Project no. 4CE439P3

URBAN_WFTP

Introduction of Water Footprint (WFTP) Approach in Urban Area to Monitor, Evaluate and Improve the Water Use

WP 5.2.4 Detailed improvement plan

Wroclaw Urban Water Footprint Lab

Start date of project: 1 November 2012 **Duration: 25 months**

Submission date: June 2014

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1 Introduction

So far in the project a water footprint methodology has been elaborated and introduced in the three urban water footprint labs, the baseline conditions for the three settlements have been assessed together with a sensitivity analysis, and potential good practices to reduce the water footprint have been identified. The next task is the drafting and subsequent implementation of water footprint improvement plans.

This document follows a common structure for the improvement plans so that all three urban water footprint labs proceed along the same lines and the resulting improvement plans (as well as the strategy and its implementation) become comparable.

2 Detailed improvement plan

2.1 Definition of the improvement objective

In the case of the Wroclaw Urban Water Footprint Lab, the Municipal Water and Sewage Company will concentrate on potential process changes and investments that improve the Nitrogen removal from sewage.

In addition, the Sustainable Drainage System, which are the solutions improving rainwater management and retention in the city, will be presented to the relevant stakeholders. Hopefully, in consequence they will encourage investors and design engineers to implement such solutions, by their promotion and possibly by introducing relevant regulations, for example incentives for rainwater harvesting, and/or fees for its discharge into the sewerage system.

2.2 Scope of the improvement plan

The improvement plan refers to the territory served by the Wroclaw Municipal Water and Sewage Company, namely, the city of Wroclaw (630 000 inhabitants) and a few small neighbouring municipalities.

2.3 Targeted footprint improvement

After implementing all solutions mentioned in the improvement plan on a full scale the real Nitrogen loading should be reduced from 10 to 8 mg/l, reducing the $WFTP_{Grey}$ from 51 135 000 to 40 908 000 m^3/year, so by 20%, when calculated for the designed effluent flow of 51 135 000 m^3/year and assumed Nitrogen concentration in the receiving water body of 0 mg/l.

The scale of implementation of the Sustainable Drainage System solutions is difficult to predict, so is an associated reduction in $WFTP_{Blue}$ and $WFTP_{Grey}$, and an increase in $WFTP_{Green}$, which depend on the system chosen, and vary widely.

2.4 Measures to be used

Specifically, the improvement plan consists of four measures with regard to wastewater treatment:

- The first one is based on the change of the operational scheme at the biological treatment stage, i.e. transformation of the anaerobic reactors into denitrification rectors in order to increase the denitrification volume. This should contribute to Nitrogen concentration reduction by approximately 0.5 mg/l, thus $WFTP_{Grey}$ decrease by 5%.
- The next solution is improvement of internal recirculation capacity by nearly 50%. This will increase the amount of nitrates recirculated from nitrification to denitrification reactor and further improve the efficiency of Nitrogen removal by enabling full utilization of increased denitrification volume. Initially, the test will be carried out on one of ten sequencing batch reactors in order to verify, if the proposed solution is effective. Full scale implementation of this solution should cause Nitrogen concentration decrease by approximately 0.5 mg/l, and $WFTP_{Grey}$ reduction by 5%.
- With higher internal recirculation flow more oxygen will be transported to the denitrification reactor. This may decrease Nitrogen removal efficiency so the third step is optimization of the aeration conditions in the aerobic reactor.
- The last project is implementation of anammox or nitrification/denitrification process of sludge dewatering liquor on a pilot scale. This is an ongoing research project. If the tested solutions prove to be effective, they will be possibly implemented on a full scale. Then a Nitrogen concentration decrease by at least 1 mg/l is expected, causing $WFTP_{Grey}$ reduction by 10%.

The example measures associated with implementation of the Sustainable Drainage System, which could improve the rainwater management and flood control in the city, are:

- Permeable green areas enabling rainwater drainage into the ground, improving water retention within the city drainage area. Having less concrete and more green space in an urban setting has also ecological and micro-climate benefits.
- Constructed wetlands, which are artificially created wetland ecosystems to treat e.g. collected rainwater or wastewater, similarly like ponds and creeks, are also a beneficial solution enhancing ecology and aesthetic value, enabling water retention for reuse for irrigation.
- Another sustainable solution, which reduces the risk of urban floods, is rainwater harvesting, which is the accumulation and storage of rainwater for reuse before it could reach the aquifer. Harvested rainwater can be used e.g. for garden watering, car washing, as well as flushing toilets. It relieves some of the pressure on other sources of water supply and it reduces the costs associated with treatment of polluted rainwater.

These solutions contribute to a reduction of $WFTP_{Blue}$ and $WFTP_{Grey}$, and a positive increase in $WFTP_{Green}$, which is a dominating WFTP in green areas.

2.5 Executing organisations

Execution of the part of the improvement plan associated with reduction in Nitrogen concentration in treated effluent is under the responsibility of the Wroclaw Municipal Water and Sewage Company (PP10). The research phase of one of the last measure is carried out in cooperation with Technical University of Wroclaw and Wroclaw University of Environmental and Life Sciences (PP9).

Regarding the Sustainable Drainage System solutions ,Wroclaw Municipal Water and Sewage Company (PP10) with support of Wroclaw University of Environmental and Life Sciences (PP9) are responsible for informing the stakeholders, especially, municipality representatives about the possibilities and benefits of their implementation. Once convinced of their advantages the stakeholders will possibly impose the implementation of chosen Sustainable Drainage System solutions on the investors and design engineers, by introducing relevant regulations.

2.6 Affected stakeholders

The reduced grey water footprint as a result of implementing the technologies enabling Nitrogen reduction in the treated effluent will limit the human influence on the receiving water body and maintain the river condition closer to natural. A lower Nitrogen concentration implies less eutrophication, thus a healthier water ecosystem. This may especially benefit communities further downstream as well the ecosystem in general.

The Sustainable Drainage System solutions are beneficial for the urban ecosystem making it closer to the natural by:

- retaining the rainwater within the city drainage area and promoting natural groundwater/aquifer recharge (where appropriate);
- managing volume and flow rates of run-off to reduce the downstream flow, destructive power of surface water and risk of flooding;
- enhancing water quality by reducing pollution from runoff;
- providing an attractive habitat for wildlife in urban watercourses;
- providing opportunities for evapotranspiration from vegetation and surface water;
- improving the quality of life and local climate within the city

These features are also beneficial to the urban community.

2.7 Preconditions of and risks to successful implementation

In order to start implementation of the technologies contributing to reduction in Nitrogen concentration in the treated effluent at the test and full scale a few preconditions must be fulfilled. First of all, during tests and research projects functioning of wastewater treatment plant must be stable in order to allow correct assessment of obtained results. Secondly during implementation phase, appropriate resources (funds, personnel etc.) must be available. There is always a risk of failure during tests and implementation phase but careful planning and realization will lower this to a low level.

Regarding the implementation of Sustainable Drainage System solutions, it depends on the free will of the stakeholders which have the legal possibilities to introduce relevant regulations encouraging and/or imposing it. Further, once the appropriate regulations or incentives are applied, the implementation of the proposed solutions depends on the investors and design engineers.

2.8 Estimated costs of implementation

The estimated costs of implementing specific technologies contributing to reduction in Nitrogen concentration are presented in the following table.

Measure	Cost [Euro]
Transformation of the anaerobic reactors into denitrification reactors	~0
Improvement of internal recirculation – research phase	~10 000
Improvement of internal recirculation – implementation phase	~500 000
Optimization of aeration conditions in the aerobic reactors	~0
Implementation of anammox or nitrification/denitrification process of sludge dewatering liquor – research phase	~750 000
Implementation of anammox or nitrification/denitrification process of sludge dewatering liquor – implementation phase	~5 000 0000

Regarding the implementation of Sustainable Drainage System solutions, the costs vary depending on the size and type of the technology/construction. In addition, the number and time of such implementations is not known. These parameters depend on the decisions of investors and design engineers.

2.9 Indicators to measure the impact

For evaluation of the effectiveness of Nitrogen reduction technologies, its concentration in effluent will be measured. Other indicators are nitrates concentrations at different phases of treatment process. These indicators are easy to obtain as on-line and laboratory Nitrogen measurements are routinely conducted at the wastewater treatment plant.

For evaluation of the effectiveness of implementation of Sustainable Drainage System solutions, the formation of relevant regulations and/or incentives will be monitored. The cases of their implementation in the new investments will be also monitored.

2.10 Monitoring and validation of results

Municipal Water and Sewage Company (PP10) is in charge of monitoring and validating the results of the Nitrogen reduction technologies. Monitoring will take place “on-line” at every stage.

In addition Municipal Water and Sewage Company (PP10) is responsible for monitoring the change in the regulations and/or incentives associated with implementation of Sustainable Drainage System solutions.

2.11 Local promotional programme and dissemination

After implementation of Nitrogen reduction technologies at the test and full scale, some results will be presented in the papers and at the conferences to reach the stakeholders from environmental engineering area. Once the technologies prove to be effective, other Water and Sewage Companies might want to implement them as well, in consequence reducing the grey water footprint in their area.

The Sustainable Drainage System solutions will be promoted among the stakeholders, especially municipality representatives and also representatives of other Water and Sewage companies from Lower Silesia region, during local meeting, Wroclaw Lab open day and workshops (as a fulfilment of WP2.2.7). Hopefully, the stakeholders informed about the benefits of such solutions will further promote them and possibly implement relevant regulations and/or incentives imposing and/or supporting their implementation by the investors and design engineers.

2.12 Assessment of results

Municipal Water and Sewage Company (PP10) is in charge of assessing the results of implementation of Nitrogen reduction technologies.

2.13 Input to the joint report

Municipal Water and Sewage Company (PP10) is in charge of reporting to other partners of the results of the measure and suggestions for the improvement of the water footprint methodology and as an input to the joint report.

2.14 Schedule of implementation

The schedule of implementation of Nitrogen reduction technologies is only a draft, as both the time might change as well as the extent of implementation. Some solutions after research phase might appear to be not effective enough and/or there might be no investment means for their implementation on a full scale. As indicated by the table below, implementation starts within the UWFT project timeline, but some of the measures will take place after the project ends.

Step/activity	Deadline	Responsible organisation
Transformation of the anaerobic reactors into denitrification reactors	Finished	Municipal Water and Sewage Company
Improvement of internal recirculation – research phase	December 2014	Municipal Water and Sewage Company (PP10), Technical University of Wroclaw and Wroclaw University of Environmental and Life Sciences (PP9)
Improvement of internal recirculation – implementation phase	July 2015	Municipal Water and Sewage Company
Optimization of aeration conditions in the aerobic reactors	December 2014	Municipal Water and Sewage Company
Implementation of anammox or nitrification/denitrification process of sludge dewatering liquor – research phase	December 2016	Municipal Water and Sewage Company
Implementation of anammox or nitrification/denitrification process of sludge dewatering liquor – implementation phase (if research proves its effectiveness)	December 2019	Municipal Water and Sewage Company

The Sustainable Drainage System solutions will be promoted among stakeholders likely in September and October this year. The results in the form of their further promotion among the investors and design engineers and possible introduction of relevant regulations and/or incentives causing their implementation in the future investments are difficult to estimate with regards to time and extent.

Literature:

Cheng Liu, Carolien Kroeze, Arjen Y. Hoekstra, Winnie Gerbens-Leenes, *Past and future trends in grey water footprints of anthropogenic nitrogen and phosphorus inputs to major world rivers,* Ecological Indicators 18 (2012) 42–49