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WATER FOOTPRINT AS A NEW APPROACH TO WATER MANAGEMENT IN THE URBAN AREAS

URBAN WATER FOOTPRINT – NOWY SYSTEM MONITOROWANIA I OCENY GOSPODAROWANIA WODĄ W MIASTACH

Wody słodkie są zasobem ograniczonym, w niektórych częściach świata nawet deficytowym, który maleje podczas gdy zapotrzebowanie na niego rośnie, wraz ze wzrostem liczby ludności i standardu życia. Dotyczy to szczególnie obszarów miejskich, w których aktualnie mieszka ponad 75% populacji Europy. Dodatkowe zagrożenie stanowią zmiany klimatyczne i ekstrema pogodowe takie jak powodzie i susze, które podobnie jak człowiek ingerują w naturalny cykl wody na danym obszarze. Istnieje więc uzasadniona potrzeba udoskonalenia technologii oczyszczania wody i ścieków, rozbudowy i poprawy działania systemów wodno-kanalizacyjnych, oraz wdrożenia nowoczesnych metod i narzędzi ich monitoringu, kontroli i zarządzania. Partnerzy z Włoch, Polski, Niemiec, Austrii i Węgier reprezentujący środowisko naukowe i sektor przemysłowy zawiązali konsorcjum, które podjęło się zrealizować projekt Urban Water Footprint – nowy system monitorowania i oceny gospodarowania wodą w miastach. Podstawowym celem projektu jest wypracowanie uniwersalnej metodologii obliczania Urban Water Footprint, czyli wskaźnika śladu wodnego miasta. Ma on umożliwić ocenę, monitoring oraz docelowo poprawę zużycia wody i gospodarowania zasobami wodnymi na obszarze miejskim. Główne działania i rezultaty projektu to opracowanie jednolitej i uniwersalnej metodologii obliczania śladu wodnego dla miast, za pomocą trzech modeli o różnym poziomie dokładności i zastosowania, przetestowanie ich dla trzech miast Europy Środkowej, aktywacja trzech Urban

Water Footprint Labs, których zadaniem jest szerzenie wiedzy i pozyskiwanie danych oraz wskazanie najlepszych praktyk, procedur i technologii. Narzędzia te będą wspomagały proces podejmowania decyzji w zakresie gospodarki wodno-ściekowej w miastach.

1. Introduction

The fresh water is a scarce resources in some areas of the world and its volume depletes while the demand increases, with time. The sensitive areas become the cities where the population migrates and concentrates. Currently over 75% of the European population lives in urbanized areas. Therefore, there was recognized a need for improvement of water and sewage treatment technologies, the condition of water supply and sewage collection networks, as well as implementation of modern tools for their monitoring, control and management. Beside the increase in population concentration, there are other factors which need to be considered such as the importance of water resources for natural and social environment and flood risks associated with climate changes and weather extremes. Correct water use and management are the key to set good climate change adaptation strategies, to ensure good quality of life of EU citizens and to support development of economic actors that work in the field of water.

Recent studies show that there is a 40% potential for water saving in European urban areas. The important issue is the development of reliable monitoring and control systems for water distribution and sewage collection, by creating databases of technical state of equipment and recording users behaviours. Another important step is complex management of the system for rainwater drainage. Currently there are no uniform methods of managing storm water drainage systems and combined sewage system. There is a need for introduction of market principles in operation of urban drainage systems, increase of water retention, implementation of control techniques for channels and surface retentions during storm weather and reduction of discharge of pollutants from rainwater to surface waters. Last but not least it is important to improve the level of waste water treatment.

The best way of studying the problem from different points of view, implementing the modern technological and management solutions and transferring the knowledge is by involving into the project representatives from different world regions. This lead the partners from Italy, Poland, Germany, Austria and Hungary representing both the scientific and industrial area to establish a consortium, which has set up the URBAN_WFTP project within the Programme for Central Europe. The project aims at improving the conservation of water resources through the deployment of new water-saving technologies and policies, starting from increasing citizens awareness in this area. The element of strong innovation consists in the application of the Water Footprint (WFTP) approach to the urban areas as a water management and planning tool. In addition, the project considers different urban contexts in order to obtain a model of common approach that will be used throughout the Central Europe in order to study and optimize water consumption by citizens.

The water footprint concept was introduced by Arjen Y. Hoekstra in 2002 [1] as an indicator of freshwater use. It is closely linked to the virtual water concept [2] which accounts for the total volume of water required to produce a product. Import and export of the products is associated with the transport of virtual water between the countries and world regions [1].

In general the WFTP considers direct and indirect (virtual) water consumption by a consumer or producer. It has three components: blue water which is the volume of surface and ground water consumed for production of a product or a service, green water defined as the volume of rainwater stored in the soil and not returned to the water basin because of evapotranspiration processes and grey water referred as the dilution volume of water required to assimilate the load of pollutants according to the existing ambient water quality standards. The water footprint components used in the urban context are discussed in more detail in the next section.

The WFTP is continuously developed by the Water Footprint Network [3]. A new ISO 14046.2 standard [4] is expected to be published, which will describe the rules, requirements and guidelines for evaluation and reporting the water footprints of products, processes and organizations within the framework of Life Cycle Assessment [5]. Nevertheless until present there is no application of water footprint to the urban areas.

2. Methodology

The water footprint concept is primarily intended to illustrate the hidden links between human consumption and water use and between global trade and water resources management [6]. While this is a powerful tool for communication, the concept bears a number of shortcomings, most important the lack of data.

As already mentioned WFTP indicator according to Hoekstra et al. [7] assesses and represents three aspects of water use called blue water, green water and grey water.

In general the blue water footprint refers to consumption of blue water resources (surface and groundwater). "Consumption" means the loss of water from the available ground-surface water body in a catchment area. Losses occur when water evaporates, returns to another catchment area or to a sea or is incorporated into a product. Within the urban context blue water footprint is defined as evaporation from impervious surfaces, long term storage and export of water outside the city boundary.

The green water footprint refers to consumption of rainwater insofar as it does not become run-off. It is therefore assumed that in the urban environment green water footprint covers this part of rainwater which is transferred from green surfaces to the atmosphere by evapotranspiration.

The grey water footprint refers to pollution and is defined as the volume of freshwater that is required to assimilate the load of pollutants given natural background concentrations and existing ambient water quality standards. For the urban conditions grey water footprint is calculated based on concentrations of treated runoff/waste water.

The term WFTP is used for both direct (real) and indirect (virtual) water use of a consumer or a producer in a certain region [6, 8]. Therefore it is assumed that the model will calculate in parallel the fluxes of virtual and real water that occur within the city boundaries (Figure 1). The virtual water fluxes that are connected to trade are reported separately, reason being that pure import-export of goods creates only a through flow of virtual water. As trading goods are neither created nor used the virtual water fluxes connected with those goods does not need to be considered specifically – but of course could be.

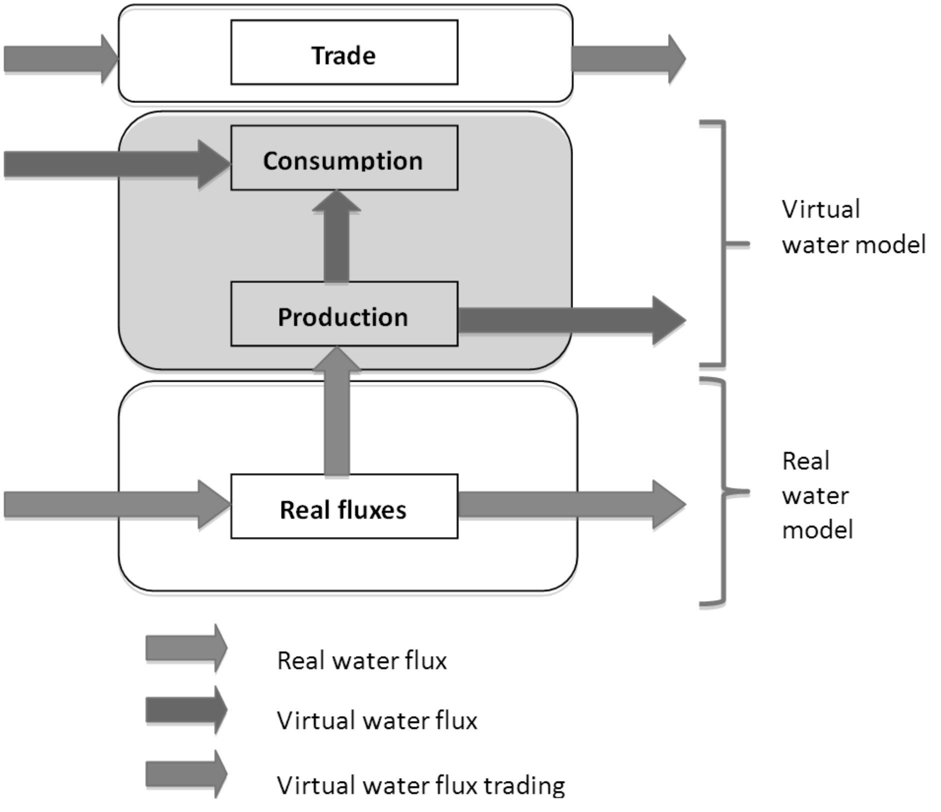

Fig. 1. Water fluxes model on city level

Rys. 1. Model przepływu strumieni wody w mieście

The real water model has been structured in three different levels of application. For each level a specific model has been drawn up. Depending on specific needs only one level needs to be applied for calculating part of water footprint resulting from real water flow model. The second part can be calculated from virtual water flow model.

Three different levels are distinguished to reflect the degree of details, the information they provide and the load of input data that are required (Figure 2). The first level is described with the global model which uses top-down approach. The city is defined as a black box, and all water fluxes are studied with an input-output approach. This model is addressed to politicians and decision makers at the municipality level, and also to the water managers. The second level is represented by the areal model and the focus is posed on different land uses that can be distinguished in the city and how they interfere with water uses. Through the use of geographical information system (GIS), it allows to create a map of the city that shows the hot spots where the WFTP is the highest. The obtained results are useful for city planners, decision makers and water managers. The last level is the local model which analyses all the structures that generate the water consumptions using bottom-up approach. Starting from the analysis of a single representative neighbourhood and its elementary modules (buildings, roads, green areas etc.), the whole city water footprint is estimated adopting a multi-linear modelling approach. It is the most complex model and requires numerous data for the calculations. The results will allow for assessment of citizens behaviour, the technologies used in residential buildings as well as the regulation on fresh-water management solutions for new buildings and discharged water.

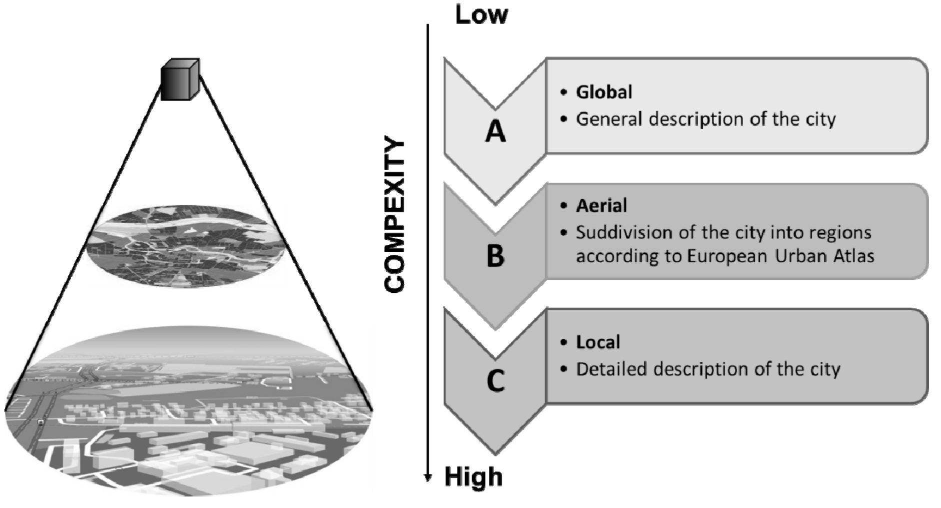

Fig. 2. Three level model of Urban WFTP

Rys. 2. Trzy poziomowy model Urban WFTP

The innovative approach used in the project allows to study the water uses in the city in order to identify points of intervention and choose the specific technologies to be introduced to reduce consumption.

The models help to describe the water use within the municipality and to predict the water use according to new urban development. Based on the gathered data the impact of local policies on water use can be assessed. Due to varying complexity of the models it is possible to calculate the WFTP of the municipality starting from a limited number of data.

3. Project results

Besides the development of methodology the URBAN_WFTP project carries out number of other activities which deal with: activation of Urban Water Footprint Labs (UWF Labs), implementation of models in three Central European cities, identification of best practices, definition of improvement plans and promotion of water footprint approach.

Urban Water Footprint Labs are the interface between water supply and water demand (Figure 3). The UWF Labs have the ability to continuously assess, evaluate and monitor changing behaviours, policies or technologies of consumers and water suppliers

which might have an impact on the demand. Additionally the UWF Labs serve as communication platform and bring together water suppliers and users from various backgrounds to raise awareness about sustainable water management and consumption. This approach supports the involvement of different stakeholder groups and avoids a top-down approach which may not stress actual challenges and requirements of a city's water management. The flexible framework makes it possible to personalize the labs depending on the individual needs of the urban area.

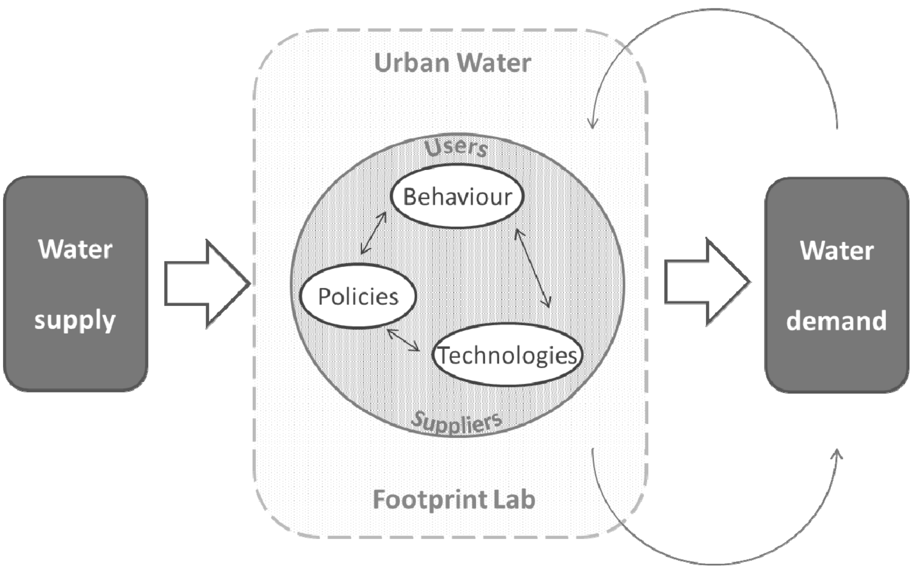

Fig. 3. Schematic set-up of an Urban Water Footprint Lab

Rys. 3. Schemat organizacyjny Urban Water Footprint Lab

Three UWF Labs have been created in Poland, Italy and Austria. MPWiK S.A. is responsible for UWF Lab in Wroclaw which is addressed to the decision-makers, such as water and sewage companies as well as politicians and planners, which have an influence on the investments and policies associated with water consumption, usage and treatment. It is important to raise their awareness about the global water scarcity and motivate them to choose environmentally friendly and sustainable solutions. Their decisions have an impact on behaviors and choices of large number of people.

Several analyses have been carried out using developed models for three central European cities: Wroclaw, Vicenza and Innsbruck. Data gathered on water use and management enabled to make assessment of WFTP baselines for the cities under consideration. The baselines are considered as the reference points to study the efficacy and efficiency of future policies and initiatives related to water resources. In order to do so for each city possible future development scenarios have been defined. The scenarios have been determined based on population growth, change of urbanized area and climate conditions, improvement of waste water treatment facilities, application of water saving technologies (e.g. rainwater harvesting) and improvement of water use practices by citizens. Based on identified scenarios a sensitivity analysis of model performance has been performed.

The output of sensitivity analysis and the inventory of local water management problems was a base for identification of best practices applied in the countries of project partners. Potential measures to improve local water management are: metering of water consumption, reduction of leakage from the drinking water network, cost recovering tariffs, introduction of water saving technologies, education of citizens on water saving and reduction of soil sealing. Most urban water management goals can be achieved through a number of different measures, and vice versa, most measures contribute to more than just one goal. In addition to defining the best practices, a SWOT analysis for the three urban areas has been done, which aimed to assess the strengths and weak points of the water use and management. All this information will be used in the future to formulate and activate improvement plans. Unfortunately most of the measures require a long time horizon of years and even decades. Therefore with the help of UWF Labs, the activities included in the improvement plans will be started within the framework of the project and will continue after it ends.

During the project the training activity is done by each UWF Lab in the towns of Vicenza, Innsbruck and Wroclaw. The general purpose of the training is to make available in the Central Europe a first nucleus of trainers well acquainted in the themes of water footprint, with special knowledge on Urban Water Footprint and the organization of a UWF Lab.

Dissemination of knowledge and project results is achieved in different ways: newsletters, project web-site (http://www.urban-wftp.eu), media appearances, participation at regional/transnational conferences and fairs, conducting face to face interviews with relevant regional and national stakeholders, organizing workshops or seminars in order to promote the knowledge about WFTP approach to local representatives, citizens and stakeholders. One of the achievements of the project is establishment of a common water technology and management database which is available on project web-site.

4. Discussion and conclusions

The URBAN_WFTP project is carried out within the framework of Central Europe Programme, Priority - Environment and the Area of Intervention - Supporting Environmentally Friendly Technologies and Activities. The project promotes better water use and management as well as reduction in water consumption, what contributes to preservation of water resources. The diffusion of innovative technologies will lead to formation of new services, companies and professionals, as well as economic growth in the area of intervention. This will result in environmental benefits such improved quality of water resources enhancing the quality of life, and economic benefits such as reduction in operational costs due to reduction in water consumption and wastewater discharges.

The project fulfils the objective of the Lisbon strategy adopted in 2000, which is to create a competitive knowledge economy that could help achieve economic growth through raising employment levels, greater social cohesion and respect for the environment. The project will contribute to these objectives by strengthening regional and internal cohesion and integration, ensuring the replicablity of the activities and upgrading central Europe's environmental policies. Knowledge and technology exchange as well as innovations in the field of water management within the Central Europe region will be an example for all Europe and also for the whole world, how to face the water scarcity issues.

The project supports implementation of Water Framework Directive 2000/60/EC [9] and its amendments by identifying and developing strategies, tools and innovative technologies that will contribute to enhancement of environmental quality standards in the field of water policy. As a result of the project a common approach for the management of water issues in Urban Areas at Central Europe river basin level has been developed. Another regulation associated with the project is Drinking Water Directive 98/83/EC [10], to which it refers by increasing monitoring and control of water use and fresh water quality and use, protecting human health. Urban Waste Water Directive 91/271/EEC [11] and its amendments is the third standard, which the project supports by developing the tools of controlling the quality of waste water discharged from urban areas.

The economic benefits of the project are related to better water management and use leading to reduction of costs. The environmental benefit is improved water quality of water resources enhancing the quality of life. The citizens and relevant stakeholders involved in the project will benefit from new local policy and regulations (e.g. better building standards), environmental achievements (better quality of water and life), new job creation (development of water technologies and services market). The economic and financial dimension will be guaranteed with investments in improvement of water management and use. These will support the growth of the local market of water use and management technologies and services.

One of the objectives of the project is to share the WFTP approach and create the awareness about water scarcity and the potential for better water management and saving solutions, however regardless how broad is the marketing campaign the addressors might be not interested in the subject. There might be problems with data gathering due to lack of data and transparency. It might be impossible to implement improvement plans because of rigidly established water supply structure, bureaucracy, etc. There might be also difficulties in the identification and access to water technologies. Therefore the role of the project is to stimulate the collaboration between municipalities, universities and water authorities, favouring and enabling the common decisions on water management issues. The project technical board and scientific board involve experts from both, the scientific and industrial sector. Local municipalities supported by the scientific world and water authorities will be able to set reasonable policies, interventions and regulations in an innovative way, based on consistent and reliable data.

Future development of the proposed approach can also be identified and considered for other potential future projects. It would be interesting to review the existing approach at the light of the forthcoming ISO standards on water footprint [4] therefore characterizing the different water use in term of impacts assessment to address the issue of scarcity or other environmental impacts such as eutrophication or acidifications. Another interesting developments would be to integrate the current framework with other interesting indicators such as the carbon footprint that has been widely applied at urban level for example in the Covenant of Mayors European initiative.

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