D.T2.7.1: BYDGOSZCZ FINAL SELF-EVALUATION REPORT

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Table of content

1. Background and objectives

1.1. Challenges and solutions

The common problem of the pilot investment is that rainwater is directed to stromwater drainage system. The areas are mostly covered with impermeable surfaces, and the green areas mainly perform aesthetic functions due to the elevation above the paved surfaces. In specific:

Location 1. Museum of Waterworks (Palace building)

The diagnosed challenges of public utility are mainly:

- Periodic ponding of rainwater, especially after heavy rainfall events;

- Low biodiversity and high impermeability of surfaces;

- The paved surfaces warm up significantly, heat island effect.

In the majority of areas there is quite good permeability and the groundwater table at a depth of 10 m b.g.l., which creates good conditions for drainage of rainwater in the ground.

Location 2. Building A of the City Hall at Grudziądzka Street

The area is covered with concrete, no green spaces are available. There is a large surface of the roof giving the possibility to collect water however due to other investment plans only part of the roof will collect water within CWC project. Selected solutions will have a demonstration character but do not solve the problem of the area, which are periodic ponding, no biodiversity, impermeable surface, heat island effect.

The solution is to implement the management of rainwater or snowmelt, assuming the implementation of raingardens for the public utility. Decentralised rainwater retention is to be demonstrated via nature-based solutions.

Demonstration will provide knowledge and foster the adaptation of innovative rainwater management methods via demonstration NBS in public buildings.

Location 1. Museum of Waterworks (Palace building)

Rainwater management includes three types of rain garden and barrels:

1) rain garden in an airtight container;

2) sealed rain garden in the ground;

3) infiltration rain garden in natural permeable soil

4) rain barrels.

All three types of rain gardens are connected to each other by a system of surface dry streams/gutters, and the rainwater reserve accumulated in barrels can be used for additional irrigation of local vegetation or rain gardens in the event of a longer rainless period.

Location 2. Building A of the City Hall at Grudziądzka Street

The solution at City Hall offices redirect the rainwater of the building's roof of few municipal departments: Property and Geodesy Department, the Department of Transport Authorities, the Department of Building Administration and the Municipal Urban Planning, to the containers with hydrophytic vegetation, located nearby the main entrance of City Hall at Grudziądzka Street. For demonstration purposes downpipes located on both sides of the northern facade of the building are replaced with new gutters. The rain garden is equipped with seating/bench for City Hall customers.

2. Experience of the pilot implementation

2.1. Lessons learned from the planning phase

Planning process covered detailed assessment of public buildings against application of the rainwater management system that involves NBS solutions. Following the internal inventory, company Retencja.pl elaborated the concept of rainwater management for several buildings.

Usually when we plan an investment, we plan it in terms of what we want to accomplish. And most often it comes out that there are not enough funds for implementation. The costs are incomparably higher than expected. When planning, we should adjust the scope to the resources we have.

We should plan a more realistic timetable for the implementation of the entire task, as practice shows that various types of arrangements require more time.

Location 1. Museum of Waterworks (Palace building)

The City of Bydgoszcz and Municipal Waterworks (MWiK) signed an cooperation agreement which described common pilot realisation. As a result Municipal Waterworks elaborated the concept and executive project with their own budget, while the implementation was covered from CWC project.

The very process of preparation and approval of this agreement by the involved parties (agreeing on the content, comments from lawyers) was also longer than expected

In addition, delays occurred due to the fact that the technical project delivered by the contracted designer was corrected by Municipal Waterworks designers themselves as the calculation of surface for raingardens was too large according to guidelines and their knowledge.

Important: describe in specification for contract which guidelines or rules the performer or project design shall obey.

In Poland, there are no standards for calculating the size of rain gardens. There are different publications and they give very divergent recommendations about the amount of rainfall to be managed or the surface area of a rain garden depending on the roof surface from which rainwater runs off. The employed designer designed a very large rain garden. MWiK did not agree to the proposed calculations and had to correct the design. This resulted in a long design period.

The basic problem in disseminating the idea of implementing rain gardens are such unclear regulations that the fear of the risk of carrying out such an investment without knowingly disregarding formal and legal requirements may effectively discourage potential investors;

- for example, in the light of Art. 34 of the Water Law Act of 20 July 2017 (Journal of Laws of 2017, item 1566), there are legal doubts as to the need to obtain a water permit for the installation of a rain garden. Only a detailed description of the project and indication of its essential elements make it possible to decide about the requirement to obtain a water permit. Hence, if it is planned to create a rain garden in an urban area, a project and its description should be prepared, and then documents should be submitted to the Basin Management Board or the Regional Water Management Board, after obtaining a permit, work can begin.

Location 2. Building A of the City Hall at Grudziądzka Street

The City of Bydgoszcz involved stakeholders in the selection of the location of the pilot demonstration and its planning process. At the third stakeholder's meeting a focus group discussed the concept. During the planning process it became clear that the area of collection of rainwater from City Offices has to be reduced due to other investment plans on the area.

Delays are caused by a long process of selection of appropriate locations and scope of works, obtaining approvals from different Municipal Departments, building facilitors.

Important:

- when realising even small works, other investments might interfere,

- when you are planning innovative solutions, educate the building management first, so they are not afraid of it.

2.2. Lesson learned from the procurement phase

The procedure for selecting a contractor for works/services is usually longer than expected, and the cost of implementation is very different from the project cost estimate, it is higher. In addition, with this type of innovative projects there is a lack of experienced professionals such as sanitary engineers among the staff, we have public servants instead.

The delay in the investment process was influenced by the need to obtain a number of agreements/decisions, including:

- agreement of the investment with the city heritage conservator, and so the pilot investment - location 1 - required agreement due to the historic nature of the object, and the pilot investment - location 2 - due to its location in the center of the city under conservation protection;

- obtaining the opinion of the city visual designer for pilot investment - location 2. The investment should be aesthetically consistent with the newly designed Park&Ride facility nearby,

- obtaining agreements with facility managers,

- reconciliation of the investment for location 1 with the State Water Company Wody Polskie, an external entity, in terms of the need to obtain a water law consent, resulting from ambiguous interpretation of the provisions of the Water Law Act (concerns rain gardens in the ground).

Location 2. Building A of the City Hall at Grudziądzka Street

An open tender procedure conducted for the selection of contractor for construction phase requires usually a lot of time. In reality it took more time than we expected.

Moreover due to the fact that costs for realisation of rain gardens in 2 sites (location 2 and 3) exceeded estimated value and available budget, in tender procedure we included additional negotiation phase, to reduce a price. However in the end we had to cancel the tender procedure for construction of rain garden at MDK, Leszczyńskiego Street.

An additional problem was the low interest of potential contractors of rain gardens. In Poland there are few big construction/environmental companies who have experience in all kinds of NBS, for them the scope of work was too little. On the other hand, local gardening companies do not yet have experience in the NBS field and participation in full tender procedure requires too much administrative work. There are few companies that have experience in it and are willing to undertake such a task. As a result only one company applied for our tender. Hopefully, in the future, there will be more competitiveness in NBS solutions.

Comment: at the stage of preparing project documentation it is worthwhile to identify the market for the availability of ready-made products (pots, monitoring).

2.3. Lessons learned from the construction/installation phase

Location 1. Museum of Waterworks (Palace building)

The historical Palace building of the Waterworks Museum is a listed monument. It is an ideal location to show to a large public how rainwater management can be implemented. A total of 96 m^2 of roof surface area of the building was usually discharged into the rainwater sewer via two downpipes, whereas rainwater from approx. 169 m^2 roof surface area was discharged into the lawn surrounding the building via 6 downpipes (Figure 1). Within the pilot implementation, this rainwater is diverted into the constructed rain gardens. Three rainwater barrels with a total capacity of 1,000 l collect rainwater from the roof for the irrigation of green space and rain gardens, especially in times of drought. The area of the lawn watered by the barrels amounts to approx. 300 m^2. Two of these barrels have an overflow connection to the rainwater sewer.

Works at this loacation went according to plan. However the costs of the pilot investment exceeded the estimation done in the concept. Therefore City of Bydgoszcz covered some of the costs from its own budget. This shows that for public institutions where public procurement rules has to be obeyed the solution is not cheap, as at the moment there are not many companies who are constructing raingardens. During consultation with other cities we learned that at the moment the rain gardens in the ground are done using their own capacity. In Poland there is a well known NGO Sendzimir Foundation https://sendzimir.org.pl/, who has many tips and publications on how to make your own rain garden, which is helpful for individuals. In November 2021 the staff of Municipal Waterworks and the City of Bydgoszcz did gardening work together – planting plants in rain gardens. Aleksandra Rajczyk – the author of the design project explained the function and structure of the demonstration gardens and solutions for rainwater management. This common activity was very beneficial, many people were interested in this event. Whenever possible it is advised to involve inhabitants to change the perception of rainwater management.

Important: the construction of rain gardens should be planned well in advance, because only in spring and autumn is a good time for planting.



Location 2. Building A of the City Hall at Grudziądzka Street

Building A of the City Hall in the centre of Bydgoszcz is a three-storey building which is almost surrounded by sealed areas. Rainwater from the roof of the building is usually discharged via a system of gutters and downpipes into the stormwater sewer. The total roof surface area which drains into the rain garden is 275 m^2 discharged via two major downpipes. The rain garden was designed in containers made of concrete and mantled with an extruded foundation membrane made of a special high-density polyethylene and placed at a distance of 50 cm from the wall of the building. The rain garden has a total area of approx. 12 m^2 (12 x 1 x 0.85 m) and an estimated retention capacity of 3.37 m^3.

The investment involved the construction of rain garden in 10 connected containers and new piping system. During the technical works, unchecked manholes were discovered, therefore it was necessary to use the workflow with their course. City office building were under the construction of parallel investment, joining these two investment was possible at that time, and it could lower the costs and the works could be ordered once. However it is not possible when realising public investment, co-financed from external sources to match the planning and implementation phase of different initiatives.

More than 170 hydrophytic plants, which purify and retain water, were planted during the social/community action, which involved City Hall employees and volunteers. During this action, the garden contractor and designer explained on what the pots are made of, as well as which plant species were chosen and why.

During the implementation phase of the pilot, we encountered some problems. Examples shown below apply to location 2:

- limited accessibility of the site (the need to maintain a fire road); high degree of sealing of the site; extensive, partially uninventoried underground infrastructure; collision of the investment with existing technical infrastructure;

- limited choice of ready-made products for the construction of the garden (the need to make containers to size - prolonged delivery time);

- lack of availability of products in the local market (prolongation of the delivery date of the monitoring station),

- an additional complication was the frequent exchange of participants in the investment process and the associated lack of knowledge about the project and adequate preparation of people involved at various stages of the investment resulted in a delay in the entire process).

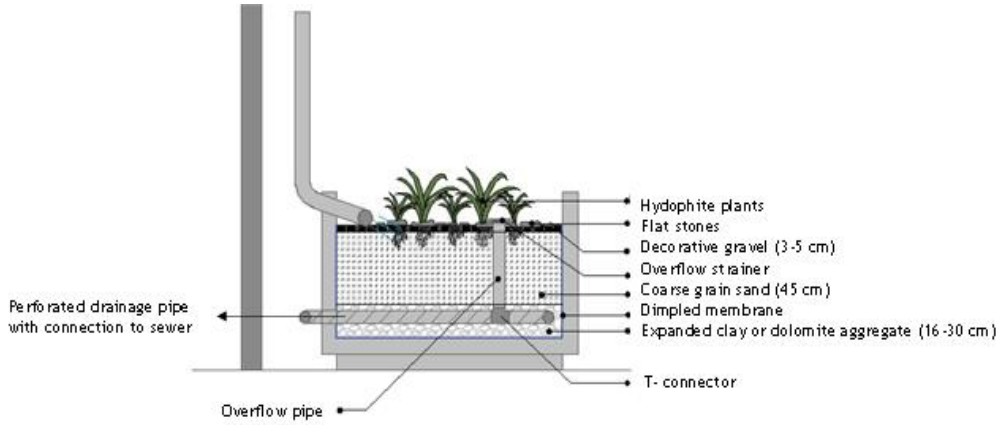
At this phase we had to make agreements and synchronize execution works with the planned partial renovation of the facility and the construction of a Park&Ride facility nearby.

Before



After





2.4. Lessons learned from operation

Location 1. Museum of Waterworks (Palace building)

- selected plants are very durable and frost-resistant, while had been planted in late autumn they were fully- grown in good condition in spring,

- even with scant amount of rainfall during springtime the plants were developing well not needing additional watering. We are convinced that the stone mulch allows the soil to retain moisture more effectively, preventing the soil from overheating and excessive water evaporation,

- there is no problem with weeds, as only a few of them have appeared. It is probably also an advantage which comes from using the stone mulch,

- during rainfall, we can notice the action of the overflow drain from the rain garden in the container. The water overflows into the dry creek and is clear, what confirms that the system works as it was intended,

- the sealed rain garden with constant water level is now covered with *conferva*. We are trying to get rid of them and purify the water. As we believe that this problem may occur again due to high temperatures, we will keep expanding our knowledge on the field of maintaining sealed rainwater tanks,

- as a result of a long-lasting drought in springtime (almost two months rainless) the barrels has not been filled with water and the wood is so dried up that some gaps are formed between the particular boards. This is a common issue of such a product but it requires to be renovated thereafter. The barrel must be refilled, and the clamping rings adjusted (tightened) to seal the barrel. Barrels should not remain not filled with water for a long time.

Location 2. Building A of the City Hall at Grudziądzka Street

The results achieved after the launch of the rain garden confirmed the theoretical assumptions of the project, such as:
- the plant species used are resistant to both periodic flooding and dryness (proper plant growth is observed),
- the use of appropriate materials and plants allows to maintain sufficient humidity in the containers,
- appropriate selection of the size of containers allows to retain rainwater drained from the roof.

3. Timeline and responsibilities

Location 1. Museum of Waterworks (Palace building)

Activity	Start Date	End date	Status	Responsible	Involved people / stakeholders	Comment
Initial Concept	03.02.2020	17.02.2020	done	Municipal Waterworks	Justyna Wolna Aleksandra Rajczyk	n/a
Development of executive project	27.02.2020	31.03.2021	done	Municipal Waterworks	Aleksandra Rajczyk Zieleniarium Rayss Group	n/a
Specification for works	04.01.2021	31.03.2021	done	Municipal Waterworks	Aleksandra Rajczyk	n/a
Selection of contractor and signinig the contract for works	07.2021	09.2021	done	Procurment Department Planning Department	Aleksandra Rajczyk	n/a

Investment works /supervision and approval	09.2021	11.2021	done	Investment Department Planning Department	Marcin Rutkowski Aleksandra Rajczyk	n/a

Location 2. Building A of the City Hall at Grudziądzka Street

Activity	Start Date	End date	Status	Responsible	Involved people / stakeholders	Comment
Initial Concept Location 2 and 3	06.2020	09.2020	done	Integrated Development Department	Hanna Lewandowska; Anna Małkiewicz; Retencja.pl	Including preparation of specification, selection of Contractor, signing a contract, development of concept
Development of a design and cost estimate documentation for rain gardens						
Announcement of inquiry: development of a design and cost estimate documentation for rain gardens Location 2 and 3	1.05.2021	14.05.2021	done	Investment Department	Lubomiła Pietkun, Arkadiusz Lwewandowski	n/a
Signing a contract and development of a design and cost estimate documentation	21.06.2021	16.08.2021	done	Investment Department	Lubomiła Pietkun, Arkadiusz Lewandowski	n/a

for rain gardens Location 2 and 3						
Obtaining a certificate of no objection to the implementation of the project Location 2 and 3	7.09.2021	18.11.2021	done	Investment Department Department of Construction Administration	Lubomiła Pietkun;	n/a
Selection of contractor, signing contract, realisation of investment and monitoring						
Selection of contractor: tender for works - construction of rain gardens at public buildings in Bydgoszcz Location 2 and 3	28.09.2021	18.11.2021	done	Procurment Department Investment Department	Rafał Ciarkowski Lubomiła Pietkun	28.09.2022 publication of tender, 22.10.2021 opening offers, 03.11.2021 opening offers after negotiation phase due too high prices, 18.11.2022 information on selection of the best offer and cancellation of the procedure for one of the bids
Signing the contract for works and realisation of investment Location 2	11.2021	02.2022	done	Procurement Department Investment Department	Rafał Ciarkowski Arkadiusz Lewandowski	n/a

Monitoring of the rain garden (precipitation and soil moisture)	04.2022	06.2022	ongoing	Department of Integrated Development	Anna Małkiewicz	n/a

4. Costs

According to Application Form

- purchase of monitoring and control devices for rainwater use needed for accurate measurements of retained water and other data that will be available online – 5 500 EUR

- the entire work including the creation of a rainwater retention and utilization system for 2 locations – 44 500 EUR

As a result of project evaluation, the following changes were made:

Location 1. Museum of Waterworks (Palace building)

- sealed and infiltration rain garden in the ground with a dry stream system

- rain garden in a container

- rainwater barrels

The cost of the total work is PLN 147 600 gross (31 534,42 EUR). The amount of PLN 100 000 (21 365 EUR) was financed from CWC project budget, and the remaining amount of PLN 47 600 (10 169,64 EUR) from the City of Bydgoszcz's own funds.

Location 2. Building A of the City Hall at Grudziądzka Street

- Project design with cost estimation for two locations (City Hall at Grudziądzka Street and MDK - Leszczyńskiego Street): PLN 17 220 gross (3 679,02 EUR).

- the budget of the project was too low, to carry out investment in these locations (2 and 3), so, with the consent of JS, a rain garden in containers was made in one location, at Grudziądzka Street for the amount of PLN 123 000 gross (26 278,68 EUR).

Cost type (e.g. planning, construction)	Description of cost (what is included into the contract, what was delivered, etc.)	Planned amount in AF (EUR)	Real amount (based on contract) PLN	Real amount (based on contract) EUR	EUR conversion rate	Description (e.g.: how well the prices were estimated, any problems that came up, what changes needed etc)
Location 1						
Planning	Project of solution of rainwater treatment including planting Technical specification for the tender /not payed from the project budget	20 000 EUR for location 1 and 2	0,00	0,00	30.06.2022 4,6806	The concept and design project of the garden were delivered by MWiK to the City of Bydgoszcz at no cost
Construction	Manufacturing of all elements: - rain garden in the ground sealed and unsealed - rain garden in a container with an overflow to the garden in the ground - dry streams - planting the gardens with wetlands - installation of rainwater barrels	44 500 EUR for location 1 and 2	147 600,00	31 534,42	30.06.2022 4,6806	The actual cost was PLN 147,600, but the amount of PLN 47,600 was paid from the City of Bydgoszcz budget as an ineligible cost.
Location 2						
Planning	Project design	20 000 EUR for location 1 and 2	17 220	3 679,02	30.06.2022 4,6806	n/a
Construction	Examples of costs: Delivery and Installation of fiberglass pots along with wooden lamellas, delivery and assembly of a bench, irrigation system with drainage. Filling the pots with filter material and soil, delivery and planting of hydrophytic plants in pots, purchase and installation of a monitoring system.	44 500 EUR for location 1 and 2 + 5500 EUR for monitoring	123 000	26 278,68	30.06.2022 4,6806	The cost assessment of the investment in two locations turned out to be too low. After negotiation phase City of Bydgoszcz desided to to allocate the task only in 1 location - at City Hall Offices, Grudziądzka Street

5. Results

The main results achieved by implementation of the pilots are:

- recovery of water discharged so far to the rainwater sewage system
- reducing the load on the rainwater drainage system
- saving water for irrigation - even 79 m^3 in the growing season (April - October) - average from 1982-2012
- protection of the building foundations against wetness
- groundwater recharge
- creating a demonstration solution for the management of rainwater from the roof of the building on its own plot - educational value
- creating a recreation area next to the building
- enriching biodiversity - instead of a lawn, we planted 30 species of plants (location 1).

6. Mentoring visit

The online mentoring visit took place at the two sites (*Location 1: Museum of Waterworks (Palace building) and Location 2: Building A of the City Hall at Grudziądzka Street)* on 25th of February 2022 between 9:00 and 13:00. The videos can be found under:

https://drive.google.com/drive/folders/1m_PVhfe4zasPVQD1T8tTYd1T3dmBaser

Attendees:
Ewelina Rejs, Municipality of Bydgoszcz
B. Katarzyna Napierała, Municipality of Bydgoszcz
Aleksandra Kowalska, Municipality of Bydgoszcz
Anna Malkiewicz, Municipality of Bydgoszcz
Mariusz Zarzycki, MWiK Bydgoszcz
Erwin Nolde, fbr
Norma Khoury-Nolde, fbr

The result of mentoring visit evaluation is that the demonstration pilots can effectively contribute to the dissemination and transfer of knowledge on local, decentralized rainwater management solutions using nature-based systems (NBS). The pilot action has a high environmental and educational value that will motivate residents and other stakeholders to adopt similar measures for the onsite management of rainwater.

Rain gardens have a high runoff cleaning potential due to passage through soil and are very effective at treating rainwater and removing pollutants. They also contribute significantly to evaporation thus reducing

the urban heat island effects. Rain gardens are also considered as cost-effective measures to control rainwater runoffs.

7. Monitoring activities and results

Monitoring activities undertaken within the project include assessment of quality of rainwater from three locations in Bydgoszcz and monitoring of rain garden in terms of precipitation and soil moisture (Location 2).

Assessment of quality of rainwater

Monitoring activities were undertaken at 3 locations: Locations 1 (*Museum of Waterworks (Palace building)* and 2 (*Building A of the City Hall at Grudziądzka Street)* and the Municipal Waterworks Headquarters at Torunska Street. Rainwater samples were collected from the roof surfaces of the buildings at the outlet of the downpipes and analysed for their physico-chemical and microbiological quality. The "first-flush" rain sample was mixed with the rainwater sample collected after 15 min of rain and averaged.

The following quality parameters were measured:

- Total Suspended Solids (TSS)
- Biochemical Oxygen Demand (BOD_5)
- Oxygen content
- Dissolved Organic Carbon (DOC)
- pH
- Conductivity
- Polycyclic Aromatic Hydrocarbons (PAHs)
- Coliforms bacteria, E. coli and Enterococci

For the rainwater quality, the parameters tested showed good results[1]. Escherichia coli was always less than 1,000 cfu/100 ml; and 4 of 6 samples of Intestinal enterococci where higher than 330 cfu/100 ml compared with the EU Directive for Bathing Water[2].

Using only a coarse screen, the first rainwater (so called "first flush") which is usually polluted will always enter the tank. To keep the first flush away from the rainwater tank, the inflow valve which is usually closed can be opened manually during the rain event to flush out the first rain. Alternatively, automatic first flush diverters could be installed instead of a screen.

Since rainwater in this pilot action is not used indoors, for example, for toilet flushing or laundry but only to feed the rain garden and for outdoor irrigation and infiltration purposes, requirements need not be stringent and no disinfection of the rainwater is necessary.

Food-grade water should not be used for every purpose. The quality requirements should be use-oriented. What has already proven successful in industry for decades should also be possible in the public, semi-public and private sectors.

Thus, if precipitation water is to be treated into drinking water, special focus should be placed on the absence of pollutants in the collection areas, in addition to the hygienic/microbiological parameters.

In cases where the precipitation water is not intended for drinking, but there is regular bodily contact with the water or aerosols, a reference to the quality requirements of the EU Bathing Water Directive is certainly indicated.

However, if the water is discharged into the soil body in rain gardens, as was the case here in Bydgoszcz, no hazard can be identified if, as the investigations show, elevated concentrations of faecal streptococci were measured, which presumably originate from the faeces of birds and which, incidentally, also reach the bed surface without the diversions via the water.

It is also relevant whether the irrigated plants are intended for consumption. If agricultural land is to be used with treated wastewater, the EU Directive on Irrigation Water in Agriculture[3] is relevant. A test for enterococci is not provided for in accordance with the EU Irrigation Directive.

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[1] Analysis of WW/GW and RW utilisation potential based on water quality testing in 4 FUAs D.T3.2.3 https://drive.google.com/drive/folders/1YNDAsLpNDAmhKYhb2GABRTymGaxo3LC6

[2] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32006L0007

[3] REGULATION (EU) 2020/741 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 25 May 2020 on minimum requirements for water reuse; https://eur-lex.europa.eu/legal-content/DE/TXT/?uri=uriserv:OJ.L_.2020.177.01.0032.01.DEU&toc=OJ:L:2020:177:TOC

Results of monitoring of the rain garden *(Location 2. Building A of the City Hall at Grudziądzka Street)*

The rain garden is monitored using:

- a compact weather station with a built-in solar panel for long-term monitoring of environmental measurements via GSM network,

- two sensors measuring soil moisture, designed to work with a wireless network,

- a rain gauge - a smart, hourglass rainfall level sensor.

The monitoring station described above was launched on April 25, 2022, at 08:05 a.m. and is operating continuously, taking measurements of precipitation [mm] and soil moisture [m3/m3] in two of the ten pots of the rain garden. Measurements are recorded at 5-minute intervals.

The results of the measurements are available to anyone at:

https://www.hobolink.com/p/9c8ec0581f1357af2b097054e50460f9

The results are presented below in tabular and graphical form.

Table 1. Average daily precipitation and soil moisture in April 2022

Line	Date	Rain [mm]	Water Content [m^3/ m^3]* sensor 1	Water Content [m^3/ m^3]* sensor 2	
1.	25.04.2022	0.00	0.3071	0.2386	
2.	26.04.2022	0.00	0.3065	0.2375	
3.	27.04.2022	0.00	0.3054	0.2358	
4.	28.04.2022	0.00	0.3048	0.2348	
5.	29.04.2022	0.00	0.3038	0.2339	
6.	30.04.2022	0.00	0.3036	0.2397	

* average daily soil moisture in the container at a depth of up to 10 cm

No rainfall was recorded from April 25 to 30 this year.

The graph below illustrates the associated gradual decrease in soil moisture in containers.

Figure 1. Changes in soil moisture in containers during the rain-free period from April 25-30, 2022

Table 2. Average daily precipitation and soil moisture in May 2022

Line	Date	Rain [mm]	Water Content [m^3/ m^3]* sensor 1	Water Content [m^3/ m^3]* sensor 2
1.	01.05.2022	0	0,3031	0,2387
2.	02.05.2022	0	0,3010	0,2336
3.	03.05.2022	0	0,3010	0,2326
4.	04.05.2022	0	0,2997	0,2305
5.	05.05.2022	0	0,2988	0,2282
6.	06.05.2022	0	0,2982	0,2275
7.	07.05.2022	0	0,2974	0,2264
8.	08.05.2022	0	0,2972	0,2251
9.	09.05.2022	0	0,2966	0,2237
10.	10.05.2022	0	0,2959	0,2206
11.	11.05.2022	0	0,2947	0,2211
12.	12.05.2022	0	0,3003	0,2230
13.	13.05.2022	0	0,3021	0,2225
14.	14.05.2022	0	0,3006	0,2212
15.	15.05.2022	0	0,2993	0,2218
16.	16.05.2022	0	0,2987	0,2229
17.	17.05.2022	0	0,2972	0,2203
18.	18.05.2022	0	0,2965	0,2190
19.	19.05.2022	0	0,3097	0,2181
20.	20.05.2022	0	0,3083	0,2120
21.	21.05.2022	0	0,3197	0,2416
22.	22.05.2022	0	0,3186	0,2486
23.	23.05.2022	0	0,3126	0,2406
24.	24.05.2022	0	0,3137	0,2392
25.	25.05.2022	0	0,3209	0,2501
26.	26.05.2022	0	0,3206	0,2508
27.	27.05.2022	0	0,3216	0,2485
28.	28.05.2022	9,4	0,3257	0,2606
29.	29.05.2022	0	0,3222	0,2570
30.	30.05.2022	0	0,3161	0,2493
31.	31.05.2022	1,6	0,3136	0,2460

* soil moisture measured at a depth of up to 10 cm

Table 3. Average daily precipitation and soil moisture in June 2022

Line	Date	Rain [mm]	Water Content	Water Content

			[m^3/ m^3]* sensor 1	[m^3/ m^3]* sensor 2
1.	01.06.2022	9	0,3246	0,2625
2.	02.06.2022	0	0,3184	0,2814
3.	03.06.2022	0	0,3162	0,2783
4.	04.06.2022	0	0,3124	0,2713
5.	05.06.2022	0	0,3092	0,2638
6.	06.06.2022	0,4	0,3131	0,2634
7.	07.06.2022	1,2	0,3222	0,2749
8.	08.06.2022	0	0,3197	0,2742
9.	09.06.2022	8,4	0,3152	0,2677
10.	10.06.2022	6,4	0,3240	0,2894
11.	11.06.2022	0	0,3158	0,2765
12.	12.06.2022	0	0,3123	0,2674
13.	13.06.2022	5	0,3203	0,2809
14.	14.06.2022	0	0,3163	0,2772
15.	15.06.2022	0	0,3122	0,2688
16.	16.06.2022	0	0,3091	0,2613
17.	17.06.2022	0	0,3066	0,2532
18.	18.06.2022	0	0,3049	0,2443
19.	19.06.2022	2,4	0,3057	0,2440
20.	20.06.2022	8,6	0,3253	0,2928
21.	21.06.2022	0,8	0,3224	0,2872
22.	22.06.2022	0	0,3157	0,2758
23.	23.06.2022	0	0,3103	0,2647
24.	24.06.2022	0	0,3062	0,2525
25.	25.06.2022	0	0,3028	0,2387
26.	26.06.2022	0	0,3004	0,2274
27.	27.06.2022	0	0,2978	0,2153
28.	28.06.2022	3,8	0,3034	0,2239
29.	29.06.2022	0,4	0,3054	0,2239
30.	30.06.2022	2,6		

* soil moisture measured at a depth of up to 10 cm

Table 4. Basic statistics of precipitation and soil moisture levels in May and June 2022

	Values	
Parameters	May' 22	June' 22
Rain [mm]	11	49,4
Sensor 1		
Mean Water Content [m3/ m3]*	0,3067	0,3126

Minimal Water Content [m3/ m3]*	0,2947	0,2978
Maximal Water Content [m3/ m3]*	0,3257	0,3253
Sensor 2		
Mean Water Content [m3/ m3]*	0,2331	0,2613
Minimal Water Content [m3/ m3]*	0,2120	0,2153
Maximal Water Content [m3/ m3]*	0,2606	0,2928

* soil moisture measured at a depth of up to 10 cm

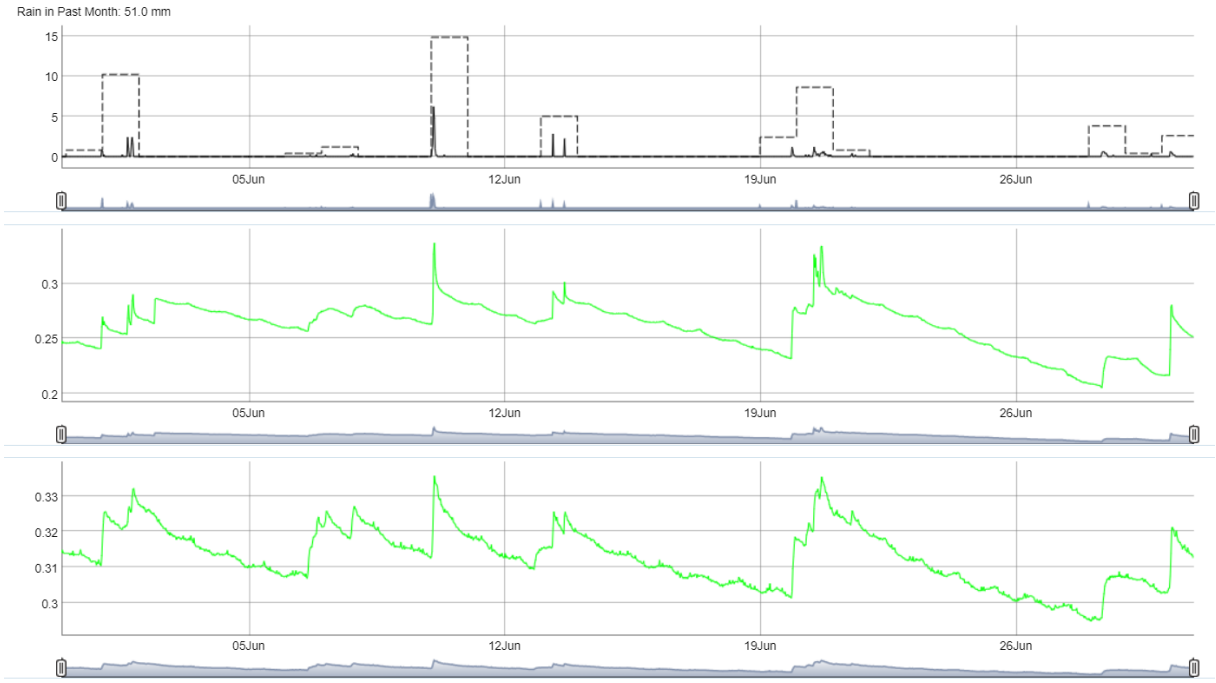
In May, there were only 2 days with rainfall. In June, there were 11 days with rainfall. A total of 11 mm of rain fell in May and 49.4 mm in June.

In June, due to higher rainfall totals, higher average soil moisture was observed in both containers. The highest 24-hour average soil moisture was recorded on May 28 (sensor 1). A total of 9.4 mm of rain fell on that day, the most during the entire study period.

The lowest 24-hour average soil moisture was recorded on May 20 (sensor 1) after a nearly month-long period without precipitation.

The graph for the last month clearly shows the dependence of soil moisture on the amount and duration of rainfall and also the length of periods without rain.

Figure 2. Relationship between the amount of rainfall and changes in soil moisture in containers in June 2022


Rain in Past Month: 51.0 mm
15
10
5
0
05Jun
12Jun
19Jun
26Jun
0.3
0.25
0.2
05Jun
12Jun
19Jun
26Jun
0.33
0.32
0.31
0.3
05Jun
12Jun
19Jun
26Jun

8. Indicators

Indicator	Description	Baseline	Achieved so far	Target value	Measurement/ monitoring method	Regularity of measurement
Output 1 (Location 1)	m^2 of redeveloped green area m^2 of the rain gardens m^2 dry stream m^2 lawn watered from barrels m^3 of water collected in rain gardens and barrels (computational rain) m^3 of water collected in rain gardens and barrels - on average of a year	0	382,4 22,4 60,0 300,0 No computational rain occurred 56,0	382,4 22,4 60,0 300,0 8,1 117,0	from project design	at the end of the project
Output 2 (Location 2)	m^2 of the rain gardens	0	12	12	from project design	at the end of the project
Result 1 (Location 1)	Harvested rainwater infiltrated (%)	0	50	minimum 50% of annual precipitation	volume of rainwater harvested and infiltrated by rain garden, calculated form rainfall data	at the end of the project

Result 2 (Location 2)	Reduction of tap water consumption for watering plants (%)	0	100	100	based on number of plants and their condition	at the end of the project
Impact 1	Increased awareness	0	60	60	number of visitors of the demonstration solutions (the museum staff)	monthly
Impact 2	Number of replicated solutions (rain gardens in the box, in the ground, collection of rainwater)	0	75	35	based on data from the Regional Environmental Protection and Water Management Fund on the implementation of the My Water program and City of Bydgoszcz data	a year
Impact 3	Number of events, actions organized disseminating the idea of circular water management and water saving (rain gardens in the box, unsealing surface, collection of rainwater)	0	1	1	based on the Urban Adaptation Plan (Miejski Plan Adaptacji)	a year

9. Pilot upscaling plans and follow-up.

Main outcomes of the online peer-review visit

The pilot peer-review visit presenting solutions for rainwater reuse developed and implemented in 2 locations in Bydgoszcz, Poland took place on 11 April 2022 from 11 a.m. to 2 p.m. on the Zoom platform.

The aim of the visit was to present and evaluate two pilot actions implemented:

- rain gardens at Museum of Waterworks (Palace building)
- rain gardens at Building A of the City Hall at Grudziądzka Street

All project partners were invited but besites Polish partners, Hungary and Slovenia were required countries to participate.

From each contry we invited:
- 2 national PPs
- relevant FUA stakeholders

Planned agenda:

10:50-11:00	**Registration**
11:00-11:05	Welcome and introduction Ms Aleksandra Kowalska, Project Coordinator, City of Bydgoszcz
11:05-11:15	Presentation of videos on pilot projects - amateur video - technical video
11:15-11:35	Presentation of pilot investment at City Hall, Grudziądzka Street Ms B. Katarzyna Napierała, Project Manager, City of Bydgoszcz
11:35-11:55	Presentation of pilot investment at Waterworks Museum Mr Marcin Zarzycki, Waterworks Company in Bydgoszcz
11:55-12:10	Questions and answers
12:10-12:30	Coffee break
12:30-13:20	Breakout room discussions
13:20-13:40	Plenary evaluation of discussion results
13:40-13:50	Questions and answers, discussion
13:50-13:55	Film about Bydgoszcz
13:55-14:00	Closing thoughts, event closure

The meeting was attended by 37 people, including project partners and stakeholders from Hungary, Slovenia, Italy and Poland.

In order to give potential participants an early overview of the topic, relevant information has been posted on dedicated areas of the CWC project google drive, prior the meeting, such as technical video oft he pilot, online mentoring visit report and video, pilots documentation in PL, intermediate self-evaluation report and draft final self-evaluation report, water quality analysis.

During the peer review visit participants learnt about realization of the pilot actions in Bydgoszcz by watching two films concerning pilot activities (technical and amatour videos) and listening to two presentations given by the representatives of the host partner.

Later the participants were divided into groups: Hungarian partners, Slovenian partners and an international group (with a representative of the Italian partner). Each group evaluated the pilot actions realized in Bydgoszcz from the point of view of their own experience and local conditions (FUA).
Discussions in the groups were conducted around the following questions:
- Do you think solutions implemented in Bydgoszcz could also be implemented in your FUA? What Bydgoszcz solutions might be useful for your FUA?
- Do you have similar solutions implemented in your FUA? Give some examples of such implementations. Are these solutions popular or not?
- Do you have similar projects planned in your CWC Water Management Strategy?
- What kind of problems/obstacles might you come across when implementing such projects in your FUA?
- What benefits (environmental, social, economic, etc.) can you foresee in your FUA from the implementation of projects similar to the Bydgoszcz pilot?
- Who could implement such projects in your FUA (institutions, etc.)?

The summary of main conclusions:
Participants agreed that the solutions implemented in Bydgoszcz can be used in partner FUAs. Partners from Slovenia indicated that individual parts of these solutions are already implemented in their country, mainly by private investors. An important issue turned out to be the education of citizens, who could implement similar solutions themselves, although on a smaller scale.
The Slovenian partners have indicated that rainwater retention solutions are implemented, especially in single family houses, but they are missing in collective living places: housing estates or housing communities, in blocks of flats. Large-scale implementations in public and industrial areas are rare. A problem in Slovenia is standing water in summer periods, which gathers mosquitoes. The development of rain gardens may escalate this problem and therefore may not be socially accepted.
Hungarian partners pointed out that in Zuglo and the 18th District there is a lack of rainwater retention solutions in public institutions and public spaces, but green roofs are developing. Several rain gardens are located in Budapest and the agglomeration. However, these are not customary solutions, rather they are still models. Hungarian cities are planning further water management and rain water management as climate change adaptation activities.
The representative of an Italian partner pointed out that in Italy a rain garden is implemented within one of the projects, in addition other solutions like green roofs are emerging.
Partners perceive a great potential of entities and institutions that could implement similar solutions in their countries. Rain gardens implementation appear in the strategic objectives of the water management strategies that partners are developing as part of the City Water Circles project. The implementation of rain gardens raises several areas of problems and obstacles that may complicate the implementation of such investments in partner countries. Moreover the participants identified environmental, economic and social benefits associated with the implementation of rain gardens.
Details can be found in D.T2.5.2 Report on online peer review study visit at https://drive.google.com/drive/folders/1QeIejuzZaC7coGDikmGMXZpW9pcYy4ld

Main outcomes of the online monitoring visit

Rain gardens not only beautify the urban landscape but also contribute to the improvement of the microclimate and biodiversity through their high potential of near-ground evaporation. Rain gardens, such as the ones implemented in Bydgoszcz, have a higher ecological benefit than underground infiltration measures, such as trenches and therefore should be preferred in places where space is available. However, to consider them as a purely stormwater management measure would be inappropriate, especially when comparing costs with those of infiltration measures such as swales or infiltration trenches.

For the future, it would be interesting to have a cost estimation for prefabricated and mass-produced rain gardens compared to conventional swale and trench systems. This can be worked out and developed in a project follow-up to yield a cost-benefit analysis.

Green roofs could also be included in the comparison, even if this comparison is only useful up to a certain extent, as the benefits are not identical. Rain gardens, such as the ones implemented in Bydgoszcz, show the viewer the path of the rainwater on its way from the downpipes to the rain garden via a conveyance structure such as a stream or a channel, which help raising public interest and environmental awareness, whereas green roofs are only visible to a limited extent and at the same time also place high requirements on the statics of the building.

In general, the goal should be that all rainwater remains on the property so that it does not have to be drained into the sewer system even during heavy rainfall events, such that the resource rainwater is used in the best possible way. Generally, there is no applicable formula for the best solution, which should be determined individually for each site. Often, this process then boils down to a combination of different measures such as rainwater utilisation inside the building (flushing toilets, laundry, etc.) combined with a rain garden or a downstream swale or infiltration trench.

An aspect which had been discussed during the mentoring visit is the impact of the implemented rainwater retention measures at the Waterworks Museum on reducing the rainwater fee, which is levied by Bydgoszcz Municipality for the discharge of rainwater into the public sewer. Calculations have not been made yet to determine the level of fee reduction. However, it is recommended to follow up this issue, since the financial benefits of these measures, besides the environmental and social benefits, can be also of significance.

An important factor for a successful and long-term and operation of rain gardens is the regular maintenance of these systems to detect any blockages and remove litter and excess soil. Clearing of inlets, outlets and overflows, cutting back and trimming are also required. Rain garden plantings require care and watering until they are established, generally the first 1-2 years after construction.

Follow up plans

The Water Management Strategy for the area of BTOF and Bydgoszcz foreseen follow up of the project in 3 areas: rainwater, greywater and wastewater.

Objective 3. Investment pilot projects in closed circuit water management in Bydgoszcz ready for funding,

Rainwater

The subject of pilot implementation of the Strategy will be rainwater management projects for: Complex of Schools and Institutions No. 1 at 53 Stawowa Street, the Youth Centre at Leszczyńskiego Street and further projects of 3 schools and an animal shelter. For the projects already prepared in terms of concepts, it is

necessary to obtain financing for the investment and obtain any permits (notifications) and approvals, and then announce a tender based on the previously prepared Functional and Utility Program.

As part of pilot projects, various activities described in the green and blue infrastructure catalogue are proposed. Projects prepared for implementation or prepared so that external funding can be applied for with a high chance of receiving external funding for construction.

Treated wastewater

Treated wastewater are not yet used in Bydgoszcz. Their use at the treatment site is reasonable. However, for this to be possible, changes need to be made to the treatment plant.

The activity covers the preparation of a concept and feasibility and economic viability analysis for the introduction of the use of treated wastewater in the treatment plant, e.g. for rinsing of sludge management facilities, washing of chemical dilution facilities, etc. Implementation is not covered by the Strategy; it goes beyond the framework currently covered by it.

In the first step the activity will concern Fordon WWTP. As alternative solutions especially for Kapuściska WWTP, the use of treated wastewater for hydrogen hydrolysis or for industry which could be located after the reclamation of former Zachem areas could be considered. Expected outcome is Reduction of tap water consumption and tangible savings, currently difficult to estimate. This is why it is necessary to undertake pilot activities and start implementation work.

In the perspective of this Strategy, the goal is to start implementing the project at the treatment plant site by taking concrete investment activities.

Greywater

Currently, there are no known examples in Bydgoszcz of using grey water in public facilities (public buildings). Carrying out such an activity will allow for the assessment of the effects and obtained benefits as well as it will have a high educational and research value, also for the City Hall's clerical staff. The activity includes:

- analysis of available technologies and potential for grey water use,
- facility selection,
- preparation of a concept,
- preparation of a feasibility study,
- design, obtaining approvals and permits,
- preparation of grant applications (it is assumed that a grant will be obtained for project implementation).

Construction/reconstruction of installations in a public facility is not included in the Strategy.

10. Conclusions

Although Bydgoszcz is known in Poland as a pioneer and experienced city regarding rainwater management, Nature Based Solutions are new in our city. There were no rain gardens implemented before the projects started. There was a catalogue of NBS prepared by Municipal Waterworks, however within the CWC project City of Bydgoszcz together with Municipal Waterworks constructed the first ones. As far as we know also developers did not use NBS at that time. We learnt there are not many companies who are desiging and

constructing raingardens in our region, which is the message that NBS must be promoted and the message spread.

These demonstrations along with the strategy and action plan is a big step forward circular water management. The new EU financial support for 2022-2027 gives a lot of opportunities to continue CWC work.

We hope that by pilot project showing different way of rainwater use we start to change perception of the rainwater and as a result we return water to the city.