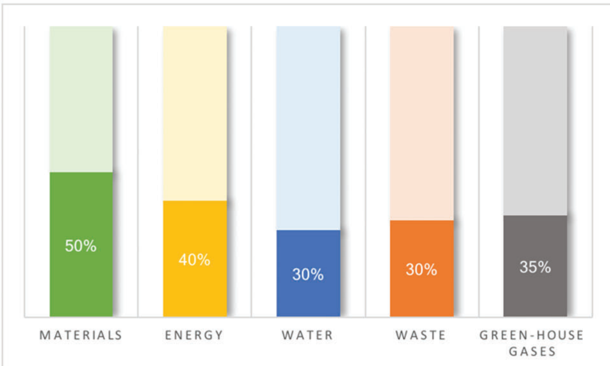
Innovative circular solutions and services for new business opportunities in the EU housing sector

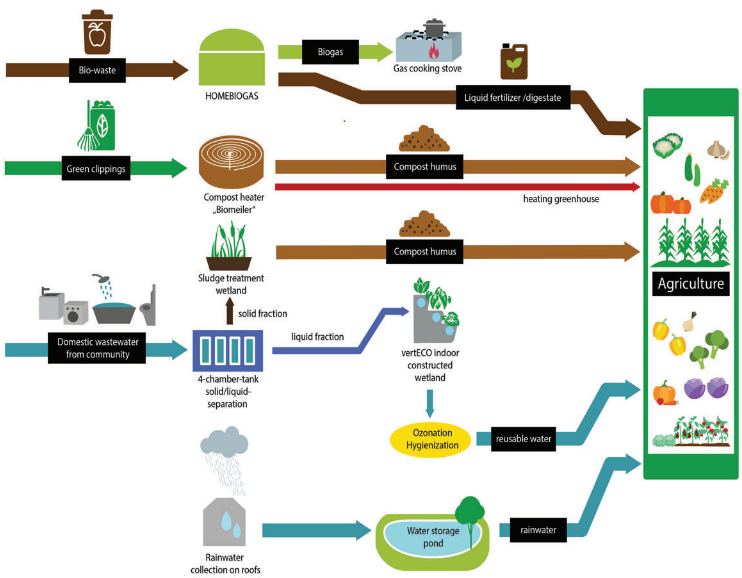


Objectives

- Circular management
- Resource recovery
- Efficient use of water, waste, energy and material resources
- Replication as Circular Economy Business Opportunities

Input and Output of the building sector





Technical solutions

- Separation of liquids/solids from waste-water
- Treatment of liquids in NBS
- Production and storage of biogas
- Air treatment in winter-garden
- Material passport & BIM
- Materials upcycling
- Nutrient-rich waste-water for green-house
- Compost cultivator
- Sourcing 2nd hand circular building materials
- Energy efficient façades & roofs
- Energy production in buildings

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 776708

www.alchemia-nova.net

ID CARD – "ICWMOM"

Investigation of Circular Water Management Opportunities on Multisectoral (Urban, Industry and Agriculture) Scale: Küçük Menderes River Basin Case Study

Istanbul Aydın University

Project contact: Dr. H.Volkan Oral
E-mail: volkanoral@aydin.edu.tr
Affiliation: Istanbul Aydın University

Framework

The Project has been prepared in accordance with the content and scope of the Working Group 2 on "Sustainable Urban Water Management", which is included in the COST ACTION named "Circular City (CA17133)".

Objectives

The project aims to develop circular water management opportunities and thus efficient water use among urban, industrial and agricultural water users in the Kücük Menderes River Sub-Basin located in the Western Part of Turkey.

Outcomes

Suggesting new methods and strategies to prevent water losses in the perspective of circular water management in the basin is one of the most important outcomes of the project.

Urban Circular Challenges

The Project will deal with water and waste treatment, recovery and reuse that is relevant to UCC in the COST ACTION CA 17133

Duration: 2022- 2024
Programme: TUBITAK COST 2519
Website: nbs.aydin.edu.tr

COST ACTION 17133 «Circular City Re.Solution» Workshop Meeting 18-19 September 2022, Aarhus, Denmark

TÜBİTAK

cost EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

Investigation of Circular Water Management Opportunities on Multisectoral (Urban, Industry and Agriculture) Scale: Küçük Menderes River Basin Case Study

Hasan Volkan Oral, Özge Çakır Lafçı, Hülya Boyacıoğlu, Deniz Dölgen, Mustafa Onur Önen, Emrah Alkaya, Sena Uzunpınar, Necdet Alpaslan, Hasan Saygın.

TUBITAK 2519 COST WORKING GROUP RESEARCH SUPPORT PROGRAMME
Project No: 121 Y 570

Abstract

This Project aims to develop circular water management opportunities and thus efficient water use among urban, industrial and agricultural water users in the Kücük Menderes River Sub-Basin. The unique value of the presented project proposal is that it brings a different and new scientific approach to water management, emphasizing circularity instead of the usual linear water use approaches on the axis of city-industry-agriculture. For this purpose, it is predicted that a unique theoretical and methodological solution can be developed to reduce water constraint problems in basins by integrating water footprint, pinch analysis, and nature-based solutions (NBS) approaches into the management model in an integrated manner.

METHODOLOGY

•*Current Situation Analysis* stage: The characterization of the basin will be revealed, NBS potential will be investigated, water use, and urban/industrial wastewater profile will be determined. The data obtained from these studies will lay the inventory groundwork for the development of circular water management opportunities considering the axis of city-industry-agriculture, by revealing the characteristics of the basin, water use and users (ICWMOM, 2021)

•*Performance Evaluation and Suggestion Development* stage*:* Water efficiency and circularity key performance indicators (KPI) will be defined, and circularity analysis of water-intensive users will be carried out. Circular water system suggestions will be developed and, their effects will be evaluated (ICWMOM, 2021).

•*Method/Procedure Development* stage: The circular water management framework will be developed in order to make the studies specific to the Küçük Menderes River Sub-Basin applicable in other basins, and it will be ensured to be repeated in different users or regions, so the outputs of this project will gain a sustainable dimension (ICWMOM, 2021).

Study Area

The study is carried out in the Kucuk Menderes River Sub-Basin, where is located in the Western Part of Turkey.

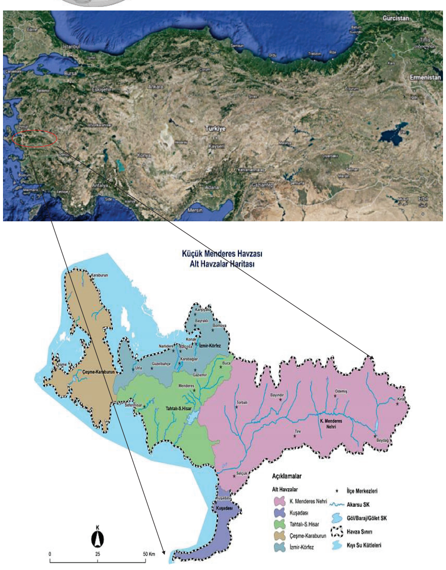


Fig. 1. Study Area (SYGM, 2019)

Study Steps

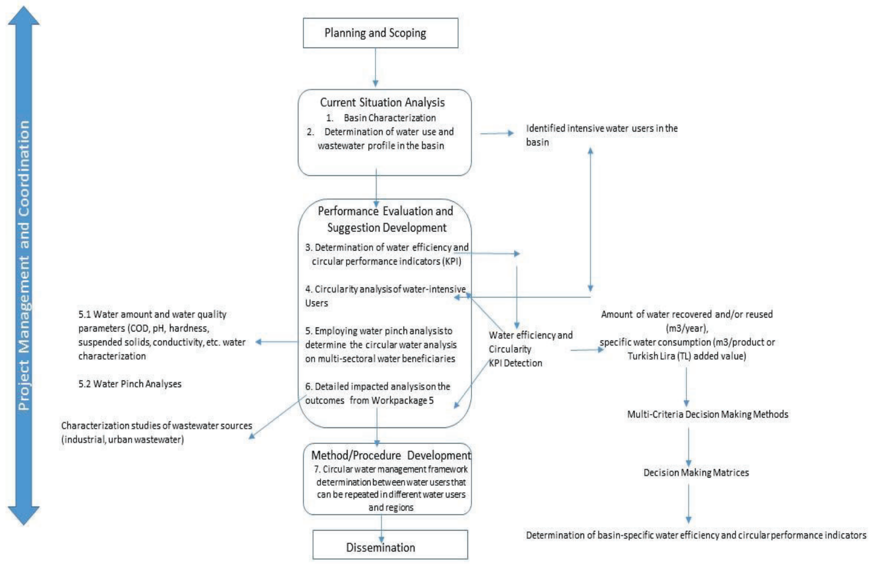


Fig. 2. **Project Study Steps**

Preliminary Results

On August 15–16, 2022, a field trip study (Figure 2) was conducted in the study area to collect data for the current situation analysis stage. Organizations that fall under the sectors of industrial, agricultural, and urban water consumers were interviewed by addressing the questions presented on Figure 5.

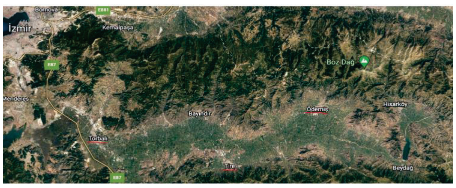


Fig. 3 Field Trip Visiting Locations (Districts of Torbalı – Ödemiş and Tire)

The preliminary results revealed that milk production progress (Figure 4) in the River Basin consumes a significant amount of water, and they exploited the natural water resources such as groundwater indiscriminately to meet their need. On the other hand, it has been noted that majority of the agricultural producers use uncontrolled wild irrigation rather than drip irrigation from the water provided by the DSI (State Hydraulic Works).

Fig.4 – Project Team visit at Tire Milk Production Facility.

COST 2519 Program TUBITAK 121Y570 Project

Developing Cyclic Water Management Opportunities on a Multisectoral (Urban, Industry and Agriculture) Scale: The Example of Küçük Menderes River Basin

Stakeholder Interviews Semi-structured Interview Questions

1. Corporate Information

Corporate Information	
Name of Institution/Organization:	
Institution / Organization Address:	
Name and surname of the officer who answered the questions:	
Position in the Relevant Institution:	
Contact information (email and phone):	
Interview Date and Time:	

2. Current Situation and General Evaluation

Current Situation and General Evaluation		
The sector in which the Institution/Organization is located (with NACE code, if known)	NACE Code: ○ Industry ○ Agriculture ○ farming ○ Urban Services	○ Mining ○ Energy ○ Tourism ○ Other (please explain)
Brief information about production/service processes		
The current state and characteristics of the water source (available water quantity, quality, etc.)		
Annual water use/consumption amount (m^3/year)	Ground-water:	
	Surface water (dam, lake, stream, etc.):	
	Municipal mains water:	
	OSB mains water:	
	Other (please explain):	

Fig.5 –. The interview questions addressed to water consumers.

References

- . ICWMOM, (2021). Investigation of Circular Water Management Opportunities on Multisectoral (Urban, Industry and Agriculture) Scale: Küçük Menderes River Basin Case Study Project Application Document
- SYGM (2019) https://webdosya.csb.gov.tr/db/scd/icerikler/ek-1-kucuk-menderes-scd-raporu-2021-20210924140435.pdf

ACKNOWLEDGEMENTS

The Project Team would like to express their sincere gratitudes to TUBITAK (Project No: 121 Y 570) for the financial support.

ID CARD – "KREIS-Haus"

Title: KREIS-Haus – Experiencing circular systems from lab to field

Project contact: Devi Bühler
E-mail: devi.buehler@zhaw.ch
Affiliation: Research associate, project manager

Zurich University of Applied Sciences

Framework

Since the building sector is responsible for 40% of the worldwide resource and energy consumption, the scientific community constantly develops new circular technologies, materials, and concepts for buildings. However, it takes a long time for this fundamental research to be applied broadly in practice. A reason for this is that there is often too great of a risk of implementing unproven innovations in practice. The KREIS-Haus fills this gap between research, industry and stakeholders by providing a space to try out new circular technologies and materials and presenting them to the public as an inhabited model house.

Objectives

The KREIS-Haus is both a vacation home and a practical laboratory in one. From the building materials to the nutrients in the wastewater – everything is in circulation. The special thing about it: visitors can try out themselves living in the house for a few nights. By doing so, they become part of the research at the interface between technology and the users. KREIS-Haus stands for the terms „Klima und Ressourcen-Effizientes Suffizienz Haus", which is German for „climate and resource efficient sufficiency house". The aims of the project are: (i) to foster research and development on circular technologies and building materials, (ii) to gain a better understanding of socio-economic drivers for circular building, (iii) to raise awareness about circular building in the larger public, and (iv) to initiate a dialogue among stakeholder.

Outcomes

KREIS-Haus was built in 2021 and is in operation since September 2021. Already the planning and construction phase allowed to gain a deeper insight into the barriers and drivers associated to circular building. Particularly the lack of markets and professional knowledge were identified as main barriers. The circular technologies, such as the closed water cycle or the energy concept, are still being tested and evaluated. Preliminary results indicate that the KREIS-Haus can be operated fully water self-sufficient under the given conditions and produces over the year four times more solar electricity than used.

Urban Circular Challenges

.Restoring and maintaining the water cycle (by rainwater management)
.Water and waste treatment, recovery and reuse
.Nutrient recovery and reuse
.Material recovery and reuse
.Food and biomass production
.Energy efficiency and recovery
.Building system recovery

Duration: 2020 - 2023
Programme: Several funding sources
Website: www.zhaw.ch/iunr/kreishaus

Zurich University of Applied Sciences

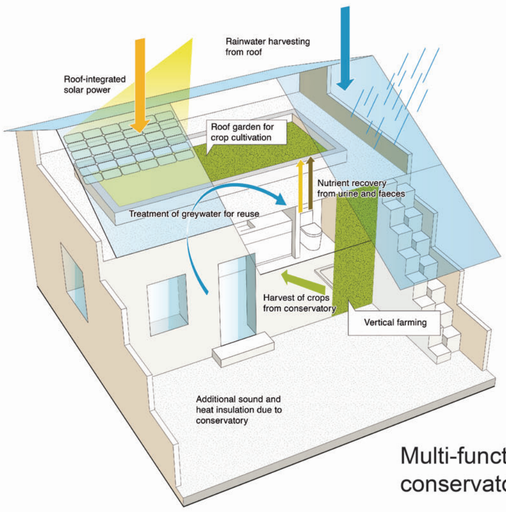
Life Sciences and Facility Management

Institute of Natural Resource Sciences

SYNERGY VILLAGE

KREIS-Haus

Experiencing circular systems from lab to field



Multi-functional conservatory

What is KREIS-Haus?

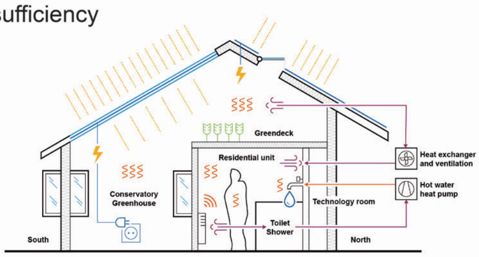
The KREIS-Haus is both a vacation home and a practical laboratory in one. As a research project for circular building and living, innovations are tested in practice and made accessible to the public. From the building materials to the nutrients in the wastewater – everything is in circulation. The special thing about it: visitors can try out themselves living in the house for a few nights. By doing so, they become part of the research at the interface between technology and the users. KREIS-Haus stands for the terms „Klima und Ressourcen-Effizientes Suffizienz Haus", which is German for „climate and resource efficient sufficiency house".

How does KREIS-Haus work?

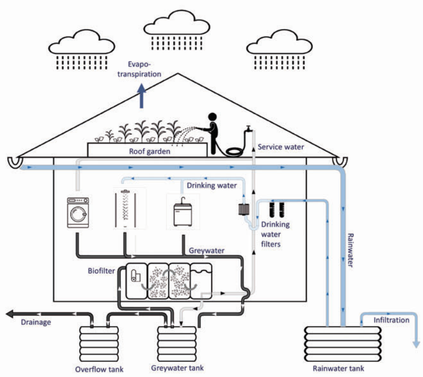
- The house consists of a residential unit with sanitary facilities and an adjacent multi-functional conservatory respecticely greenhouse.
- Natural building materials (such as clay and wood) as well as durable, recycled and reused materials (such as second-hand windows and recycled glass shards for the floor) were used for the construction.
- The dry separating toilet saves water and allows for nutrients to be reclaimed and used as fertilizer in the rooftop garden.
- Rainwater from the roof is stored in a tank under the house and after treatment used as drinking water. Lightly polluted greywater from the kitchen and bathroom is biologicaqlly treated in the building and used for irrigation of the roof garden and for the washing machine.
- Semi-transparent solar panels are integrated in the roof of the conservatory and produce the required electricity for the house. Any surplus electricity is stored in Second-Life batteries.
- The house is heated by the hot air accummulating in the conservatory and a solar-powered infrared heating.
- The entire house is built on a screw foundation without the use of concrete.

Contact

Devi Bühler
Zurich University of Applied Sciences
Institute of Natural Resource Sciences
8820 Wädenswil, Switzerland
devi.buehler@zhaw.ch



Energy concept



Water concept

ID CARD – “NBS for flood protection”

Title: Land Restoration as a NBS to reduce the flood and drought risk

. David Christian Finger
Reykjavik University

Project contact: Davic Christian Finger
E-mail: davidf@ru.is
Affiliation: Reykjavik University, Iceland

Framework

Ecosystems that are in equilibrium provide vital resources to local inhabitants, including protection from naturally occurring disasters. Natural vegetation cover has been optimized over many years to retain a maximum of rainfall runoff by increasing the field capacity (FC) of the soil cover, securing water availability during droughts and reducing the flood risk during heavy precipitation events. In this project we investigate the effects of ecosystem restoration on the runoff dynamics of rainfall water in Rangárvellir, a restoration area in southern Iceland. The Rangárvellir area presents ideal conditions for such investigations. Dramatic deforestation during the last millennium and year round livestock grazing along with devastating ash depositions during volcanic eruptions and a harsh sub-polar oceanic climate have led to severe degradation in Rangárvellir. Since the beginning of the 20th century diverse restoration measures have been implemented making Rangárvellir an ideal case study to investigate the effects of restoration on hydro-meteorological risk reduction. More information about ongoing research can be found here: http://rangarvellir.ru.is/

Objectives

The objective of the project is to assess and quantify the evolution of water resources in Rangárvellir by assessing the runoff dynamics in the main rivers of Rangárvellir under four main scenarios:
1) present conditions, 2) degraded conditions as was the case 100 years ago, 3) under hypothetical fully restored ecosystems and, finally, 4) under conditions of a scenario developed in collaboration with local stakeholder groups to optimize socio-ecological benefits. For this purpose the dynamics of the relevant hydrological processes in the area (incl. river runoff, ground water table, snow cover duration, and soil moisture dynamics) will be reconstructed using hydrological models to run the above mentioned scenarios. The scientific findings and conclusion of this project will generate valuable insights on the effects of land restoration on hydro-meteorological risk reduction. The presentations will outline the main methods used during the project and conclude by providing an outlook on the expected results.

Outcomes

Preliminary results reveal that land restoration and reforestation significantly increases the water holding capacity. This will reduce the floods peak during heavy precipitation events and decelerate the water depletion of the aquifer during droughts. Furthermore, numerous beneficial side effects can be observed, ranging from reduced water and wind erosion, to increased biodiversity and significant carbon sequestration, to name just the most important ones.

Urban Circular Challenges

The following urban circularity challenges (UCC) for shifting to circular management of resources can be addressed with this project (source: : https://doi.org/10.1007/s43615-021-00024-1):

- Restoring and maintaining the water cycle (by rainwater management)
- Nutrient recovery and reuse
- Food and biomass production

Duration: 2015-present
Project Website: http://rangarvellir.ru.is/
University Website: https://www.ru.is/

Land Restoration as a NBS to reduce the flood and drought risk

CA17133 - Implementing nature based solutions for creating a resourceful circular city (Circular City Re.Solution) 18-19 September 2022, Aarhus, Denmark

David Christian Finger, davidf@ru.is
Reykjavik University, Menntavegi 1 102 Reykjavík, Iceland

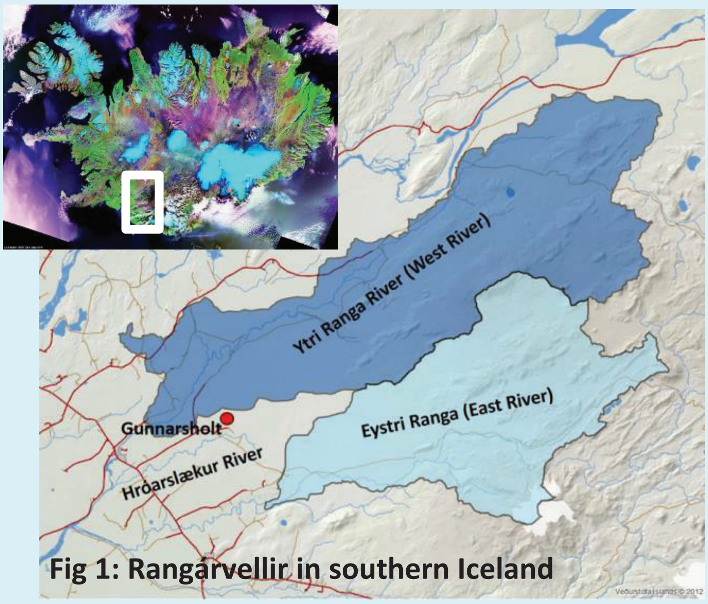


Fig 1: Rangárvellir in southern Iceland

Restoration as a NBS for flood protection

In this project we investigate the effects of ecosystem restoration on the runoff dynamics of rainfall water in Rangárvellir, a restoration area in southern Iceland. Since the beginning of the 20th century diverse restoration measures have been implemented making Rangárvellir an ideal case study to investigate the effects of restoration on hydro-meteorological risk reduction. More information about ongoing research can be found here: http://rangarvellir.ru.is/v

The human interaction

- Intense grazing, e.g. horse and sheep grazing
- Deforestation
- Climate change impacts

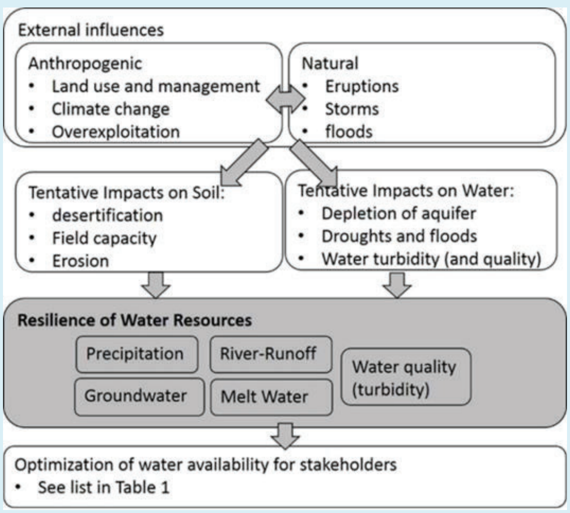


Fig 2: Schematic human interaction

Objective: Quantify the effects of restoration

The following scenarios are being investigated:

- present conditions (Fig 3a)
- degraded conditions as was the case 100 years ago (Fig 3b)
- under hypothetical fully restored ecosystems (Fig 3c)

Fig 3: Vegetation in Rangárvellir

Results:

- Water budget (Fig.4): complex volcanic geology
- Grazing (Fig. 5) impacts erosion
- Restoration takes a long time (Fig. 6)

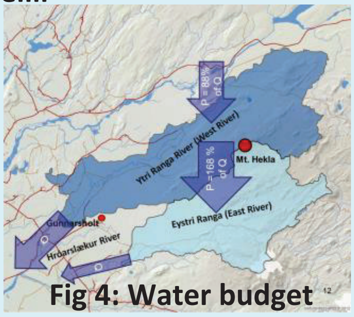


Fig 4: Water budget

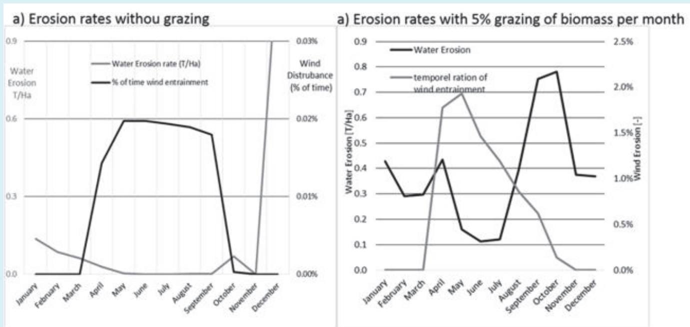


Fig 5: Erosion rates

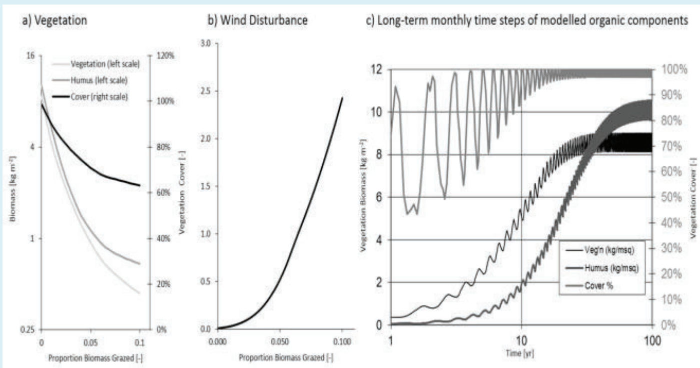


Fig 6: Restoration process

Conclusion:

- Restoration is a NBS for flood and drought protection, but clear trends take a long time
- Numerous beneficial side effects can be observed, e.g. reduced erosion, enhanced biodiversity, carbon sequestration

ID CARD – MULTISOURCE

MULTISOURCE

Title: ModULar Tools for Integrating enhanced natural treatment SOlutions in URban water CyclEs

Project coordinator: Jaime Nivala
E-mail: jaime.nivala@inrae.fr
Affiliation: INRAE, France

MULTISOURCE

Pedro Carvalho (Aarhus University)
Fabio Masi (IRIDRA)
Joaquim Comas (ICRA)
Maria Wirth (Alchemia Nova)

Framework

Increasing urbanization poses a range of challenges worldwide. To satisfy their water demand, cities rely on extensive supply infrastructure to transfer water over long distances. This limits the resilience of cities against the effects of climate change because the infrastructure cannot be easily or cost-effectively adapted, expanded, or repaired. Therefore, the integration of decentralized approaches into existing centralized infrastructure is essential for achieving sustainable, efficient, and affordable water resource management, increased water reuse, and establishing a circular water economy.

Objectives

NATURE-BASED SYSTEMS	Demonstrate enhanced nature-based systems in operational environments for a wide range of polluted urban waters
NBS TECHNOLOGY	Develop state-of-the- art guidance for NbS technology selection and preliminary design
CITY-WIDE SCALE NBS	Provide comparative spatial environmental and economic scenarios for implementing NbS on a city-wide scale
URBAN WATER TOOLS	Engage urban water stakeholders in the development of urban water planning tools
GOVERNANCE & POLICIES	Improve urban governance and policies related to NbS and water reuse

Outcomes

MULTISOURCE will facilitate the systematic, city- wide planning of nature-based solutions for urban water treatment, storage, and reuse. With seven technical pilots across Europe and USA, a wide range of urban waters will be treated throughout the project, and decision support tools will be co-designed together with the cities of Girona, Oslo, Lyon and Milan as well as other local, national, and international stakeholders.
MULTISOURCE will demonstrate the benefits of increased water quality, water storage, reuse, but also contribute to the creation of valuable urban habitats and the provision of other important ecosystem services.

Urban Circular Challenges

Restoring and maintaining the water cycle (by rainwater management)
Water and waste treatment, recovery and reuse

Duration: 2021-2025
Programme: H2020-SC5-2020-2
Website: https://multisource.eu/

MULTISOURCE

Coordinator: INRAE | 20 Partners | 12 Countries | 7 Pilots | €5,169,165.00 | 2021 - 2025

MULTISOURCE will facilitate the systematic, citywide planning of nature-based solutions for urban water treatment, storage, and reuse. With seven technical pilots across Europe and USA, a wide range of urban waters will be treated throughout the project, and decision support tools will be co-designed together with municipality partners in Girona, Oslo, Lyon and Milan as well as other local, national, and international stakeholders.

MULTISOURCE will demonstrate the benefits of increased water quality, water storage, reuse, but also contribute to the creation of valuable urban habitats and provide other important ecosystem services.

OBJECTIVES

- Nature-based systems
- NBS technologies
- City-wide scale NBS
- Urban water tools
- Governance and policy

7 TECHNICAL PILOTS

RAW WASTEWATER
Location: Lyon, France
Technology: Rhizosph'air aerated french wetland
Main innovation: Compact (<1m2/PE*), new design guidance; innovative/ICT monitoring approaches

PRE-TREATED WASTEWATER
Location: Leper, Belgium
Technology: Phytoparking®
Main innovation: Compact (<1m2/PE*) can be retrofit in parking lots and provide secondary use for parking

COMBINED SEWER OVERFLOW
Location: Merone, Italy
Technology: Aerated + free water surface wetland
Main innovation: Increase urban resilience to extreme events, reduce pressure on sewers; new NBSWT market opportunities

HIGH-STRENGTH WASTEWATER
Location: Bozeman, USA
Technology: VF wetland with recycle and partial saturation
Main innovation: Seasonal operation, recirculation for increased nutrient removal from high-strength wastewater

RAINWATER
Location: Leipzig, Germany
Technology: Green roof + storage (five variations)
Main innovation: Improvement of evaporation efficiency and biodiversity via vegetation selection and management

ROAD RUNOFF
Location: Oslo, Norway
Technology: Raingarden, water-treatment, storage and potential irrigation
Main innovation: Exploring possibilities for alternative water sources for irrigating urban green areas. Demonstrating the use of innovative sorption materials for water treatment.

GREYWATER
Location: Girona, Spain
Technology: Aerated + free water surface wetland
Main innovation: Increase urban resilience to extreme events, reduce pressure on sewers; new NBSWT market opportunities

INRAE · INSA · INRAE transfert · GRANDLYON la métropole · UFZ HELMHOLTZ Centre for Environmental Research · AARHUS UNIVERSITY · Rietland · Oslo · NIVA Norwegian Institute for Water Research · IRIDRA · alchemia nova · Ajuntament de Girona · FORUM ZA ENAKOPRAVEN RAZVOJ · ICLEI Local Governments for Sustainability · ICRA Catalan Institute for Water Research · Water Europe Technology & Innovation · Città metropolitana di Milano · UNIVERSIDADE FEDERAL DE SANTA CATARINA · MONTANA STATE UNIVERSITY · BK TP.HCM

www.multisource.eu · MultisourceEU
info@multisource.eu · Multisource-eu

This project has received funding from the European Union's Horizon H2020 innovation action programme under grant agreement 101003527.

ID CARD – "MacGroves" - Macao Mangroves

Title: Nature-based solutions for a cleaner and safer Macao

Project contact: Karen Araño Tagulao
E-mail: karentagulao@usj.edu.mo
Affiliation: Institute of Science and Environment, ISE—University of Saint Joseph, Macao SAR China

. Cristina Calheiros
. USJ &CIIMAR

Framework

This projects aims to investigate ways in which nature-based solutions (NBS) can be applied to enhance the water quality and availability of coastal waters in Macao, and take advantage of the ecosystems services that they provide. The application of NBS for water may also generate co-benefits in the city such as the reduction of water-related risks (e.g. flooding due to impact of storm surge), ecosystems rehabilitation and maintenance as well as enhancement and protection of biodiversity in the local coastal wetland ecosystems. To accomplish this, both scientific investigations and public awareness activities are being carried out.

Objectives

1. To assess native wetland plant species that can be utilized for phytoremediation.
2. To investigate the efficiency of the selected wetland plants (mangroves, etc.) in the removal of water pollutants.
3. To promote nature-based solutions for water concept through information campaigns and activities.

Outcomes

Funded by Clean the World foundation and Las Vegas Sands, this project is developed within the framework of the Drop by Drop Project that reinvests capital from water stewardship efforts into innovative projects.

Urban Circular Challenges

The following urban circularity challenges (UCC) for shifting to circular management of resources can be addressed with NBS:
.Restoring and maintaining the water cycle (by rainwater management)
.Water and waste treatment, recovery and reuse
.Nutrient recovery and reuse
.Material recovery and reuse
.Food and biomass production
.Energy efficiency and recovery

Duration: 2021-2022

Programme: Clean the World foundation and Las Vegas Sands supports the project being developed within the framework of the Drop by Drop Project.

Website: https://ise.usj.edu.mo/research/projects/nature-based-solutions-for-a-cleaner-and-safer-macao/

Mangroves as nature based solution providing ecosystem services in urban context towards circularity

Karen Araño Tagulao[1], Wai-Ian Lai Vanessa[1], Cristina S. C. Calheiros[1,2]

[1] Institute of Science and Environment, ISE—University of Saint Joseph, Macao SAR China. karentagulao@usj.edu.mo

[2] Interdisciplinary Centre of Marine and Environmental Research (CIIMAR/CIMAR), University of Porto, Portugal; cristina@calheiros.org

Framework

Macao, a coastal city situated on the west shore of the Pearl River is home to several species of mangroves. The Pearl River Delta (PRD) Economic Zone is one of the most industrialized regions in the world and several studies indicate significant levels of aquatic pollutants in the area. Eutrophication is one of the most serious water pollution problems in the PRD mainly due to anthropogenic causes. Eutrophication index in Macao, especially in the Inner Harbor area, indicated a significant increasing trend in the last 5 years. This is mainly due to the direction of water flow, topographical conditions and inputs of pollutants from upstream. Although regular monitoring of nitrogen and phosphorus pollution are being carried out in Macao, no studies have been reported so far on the use of nature–based solutions to address this issue. Based on modelling studies, the area is also vulnerable to flooding due to impact of sea level rise and predicted precipitation rates in the region.

Mangroves and Ecosystem Services

Mangroves are a group of trees and shrubs that live in the coastal intertidal zone, being found along tropical and sub-tropical coastlines, with a particularly heavy presence in Asia, followed by Africa and South America. Mangrove forests form a unique wetland ecosystem that are well-adapted to living in saline (salty) and brackish environments. They are thus one of the most important coastal ecosystems in the world, providing a wide variety of ecosystems services. They are considered as natural wastewater treatment plants because of their ability to filter and/or uptake pollutants in the water. In a coastal urban context, they provide reduction of water-related risks, ecosystems rehabilitation and maintenance as well as enhancement and protection of coastal erosion.

WOOD 木材
Its density makes mangrove wood a valued source of timber and fuel.
高密度的紅樹林是優質的木材及燃料來源。

LIVELIHOODS 生計
120 million people living near mangroves.
約有12億人居住在紅樹林附近。

MANGROVE ECOSYSTEM SERVICES 紅樹林生態系統服務
Worth US$ 33,000-57,000 per ha per year x 14 million ha = to US$ 800 billion per year.
每公頃價值約33,000-57,000美元，全球共1400 萬公頃，因此其總價值約為每年8000億美元。

CLIMATE REGULATION 氣候調節
Carbon storage potential of mangroves is 3-5x higher than that of tropical upland forest due to strong carbon storage in the soil, CO_2 released by global mangrove loss annually could be as high as the annual emissions of Australia.
紅樹林土壤強大的儲碳能力使其儲碳潛力比其他熱帶森林高出整整3-5倍，每年全球因失去紅樹林而造成的二氧化碳排放量差不多等於一個澳大利亞的年排放量。

COASTAL PROTECTION 海岸保護
Restoring mangroves for coastal defence up to 5x more cost- - effective than “grey infrastructure” such as breakwaters.
以紅樹林來保護海岸的成本效益比建設防波堤等“灰色基礎設施”高出足足5倍。

WATER FILTRATION 水淨化
2-5 ha of mangroves may treat the effluents of 1 ha of aquaculture.
每2-5公頃的紅樹林可以處理近1公頃由水產養殖業所產生的廢水。

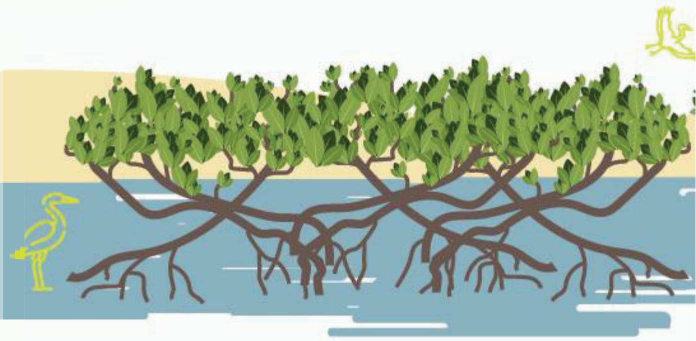
TOURISM 旅遊
There are over 2,000 mangrove related attractions globally, such as boat tours, boardwalks, kayaking and fishing.
全球約有2,000多個與紅樹林相關的旅遊項目，包括遊船、木棧道游、划艇和釣魚等。

FISHERIES 漁業
More than 3,000 fish species are found in mangrove ecosystems.
超過3000多種的魚類生活在紅樹林中。

Ongoing Work

This study, aims to evaluate the ability of mangroves to remediate nitrogen and phosphorus pollution in Macao’s coastal waters. It also explores other co-benefits, like coastal protection, through wave tank experiments.

This is an ongoing work that will bring new insights on nutrient pollution (nitrogen and phosphorus enrichment) along various locations (with and without mangroves) in Macao’s coastal waters as well as results of mesocosm experiments to evaluate specific nutrient uptake capabilities of local mangroves species.



Acknowledgements

Authors are thankful for the funding support by Clean the World foundation and Las Vegas Sands to the project “Nature-based solutions for a cleaner and safer Macao”, being developed within the framework of the Drop by Drop Project. Calheiros C. is thankful to FCT—Fundação para Ciência e Tecnologia within the scope of UIDB/04423/2020 and UIDP/04423/2020.

ID CARD – "KO-TRANSFORM"

Novel Pathways to Achieving Agreement in the Transformation of Urban Spaces for Water Management and Climate Adaptation

Katharina Kearney, Institute of Sanitary Engineering and Water Pollution Control

Project contact: Katharina Kearney
E-mail: katharina.kearney@boku.ac.at
Affiliation: Institute of Sanitary Engineering and Water Pollution Control, University of Natural Resources and Life Sciences Vienna (BOKU)

Framework

With climate change progressing, communities around the world are facing serious challenges related to changing precipitation patterns and an increase in days with record high temperatures. To mitigate the effects of a changing climate and to combat the heat, cities, and communities are increasingly turning to Blue-Green-Brown Infrastructure (BGB-I) and Urban Green Spaces (UGS) as sustainable, multi-functional solutions. Benefits of these interventions include improved micro-climates through evapotranspiration (ET) and shade provision, improved biodiversity, contributions to stormwater management through retention and infiltration, improved air quality as well as enhanced well-being of urban dwellers. Current experiences with BGB-I and UGS implementation in cities suggest that their long-term success and acceptance rely on the active involvement of citizens, the end-users, throughout all stages of the decision-making and implementation process. The limited space in urban areas is often subject to conflicting interests and ideas of different stakeholder groups, and due to their relative novelty, BGB-I and UGS may be met with skepticism.

Objectives

In the KO-TRANSFORM project, a method for better consensus building in the climate-sensitive transformation of urban water systems and green space management was tested in a multi-stage co-creation process with the municipality of Gleisdorf. For this purpose, the method of Quantitative Storytelling was combined with a subsequent multi-criteria decision analysis conducted by the local stakeholders using an online tool for ranking different measures according to their personal preferences.

Outcomes

Two participatory workshops were held in the community to facilitate transdisciplinary collaboration on climate change adaptation and to generate ideas and preferences regarding the transformation of urban green and open spaces. A particular focus was on using Blue-Green-Brown infrastructures in urban water management adaptation and as measures for enhancing livability in public spaces. These measures were generally considered attractive and effective by stakeholders. However, they were not universally regarded as desirable solutions for the city of Gleisdorf. Regulatory restrictions, competing uses of the limited space in the settlement area, and diverging ideas and desires regarding the design and feel of the cityscape were identified as key challenges in the context of climate adaptation measures during the participatory process.

Urban Circular Challenges

.Restoring and maintaining the water cycle (by rainwater management)

Duration: 01.11.2021-01.10.2022
Programme: StartClim2021/22
Website: https://startclim.at/projektliste

KO-TRANSFORM

Novel Pathways to Achieving Agreement in the Transformation of Urban Spaces for Water Management and Climate Adaptation

Katharina Kearney, MSc.[*1], Prof. Dr. Thomas Ertl[*1], Lisa Waldschütz, BSc.[*1], Prof. Daniela Fuchs-Hanusch[*2], DI Anika Stelzl[*2], DI Martin Regelsberger[*3]

*1 University of Natural Resources and Life Sciences, Vienna (BOKU)

*2 Graz University of Technology

*3 Technisches Büro für Kulturtechnik Regelsberger

Contact: katharina.kearney@boku.ac.at

Introduction

With climate change progressing, communities around the world are facing serious challenges related to changing precipitation patterns and an increase in days with record high temperatures. To mitigate the effects of a changing climate and to combat the heat, cities are increasingly turning to **Blue-Green-Brown Infrastructure (BGB-I)** and **Urban Green Spaces (UGS)** as sustainable, multi-functional solutions for climate adaptation.

Benefits of these interventions include improved micro-climates through evapotranspiration and shade provision, improved biodiversity, contributions to stormwater management through retention and infiltration, improved air quality as well as enhanced well-being of urban dwellers.

KO-TRANSFORM seeks to find new pathways to achieving consensus in the transformation of urban spaces, helping communities to improve participation and decision-making processes for climate adaptation [2,3,4].

Figure 1: Main topics in KO-TRANSFORM project

A multi-stage participatory approach was used in the case study municipality of Gleisdorf, with the following goals:

1. Test out Quantitative Storytelling method
2. Develop new pathways for urban water management and green space design
3. Raise awareness around the topic of climate adaptation in Gleisdorf

Figure 2: Main goals in KO-TRANSFORM project

Work Packages and Case Study

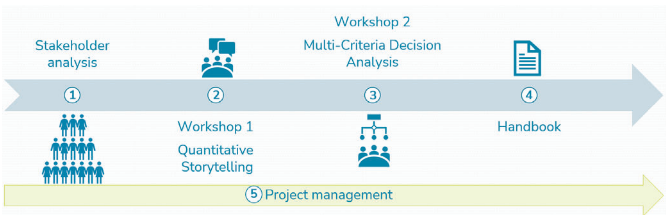


Figure 3: Workpackages and steps in KO-TRANSFORM project

The project duration is 10 months, and the starting date was in **November 2021**. After an initial introduction to the city of Gleisdorf, the multi-stage process was initiated with a detailed stakeholder analysis.

Local decision-makers, housing developers, property owners and members of the general public were invited to take part.

WP 1: Stakeholder analysis

Figure 4: Steps in stakeholder analysis and interviews conducted

Acknowledgements & Financial Support

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umweltbundesamt — PERSPEKTIVEN FÜR UMWELT & GESELLSCHAFT

WP 2: Quantitative Storytelling

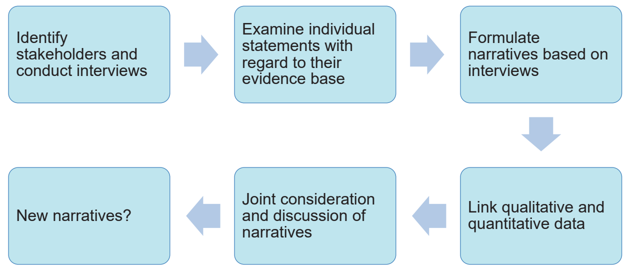

Figure 5: QST steps based on Cabello et al. 2021

- Analysis of interview transcripts
- Formulation of four distinct narratives
- Illustration of narratives for handout

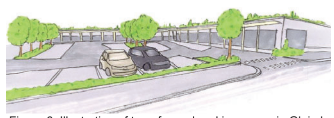

Figure 6: Illustration of transformed parking space in Gleisdorf – Anika Stelzl

Case Study City – Gleisdorf, Styria

Population ca. **11,000**

Steady population growth with accompanying pressure to provide adequate housing while still offering green spaces for leisure and recreation has caused conflicts in spatial planning decisions.

Issues such as zoning, building plans and new housing developments have become topics of dispute between local decision-makers, housing developers, property owners and stakeholders in the general population.

Figure 7: Illustration Gleisdorf main square – Anika Stelzl

Preliminary results

Participants were asked to develop concrete adaptation options for specific sites in the town (Workshop 2). The proposed sites were:

- Main Square
- Settlement area & school center
- Shopping center
- Industrial area

5 transformation options for these sites were then transferred to an online tool for performing the Analytical Hierarchy Process. 3 criterions were used to compare each of the transformation options based on the participants wishes and priorities:

1. Approaching the natural water balance
2. Increasing quality of stay & life
3. Minimizing the degree of soil sealing

"**Increasing quality of stay & life**" came out as the most important criterion, and the option "**more life in the main square**" scored as the most favorable option in this study.

Challenges encountered in participatory process include:

- Shared responsibilities
- Declining stakeholder interest as the project progresses
- Unspoken expectations, concerns, or questions
- Lack of commitment and time as limiting factor
- Dealing with dual roles in the community
- Strongly diverging feelings of concern and personal affectedness

References

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ID CARD – PQAP

Porto Fifth Facade Project

Project contact: Cristina Calheiros[1,2], Beatriz Castiglione[1], Paulo Palha[1]
E-mail: ccalheiros@ciimar.up.pt
Affiliation: [1]Portuguese National Association of Green Roofs, Portugal & [2]Interdisciplinary Centre of Marine and Environmental Research (CIIMAR/CIMAR), University of Porto, Portugal

Framework

Porto Fifth Facade Project (Projeto Quinto Alcado do Porto-PQAP) resulted from the collaboration between the Portuguese Association of Green Roofs (ANCV) and Porto City Council, Portugal. This was an innovative consultancy project, since it was the first time that a City Council in Portugal has manifested its will to include green roofs in the urban planning documents of the city.

From the beginning of the project, special attention was given to the performance of the green roofs, since it is important to define what kind of green roof are wanted in cities, according to the services they can offer and the different environmental needs for each city. The project began in August 2016 and was attended by a large group of people from different departments of the Porto City Council, as well as different universities, foreign municipalities, the European Federation of Green Roofs and Walls Associations, and the World Green Infrastructure Network, among other institutions. The Project was then delivered in August 2017 and is currently under evaluation by the different sectors of the municipality, in order to decide if it will become a policy and in what way.

Objectives

The PQAP had the objective to define which models the municipality of Porto should follow in order to include green roofs into the urban planning, environmental, and climate change strategy of the city.

Outcomes

It is essential that the inclusion of green roofs in a city is accompanied by a strategy of dissemination and environmental education that shows the population, and the different groups of professionals related to the theme, the diverse and significant benefits they offer.

Main outcomes comprise: selection of municipal buildings to receive green roofs, strategies to promote green roofs in Porto and publication of technical documents (good practices of design, installation, and required performance of green roofs)

Urban Circular Challenges

The following urban circularity challenges (UCC) for shifting to circular management of resources can be addressed with NBS:

.Restoring and maintaining the water cycle (by rainwater management)
.Material recovery and reuse
.Food and biomass production
.Energy efficiency and recovery
.Building system recovery

Duration: 2016-on going
Website: https://www.greenroofs.pt/en/pqap

ANCVGREENROOFS.PT
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ciimar

Nature Based Solutions towards responsible cities: Green roofs in urban planning

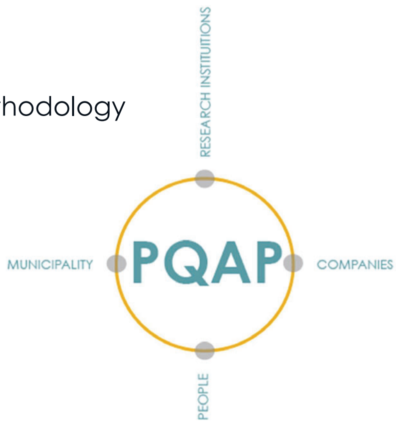
Cristina S. C. Calheiros[1,2], Beatriz Castiglione[2], Paulo Palha[2]
[1]CIIMAR - Interdisciplinary Centre of Marine and Environmental Research of the University of Porto, Portugal.
E-mail: cristina@calheiros.org
[2]Portuguese National Association of Green Roof, Portugal. E-mail: baseancv@greenroofs.pt, presidencia@greenroofs.pt

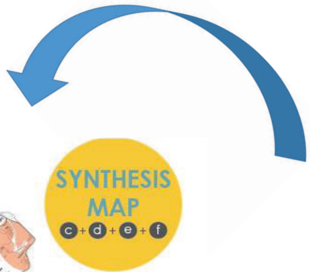
The evidence of many services that green roofs can bring to the urban environment makes them part of the environmental strategy of modern cities. There is an absolute need to introduce the green roofs in the cities, demonstrating the urgency to consider vegetation as a mandatory building material.
The importance of collaborative projects between entities are of great relevance to promote the inclusion of Nature based solutions in cities. Example of this is the PQA project between the **Portuguese National Association of Green Roof (ANCV)** and the **Porto City Council (Portugal).** This was the first time that a City Council in Portugal has manifested its will to include green roofs in the urban planning documents of the city.

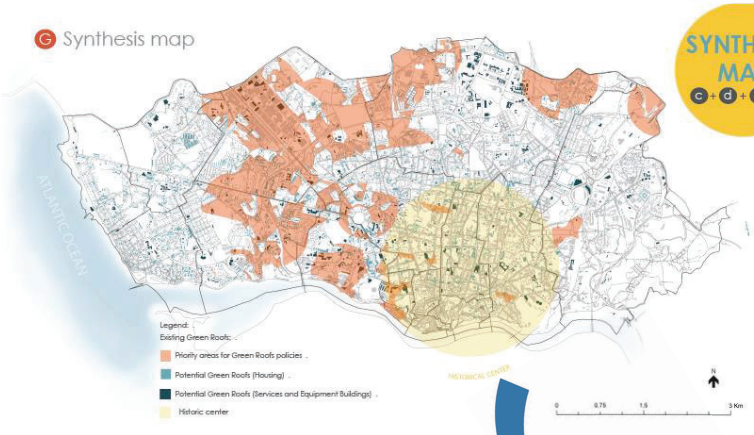
ANCV
Is a NGO-Non-Governmental Organization, which aims to promote green infrastructures in cities, especially those that can be installed in buildings (new or pre-existing) such as green roofs, highlighting their enormous importance, and the numerous contributions they can give to the possibility to create healthy, sustainable, biodiverse and resilient urban territories.

PQAP -"Projeto Quinto Alçado"/ "Porto Fifth Facade Project"
Which models the Porto city council should follow to include green infrastructures, in particular green roofs, into the urban planning, environmental and green spaces strategy of the city.

Methodology







Geographic Information System (GIS)
» the potential of the buildings of Porto to receive GR
» the priority areas of the city to receive GR

Outcome
. Selection of municipal buildings to receive green roofs
. Strategies to promote green roofs in Porto
. Publication of technical documents (good practices of design, installation, and required performance of green roofs)

Reference
Calheiros C.S.C., Castiglione B., Palha P. 2022. Chapter 14-Nature-Based Solutions for social and environmental responsible new cities: the contribution of green roofs. In: Circular Economy and Sustainability, Volume 2. Editors: Stefanakis A. & Nikolaou I. Elsevier. Pp: 235-255, ISBN 9780128216644, doi.org/10.1016/B978-0-12-821664-4.00015-7.

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Circular City
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ID CARD – "SantUrbLab"


• ***Contact persons:*** Enriqueta Martín-Consuegra[1,2] and Rocío Pineda-Martos[3]

• ***Institutions:*** [1]University of Córdoba, School of Agricultural and Forestry Engineering (ETSIAM-UCO), Spain; [2]IMGEMA – Royal Botanical Garden of Córdoba, Spain; [3]University of Seville, School of Agricultural Engineering (ETSIA-US), Spain

Title: Implementing nature-based solutions in "Santuario" Neighbourhood

Project contacts: Enriqueta Martín-Consuegra & Rocío Pineda-Martos
E-mails: cr1mafee@uco.es; rpineda@us.es
Affiliations: ETSIAM-UCO; IMGEMA; ETSIA-US

Framework

The Sanctuary Neighbourhood Association (Asociación Vecinal Santuario, A.VV. Santuario) – located in the city of Córdoba, Spain – has established a network with the IMGEMA - Municipal Institute of Environmental Management, Royal Botanical Garden of Córdoba for mutual collaboration of interest and advice on the management of privately owned urban green spaces, although for public use, placed in the neighbourhood. The condition of these green spaces – *i.e.*, private for public use – are not exclusive to this neighbourhood as they are distributed throughout different areas of the city and cause certain management inconveniences to the neighbours. According to the General Urban Planning Plan (PGOU) – general planning instrument defined in the urban regulations of Spain, and the document that governs the urban evolution of the city –, these spaces are called as "Open Planning" and generate others "Private Zones for Public Use". These urban green spaces have been implemented among buildings accepting synonymous as: internal access roads, passageway, footpath, or pedestrian street; being usually defined as those spaces for public use, intended for the circulation of pedestrians or vehicles which provide access to internal areas of a plot or block – *e.g.*, streets, gardens, and open spaces. Affected associations of neighbours acquire land of their property but that can and must be used by all citizens.

Objectives

- To recommend strategies on nature-based solutions (NBS) implementation to better assist the Sanctuary Neighbourhood Association requirements.
- To develop a management plan for the enhancement of private green spaces in the neighbourhood.

Outcomes

(2021 – 2022)

- Current diagnosis – *i.e.*, inventory of green spaces, planimetry, and technical sheets of plant species; and
- Recommendation on implementing innovative NBS to address urban circularity challenges (UCCs) and climate change mitigation and adaptation, following the recently published framework of the COST Action CA17133 Circular City (https://doi.org/10.3390/w13172355).

Urban Circularity Challenges

The following urban circularity challenges (UCCs) for shifting to circular management of resources can be addressed with NBS (source: https://doi.org/10.1007/s43615-021-00024-1):

- UCC1 – Restoring and maintaining the water cycle (by rainwater management)
- UCC2 – Water and waste treatment, recovery and reuse
- UCC3 – Nutrient recovery and reuse
- UCC5 – Food and biomass production
- UCC6 – Energy efficiency and recovery
- UCC7 – Building system recovery

Duration: 2021-_
Programme: —
Website: https://zonascomunessantuario.wordpress.com/

Implementing nature-based solutions for creating a resourceful circular city - COST Action CA17133 workshop
Coast to Coast Climate Challenge & The European Science Network "Circular City" - DONE. WHAT'S NEXT
18 – 19 September 2022, Aarhus, Denmark

SantUrbLab – Implementing nature-based solutions in "Santuario" Neighbourhood

E. Martín-Consuegra[1,2*], D. Olivares-Pérez[1], R. Pineda-Martos[3*]
[1]Department of Forestry Engineering - Botany Area, School of Agricultural and Forestry Engineering (ETSIAM), University of Córdoba (UCO), Ctra. Madrid-Cádiz km. 396, 14014 Córdoba, Spain
[2]Royal Botanical Garden of Córdoba, Avda. Linneo s/n, 14004 Córdoba, Spain
[3]Department of Aerospace Engineering and Fluid Mechanics - Agroforestry Engineering Area, School of Agricultural Engineering (ETSIA), University of Seville (US), Ctra. de Utrera km. 1, 41013 Seville, Spain
*Corresponding authors: cr1mafee@uco.es; rpineda@us.es

INTRODUCTION

- The modernization of cities through their renaturalization with nature-based solutions (NbS) is a line of work of great importance in the EU, due to the threat of climate change and the need to adapt our cities to it.
- The urban laboratory aims to explore and identify a problem in the city associated with climate change and the type of NbS to apply and implement. Urbans labs are experimented by putting into practice NbS systems for their evaluation and redesign. The impacts, effects and profitability of the pilot projects are evaluated and analyzed; and, finally, results are shared and extrapolated to other neighborhoods in the city.
- Our urban lab is inspired from the "Asociación de Vecinos Santuario (Córdoba)"; being the IMGEMA - Municipal Institute of Environmental Management, Real Jardín Botánico de Córdoba (Spain) the institution that advises on NbS – to the neighborhood and *via* the urban lab.

OBJECTIVES

Strategies on NBS for the management of private green spaces in the Neighborhood of "Santuario" (Córdoba, Spain).

MATERIALS AND METHODS

1. Location

37.896840,-4.801617 37.88114,-4.75797

2. Current diagnosis
   a. Inventory of green spaces and species.
   b. Planimetry.
   c. Technical sheets of the species.

URBAN CIRCULARITY CHALLENGES (UCCs)

According to Atanasova *et al.*, 2021, the urban circularity challenges (UCCs) for shifting to circular management of resources that can be addressed by the project are as follows:

- UCC1 – Restoring and maintaining the water cycle (by rainwater management)
- UCC2 – Water and waste treatment, recovery, and reuse
- UCC3 – Nutrient recovery and reuse
- UCC5 – Food and biomass production
- UCC6 – Energy efficiency and recovery
- UCC7 – Building system recovery

REFERENCES

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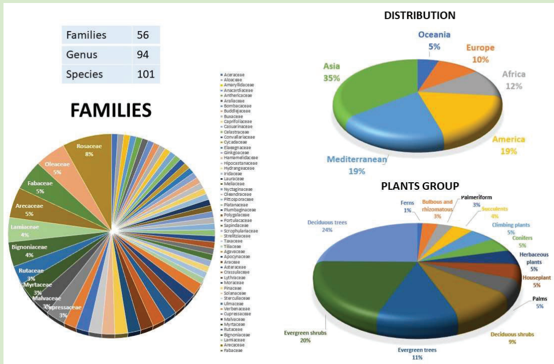
Langergraber, G., Castellar, J.A.C., Pucher, B., Baganz, G.F.M., Milosevic, D., Andreucci, M.-B., Kearney, K., Pineda-Martos, R., Atanasova, N. (2021). A framework for addressing circularity challenges in cities with nature-based solutions. *Water* **13**, 2355.

RESULTS

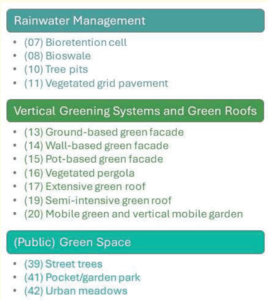


More than one hundred technical sheets were made for each of the species with botanical, morphological and ecophysiological data.

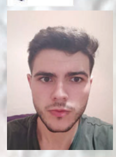
The 16,000 m² of green areas in the "Santuario" Neighborhood are divided into twenty-three plots. The planimetry of all the plots has been drawn. The images show in 2D and 3D the plan of plot A1.

RECOMMENDATIONS AND CONCLUSIONS

Recommendation on implementing innovative NBS units and interventions selected as potential for their implementation in the Sanctuary Neighborhood (based on Langergraber *et al.*, 2021).




E. Martín-Consuegra


D. Olivares-Pérez


R. Pineda-Martos

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ID CARD – "BEJOND"

. Katharina Kearney, Institute of Sanitary Engineering and Water Pollution Control

Stormwater Management Beyond Design Rain Events and Standard Operating Conditions

Project contact: Katharina Kearney and Prof. Thomas Ertl
E-mail: katharina.kearney@boku.ac.at; thomas.ertl@boku.ac.at
Affiliation: Institute of Sanitary Engineering and Water Pollution Control, University of Natural Resources and Life Sciences Vienna (BOKU)

Framework

Climate change and rapid urbanization are putting existing stormwater systems under pressure and increasing the risk of urban flood events, yet a lack of empirical data on infrastructure responses to these developments makes it difficult for municipalities to take targeted and effective action in the form of protective measures and emergency response planning. The BEJOND research project is a cooperation between three Austrian Universities focusing on the effects of extreme weather events and failure incidents on stormwater infrastructure (SWI) and the connected management systems. The research conducted in this project considers various types of SWI in terms of system performance and resilience, extending to both centralized, grey infrastructure (standard engineering solutions) and decentralized, blue-green infrastructure (nature-based solutions). The BEJOND project focuses on small- to medium-sized municipalities in Austria and considers site-specific conditions as well as localized knowledge by working with two case-study municipalities.

Objectives

The central questions addressed in the BEJOND project include:

- How does standard-dimensioned stormwater infrastructure respond to different extreme events?
- How can the resilience of different SWI types be assessed?
- How can an incident and emergency management plan regarding such disturbances be developed and improved, and what might an appropriate and effective communication strategy look like?

The following objectives were set to align with the above-listed research questions:

- Conduct a comprehensive analysis of the impacts of extraordinary events and unscheduled operating conditions on a range of different SWI
- Explore quantitative and qualitative approaches for assessing the resilience of SWI and their surrounding environment
- Outline the possible impacts of climate change and spatial-structural changes on stormwater management systems in the urban context
- Develop recommendations regarding the design and dimensioning of various SWI considering the likelihood of more frequent and severe extremes and altered operating conditions
- Compile a catalogue of measures to prevent system failures and reduce the impacts of extraordinary events in the short-, medium- and long-term.
- Formulation of an incident and emergency management plan at the municipal level, as well as a communication strategy for extreme events and resulting emergencies.

The close cooperation with case study municipalities ensures practice-oriented approaches and research outcomes and provides the basis for a practical handbook directed towards and made available to other Austrian municipalities.

Outcomes

The outcomes of the BEJOND project will include, aside from the final written report and presentations, a practical handbook directed towards Austrian municipalities, entailing recommendations and best-practice approaches to dealing with extreme weather events in the urban context, with a distinct focus on heavy rain events and the resulting risk of flooding, flood damages and disruption of daily-life. This handbook will be made available for free and for download online.

Urban Circular Challenges

.Restoring and maintaining the water cycle (by rainwater management)

Duration: 01.09.2020-31.08.2023
Programme: Nationally funded research project – FWF
Website: N/A

Bundesministerium Landwirtschaft, Regionen und Tourismus
WISSENSCHAFT · FORSCHUNG NIEDERÖSTERREICH
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BEJOND

Stormwater Management Beyond Design Rain Events and Standard Operating Conditions

Katharina Kearney, MSc.*1, Prof. Dr. Thomas Ertl*1, Prof. Dr. Manfred Kleidorfer*2, Fabian Funke, MSc.*2, Prof. Dr. Dirk Muschalla *3, DI Stefan Reinstaller*3

*1 University of Natural Resources and Life Sciences, Vienna (BOKU)
*2 University of Innsbruck
*3 Graz University of Technology

Contact: katharina.kearney@boku.ac.at

BEJOND

Introduction

Urban drainage systems are conceived to function up to specific design conditions, usually expressed in the statistical frequency of a given magnitude of rain event, also known as the return period. **Extreme precipitation events** that go beyond the design parameters will likely compromise stormwater infrastructure (SWI) performance and/or result in the failure of said structure [1, 2].

There is a lack of empirical data on the **behavior** of above-ground SWI under extreme events, and a high degree of **uncertainty** regarding future climate and socio-economic scenarios.

SWI in many cities is ageing and being expanded by above-ground, decentralized stormwater management measures. The result is a **complex heterogeneous system**, the condition and extent of which is not always well known by system operators, local planners and government [3].

Figure 1: Central topics in BEJOND project

Figure 1 lists the principal topics addressed in this project. Three **central questions** follow:

- How does standard-dimensioned stormwater infrastructure **respond** to different extreme events?
- How can the **resilience** of different SWI types be assessed?
- How can an incident and **emergency management plan** regarding such disturbances be developed and improved, and what might an appropriate and effective **communication strategy** look like?

The SWI considered in this research ranges from traditional centralized structures, often described as gray infrastructure, to decentralized SWI for dealing with precipitation on site, which includes various blue-green solutions like green roofs, detention ponds and infiltration options.

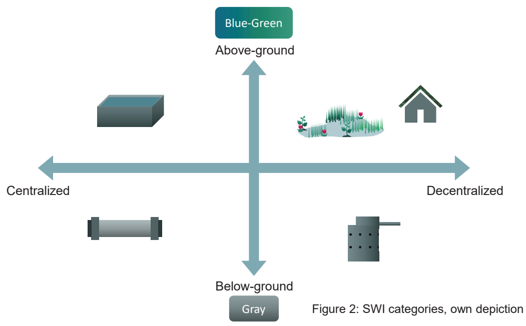

Figure 2: SWI categories, own depiction

Extreme events and extraordinary conditions considered include:

- Hydrological extremes like heavy rains, fluvial flooding and drought
- Power outages and blackouts
- Technical failures like damages to power/electrical grid and communication networks
- Inappropriate operation of infrastructures and machinery
- Illicit and inappropriate (ab)use of public infrastructure by end-users
- Inappropriately dimensioned and/or designed systems

Acknowledgements & Financial Support

Bundesministerium
Landwirtschaft, Regionen
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Project Phases and Research Approach

Phase 1: comprehensive system analysis delineating State of the Art in the dimensioning of urban drainage infrastructure; resilience assessment

Phase 2: methods for assessing system behaviour and consequences of extreme events and failure incidences;

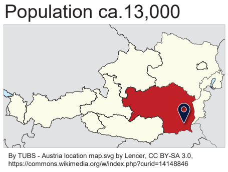
Phase 3: measures to reduce risk; recommendations and strategies to improve flood safety. Incident management scheme and communication strategy. Information for the adaptation of national regulations and design standards;

Phase 4: final report and practical guideline for communities, planners and operators

This project is focused on **small- to medium-sized municipalities** in Austria, and the research approach was designed to deliver relevant and practically applicable knowledge outcomes for municipalities, system planners and operators. The research has been conducted in close cooperation with two **case study municipalities:**

(I) Feldbach, Styria

Population ca.13,000



- Stakeholder workshops (focus group brainstorming, Hot-Spot map)
- Hydrodynamic model of central catchment area [4]
- Participatory Modelling using Fuzzy Cognitive Mapping and interviews

Figure 3: Location of Feldbach, Styria in Austria (Map)

(II) Kufstein, Tyrol

Population ca. 20,000

Stakeholder workshop with focus on extreme flooding event in July 2021, covering i) Prevention and preparedness, ii) Response and iii) Recovery phases.

The interactive formats used during the workshops enabled knowledge-sharing in a diverse group of experts and decision-makers

Figure 4: Interactive mapping session in Kufstein, Tyrol (workshop August 2022)

Preliminary results

Participatory Modelling Feldbach (FCM) [1, 5]

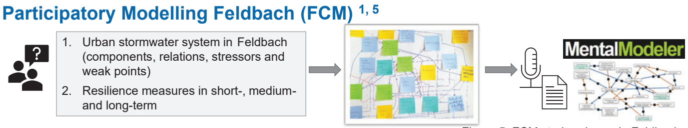


Figure 5: FCM study scheme in Feldbach

Var ID	Map ID	Measures	Category
9	1	Flood-sensitive land management with focus on hillside areas	Land management
25	2	Regular and effective awareness and education campaigns	Communication
41	2	Appropriate intervals for inspection and servicing of stormwater systems	Operation and maintenance
55	3	Involvement of farmers (adapted cultivation methods)	Communication
77	4	Information campaigns in agricultural sector	Communication
89	4	Regular and appropriate communication with public	Communication
104	5	Investment in additional stormwater infrastructure	Structural measures
107	5	Runoff- and erosion-reducing practices in agriculture	Land management
111	6	Information campaigns on self-protection (private citizens)	Communication
119	6	Adjustment of design specifications for the dimensioning of stormwater infrastructure	Legal and regulatory framework
133	7	Adjustment of design specifications for the dimensioning of stormwater infrastructure	Legal and regulatory framework
140	7	Sensitization of private citizens toward on-site stormwater management	Communication
141	7	Implementation of on-site stormwater management measures	Structural measures

Figure 6: FCM data workbench showing suggested resilience measures and their respective category

References

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ID CARD – UniNEtZ

Title: UniNEtZ and SDG 6 in Austria

Project contact: Verena Germann, Günter Langergraber
E-mail: verena.germann@boku.ac.at; guenter.langergraber@boku.ac.at
Affiliation: University of Natural Resources and Life Sciences, Vienna (BOKU), Department of Water, Atmosphere and Environment, Institute of Sanitary Engineering and Water Pollution Control, Muthgasse 18, A-1190 Vienna, Austria

Verena Germann University of Natural Resources and Life Sciences, Vienna (BOKU)

Framework

The framework of this research is a project called UniNEtZ - "Universitäten und Nachhaltige EntwicklungsZiele" or translated "Universities and Sustainable Development Goals" (SDGs) ("Uni" being short for Universities and "Netz" German for network). UniNEtZ is a network of Austrian universities and research institutions aiming at strengthening interactions between science, policy and society, intensifying interdisciplinary cooperation between universities and research institutions, integrating sustainable development in research and education and contributing to sustainable development in general. For this purpose a set of policy relevant but not prescriptive options for action to implement the SDGs in Austria for decision-making support was developed in phase I.

Objectives

The aim of the research presented here is to introduce the project and to illustrate the work and results of the SDG 6 working group in UniNEtZ. The work mainly consisted in critically analyzing the SDG 6 targets and indicators and their status quo in Austria as well as developing and evaluating options for action to advance SDG 6 in Austria, thereby supporting decision- and policy-making and illustrating challenges beyond water and sanitation provision.

Outcomes

Core SDG 6 indicators do not fully cover the aims of the specific targets and several aspects of sustainability. Indicators need to be complemented and discussed within a broader national context. Identified challenges relating to (urban) circularity include e.g. diffuse pollution, the requirement to increase recycling rates of plant nutrients, the need to increase blue-green-brown infrastructure for a near natural water cycle, inclusive water and sanitation facilities in public space and participation. For SDG 6, in total eleven options and 85 specific measures were identified and evaluated. Their effects on the SDG 6 Targets were found to be unanimously positive or neutral but trade-offs might arise when evaluating them against Targets of other SDGs in the follow-up research steps.

Urban Circular Challenges

The following urban circularity challenges (UCCs; source: https://doi.org/10.1007/s43615-021-00024-1) for shifting to circular management of resources with NBS are addressed by options and measures developed:

– Restoring and maintaining the water cycle (by rainwater management)
– Water and waste treatment, recovery and reuse
– Nutrient recovery and reuse
– Material recovery and reuse
– Energy efficiency and recovery

Duration: Jan 2019 - Dec 2024
Programme: UniNEtZ
Website: www.uninetz.at

UniNEtZ Verantwortung für nachhaltige Entwicklung

BOKU

SIG Institute of Sanitary Engineering and Water Pollution Control

UniNEtZ and SDG 6 in Austria

Setting the Sustainable Development Goal 6 in the Austrian Context by Identifying Policy Relevant Indicators and Options for Action

Germann Verena, Günter Langergraber

University of Natural Resources and Life Sciences, Vienna (BOKU), Department of Water, Atmosphere and Environment, Institute of Sanitary Engineering and Water Pollution Control, Muthgasse 18, A-1190 Vienna, Austria

verena.germann@boku.ac.at; guenter.langergraber@boku.ac.at

SIG Institute of Sanitary Engineering and Water Pollution Control

UniNEtZ Verantwortung für nachhaltige Entwicklung

Framework – The UniNEtZ Project and the SDGs

In 2015 the United Nations agreed upon the Agenda 2030 including 17 ambitious Sustainable Development Goals (SDGs) to transform our world. With SDG 6 a self-standing goal on clean water and sanitation for all was established, with its targets encompassing the whole water cycle (Figure 1). The Goals are designed to be indivisible, integrated and universally applicable and, to be achieved, demand for coherent, context-specific implementation at the local level. To contribute to this implementation and sustainable development in general, the project **UniNEtZ** - "**Uni**versitäten und **N**achhaltige **E**ntwicklungs**Z**iele", translated "Universities and SDGs", a network of Austrian universities and research institutions, was established. It aims at strengthening interactions between science, policy and society, intensifying interdisciplinary cooperation between universities and research institutions, integrating sustainable development in research and education and developing and evaluating a set of policy relevant but not prescriptive options for action to achieve the SDGs in Austria and support decision-making.

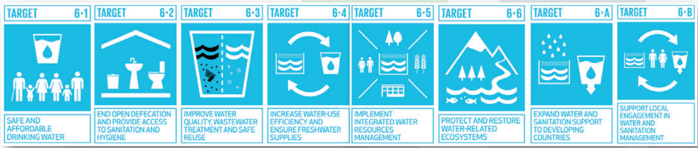

Fig. 1 The eight SDG 6 Targets cover the whole water cycle.

> "***All countries take action, with developed countries taking the lead, taking into account the development and capabilities of developing countries.***" (UN, 2015, para. 28)

Materials and Methods

The UniNEtZ project is organized in SDG specific as well as SDG overlapping working groups. The SDG groups formed based on a mapping of expertise on the SDGs in the Austrian research arena (Körfgen et al., 2019). A working group on methods designed a manual to allow for a common methodological basis in the interdisciplinary work, particularly for the contextualization of the targets and the development and evaluation of the options (Horvath et al. 2021).

Within the SDG 6 working group problem areas were identified based on conceptual system models, several discussions, a thorough contextualization of the targets and a critical appraisal of the indicators (Germann and Langergraber, 2022). Derived from that, the options were drafted by the experts and further developed and refined using literature, internal and external reviews, discussions within the SDG 6 working group, with the other SDG groups and stakeholders. The descriptions of the options developed include objectives, background, specific measures, expected impacts, previous experiences and potential interactions with other SDGs.

Following an evaluation of methods to assess SDG entity interactions (Horvath et al., 2022), a method of Nilsson et al. (2016) was adapted to assess effects of the options developed on the SDG targets within the UniNEtZ project (Horvath et al., 2021). The method uses a 7-point-scale as depicted in Table 1. Within the SDG 6 working group, each measure was assessed against all eight SDG 6 Targets. Based on the individual evaluation of at least three experts and by discussing within the SDG 6 working group until a consensus was found, the effects of the measures and, derived from that, of the options were evaluated.

+3	+2	+1	n	-1	-2	-3
Indivisible	Reinforcing	Enabling	Consistent	Constraining	Counteracting	Inhibiting

Tab. 1 Evaluation method adapted from Nilsson et al. (2016) for UniNEtZ (Horvath et al., 2021)

Results and Discussion

Many complementary indicators are available for Targets 6.1-6.6 but are lacking for Targets 6.a and 6.b. The critical appraisal illustrates that the globally defined core indicators do not fully cover several aspects of sustainability and outlined in the targets, lacking e.g. aspects on reuse and recovery. Several challenges to achieve SDG 6 in Austria are identified (Germann and Langergraber, 2022).

Eleven options with in total 85 specific measures were developed and evaluated by the SDG 6 working group and are available online. A summary of the options and their evaluation is displayed in Table 2.

In line with the targets and identified problem areas, the options include measures on resource recovery, diffuse pollution, hydro-morphological status of water bodies and more natural (urban) water and nutrient cycles. Effects of the options on the SDG 6 Targets are evaluated to be unanimously positive or neutral.

Tab. 2 Summary of the SDG 6 options (Allianz Nachhaltige Universitäten in Österreich, 2021) and evaluation of their effects on the SDG 6 Targets. Evaluation scale see Table 1. For details see Germann et al. (submitted).

	Option	6.1. Drinking water	6.2. Sanita-tion	6.3. Water quality	6.4. Water efficien-cy	6.5. IWRM	6.6. Ecosy-stems	6.a. Int. Co-opera-tion	6.b. Partici-pation
6.1	Resources-oriented sanitation	+1	+1	+3	+2	+2	+2	+1	+2
6.2	Increased use of Blue-Green-Brown Infrastructure	+1	+1	+3	+3	+2	+2	+1	+2
6.3	Promoting efficient use and management of water resources	+2	n	+2	+3	+2	+1	+1	+1
6.4	Maintain and restore the ecological functions of inland waters (incl. peatlands and wetlands)	+1	n	+1	n	+2	+3	n	+1
6.5	Reduction of diffuse discharge of nutrients and problematic substances	+2	n	+3	+1	+2	+3	n	+1
6.6	Reduction of trace substances	+2	n	+3	+1	+2	+3	n	+1
6.7	Drinking water and sanitation in public spaces	+3	+3	+1	+1	n	n	+1	+2
6.8	Improved groundwater protection through needs-based research	+2	n	+2	+2	+2	+2	+1	n
6.9	Strengthening Integrated Water Resources Management for sustainable use of water resources	+2	n	+2	+2	+3	+3	+1	+2
6.10	Increasing WASH-relevant development cooperation	n	n	n	n	n	n	+3	n
6.11	Promoting transformation processes through co-design and co-creation	+1	+2	+3	+2	+3	+2	+1	+3

Conclusions and further research

Based on our research, we conclude that complementary indicators are particularly relevant to understand national contexts and challenges beyond basic water and sanitation provision, and consequently to fulfill the Agenda's aspiration for universal applicability. The results underline the need to discuss the targets and indicators considering national and local circumstances to be able to support decision-making at the local level.

By proposing a diverse set of options and evaluating the effects on all eight targets, the required systemic perspective within SDG 6 shall be enhanced and multiple potential ways to contribute to the achievement of the SDG 6 Targets are presented. Yet, while SDG 6 is generally found to have many synergies with other SDGs, even a "catalytic effect" (UN Water, 2021, p. 4), trade-offs might arise when assessing effects of the options on targets of other SDGs (e.g. SDG 7 on energy). This research step is important for coherent implementation and is an ongoing process in the UniNEtZ project. Comprehensive results are not available yet.

Further research is needed on localization, disaggregation (by gender, age or water body) of the indicators, closing of data gaps and complementary indicators, particularly for Target 6.a and 6.b.

The results neither should be seen as exhaustive, finalized set of options nor do allow prioritizing or ranking of the options. The critical appraisal of the targets and indicators, the options and their evaluation should rather support follow-up transdisciplinary discussions and serve as baseline and give an impetus to decision-making on how to achieve SDG 6 in Austria.

Acknowledgements

We thank the UniNEtZ SDG 6 Working Group for the critical discussions on the SDG 6 targets, indicators and the status quo in Austria and for the development of the SDG 6 options. Funding of the UniNEtZ project by the Austrian Ministry of Education, Science and Research is greatly acknowledged. Additionally, the work of Verena Germann is supported by the BOKU doctoral school "Transitions to Sustainability (T2S)". We also thank the BOKU Rectorate for the support.

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ID CARD – "UVG"

Urban Vertical Green 2.0

Project contact: Karin Hoffmann
E-mail: karin.hoffmann@tu-berlin.de
Affiliation: Technische Universität Berlin
Institute of Ecology
Chair of Ecohydrology and Landscape Evaluation
Ernst-Reuter-Platz 110587 Berlin

Bernhard Pucher
BOKU University, Institute of Sanitary Engineering, Vienna

Framework

Our project will re-invent and re-introduce vertical green systems (VGS) as nature-based solutions which have the capacity to close cycles of energy, nutrients and water. VG re-introduces biological primary production to unproductive land while 2.0 points directly to the participation of all relevant stakeholders when it is about designs, maintenance plans and business models, no matter if profit or non-profit oriented.

Objectives

INCLUSIVE PUBLIC SPACES FOR URBAN LIVABILITY: Vertical green 2.0 re-defines spaces in urban areas as the horizontal space is limited in cities, we resource the vertical space. 2.0 refers to the involvement of stakeholders such as tenants and house-owners. This offers the opportunity to develop profit and non-profit business models for the management of vertical green.
SUSTAINABLE LAND-USE AND URBAN INFRASTRUCTURES: Vertical green 2.0 combines urban infrastructure and sustainable land use, as the urban infrastructures are used as land and resources such as waste water, wasted energy and wasted nutrients are used to produce biomass. VG shades buildings and reduces overheating

Outcomes

The key findings of the project are strategies on how to implement vertical green successfully into the urban system. That contains technology as well as socio-economic and ecological strategies.
Using the delivered models for water consumption and energy efficiency of Vertical greenery Systems, its impact can be quantified in the planning process which fosters investment; The developed prototype for automated harvesting and maintenance is ready to be economically exploited. The low-input design alternative has been developed and tested, and is an easily scalable low-cost greenery system;
Demonstrator developed at BOKU Vienna to be used for on-site greywater treatment for the integration in plant-nutrient cycle; Potentials of decentralized rainwater harvesting and greywater use for irrigation of VGS in line with the circular city approach quantified in a model

Urban Circular Challenges

.Restoring and maintaining the water cycle (by rainwater management)
.Water and waste treatment, recovery and reuse
.Food and biomass production
.Energy efficiency and recovery

Duration: 2018-2021
Programme: Sustainable Urbanisation Global Initiative (SUGI)/Food-Water-Energy Nexus
Website: https://www.urbangreen.tu-berlin.de/menue/urban_vertical_green_20/

Urbanistični inštitut Republike Slovenije
Urban Planning Institute of the Republic of Slovenia
National Taiwan University
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Urban Vertical Green

Evaluation of the multifunctionality of a vertical greening system using different irrigation strategies on cooling, plant development and greywater use

Bernhard Pucher[a], Irene Zluwa[b], Philipp Spörl[b], Ulrike Pitha[b], Günter Langergraber[a]

[a] University of Natural Resources and Life Sciences, Vienna, Department of Water, Atmosphere and Environment, Institute of Sanitary Engineering and Water Pollution Control, Muthgasse 18, 1190 Vienna, Austria; bernhard.pucher@boku.ac.at

[b] University of Natural Resources and Life Sciences, Vienna, Department of Civil Engineering and Natural Hazards, Institute of Soil Bioengineering and Landscape Construction, Peter-Jordan-Straße 82, 1190 Vienna, Austria

SIG Institute of Sanitary Engineering and Water Pollution Control

Introduction

The objective of this study is to evaluate the multifunctionality of VGS using a low-tech irrigation system (Pucher et al., 2020). Water flows horizontally through each planter box, and enters the lower planter box. the capacity of the VGS for local cooling, the decision regarding suitable plants and the use and treatment of greywater were under investigation by comparing three different scenarios in parallel. Scenario a): water- saving scenario—limited irrigation to achieve the lowest possible water demand. Since dry periods can occur, the plants should be drought resistant. Scenario b) daily irrigation to provide the highest possible ET performance and comparing the effect of tap water and greywater on the plant vitality and biomass development. Scenario c) the treatment of greywater for further reuse purposes. In this scenario, especially the PGM utilized, as well as the chosen plants, are of interest due to higher hydraulic and pollutant loads compared to general irrigation. The result will provide information on the capability of a VGS design to provide multiple functions in the urban space and thereby acting as a key technology for sustainable urban water management. The content of this poster is based on Pucher et al. (2022).

Method

- **Experimental setup**

Four independent VGS are installed at BOKU University (Figure 1). For all Walls the near surface air temperature is measured and compared to the measurement of the Bare Wall. Plant vitality and plant biomass was investigated periodically. Based on these parameters the effect of greywater on the plants as well as the effect of the different irrigation schemas on the cooling effect is investigated.

Dry system, irrigated once per week with 25L; increased to 30L three times per week

Comparision of using greywater and tapwater for irrigation. Dayily irrigation with 25L

Treatment of greywater for one person using only 5 planter boxes

Figure 1: Overview of the experimental vertical greening system

- **Operational schemas using greywater**

For the use of greywater two operational schemas are investigated (Table 1), (i) treatment of greywater for further reuse using 5 planter-boxes, and (ii) daily irrigation with greywater for 10 planter boxes.

Table1: Operational parameters of the greywater treatment system (Wall 4) and the system irrigated with greywater (Wall 3). For the hydraulic and the organic loading rate (HLR, OLR), the value for the surface area of the top planter-box as well, as for the total surface area, are given.

Parameter	Unit	Wall 4	Wall 3
Surface area of one box	(m^2)	0.3	0.3
Number of planter-boxes	(–)	5	10
Surface area total	(m^2)	1.5	3
Feedings per day	(–)	10	1
Feeding interval	(–)	every 2 h	–
Feeding duration	(min)	3	8
Volume per feeding	(L)	9	25
Volume per day	(L)	90	25
HLR-top	($L.m^{-2}.d^{-1}$)	300	83
HLR-total	($L.m^{-2}.d^{-1}$)	60	8.3
OLR-top	($g.m^{-2}.d^{-1}$)	115	32
OLR total	($g.\ m^{-2}.d^{-1}$)	23	3

Results

- **Plant development**

The plant development in the irrigation system Wall 2 and Wall 3 showed no difference for the type of water used (tap water and greywater). Therefore the irrigation with greywater is a valid solution to maximize the vertical greened area without the need for fresh water. The same is observed for the greywater treatment system (Wall 4). For the full list of suitable plants see Pucher et al. (2022).

- **Treatment of greywater for two operational schemas**

The overall treatment performance of Wall 4using 5 planter-boxes (Figure 2) was 80% for COD, 81% for NH_4-N, 70% for TNb and 79% for Turbidity. For Wall 3, which was daily irrigated with greywater higher performances for the parameters were achieved (COD 94%; TNb 94%, NH_4-N 99% and Turbidity 95%). This is explained by the lower loading rates and the additional numbers of planter-boxes used.

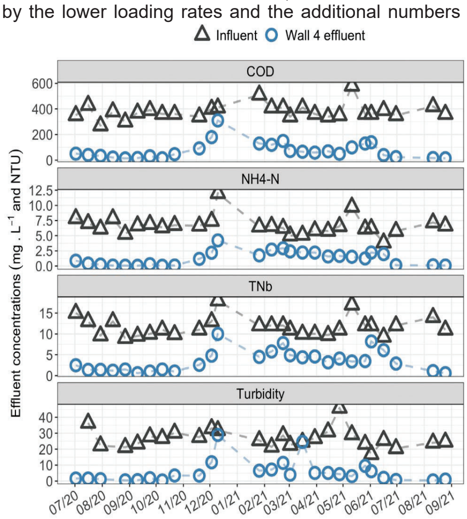

Figure 2: Influent and effluent concentrations of Wall 4

- **Near surface air temperature**

Based on the different irrigation schemas, a significant difference in the air temperature reduction was measured. This leads to the conclusion, that an increase in irrigation water volume leads to a higher cooling effect.

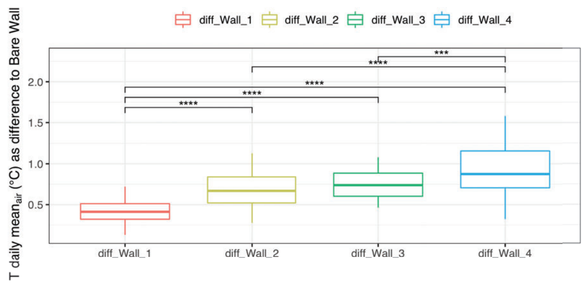

Figure 2: Calculated differences of air temperature between the Bare Wall and Wall 1, Wall 2, Wall 3, Wall 4. Level of significance is indicated by star code * $p < 0.05$. No significant difference is found between Wall 2 and Wall 3 (n = 61)

Conclusions

- The shown VGS design is generally capable to be used for multiple irrigation strategies as well as for greywater treatment.
- Overall a good greywater treatment performance was found
- The function of VGS to cool the near surface air temperature is directly related to the irrigation water amount.
- The substitution of tap water with greywater for irrigation purposes is a valid and needed option to stop water depletion by irrigation of NBS.
- Direct use of greywater for irrigation and thereby maximizing the vertical greened area maximizes the multifunctionality of VGS
- The use of greywater for irrigation over two growing periods showed no quantifiable negative effects on the plant development.

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