ASM – Market Research and Analysis Centre

A study on the organization of international study visits disseminating good practices regarding water recovery and reuse technologies among AQUARES Partners (Interreg Europa)

Report commissioned by
Marshal Office of the Lodz Voivodeship
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Introduction

This document was prepared as part of the AQUARES project by one of the consortium members - Lodzkie Region. It was elaborated to deliver input documentation for project's study visits aimed at facilitating the exchange of experience on water reuse implementation and monitoring issues in Europe and its regions represented in the AQUARES.

Lodzkie Region is partner responsible for organisation of the first AQUARES study visit in Poland, and due to this fact Lodzkie is also in charge of preparation this input paper to be used as compendium of knowledge on study visits for the events' participants and their hosts.

This input paper is aimed to be used as the source of information describing the topic which is at the heart of AQUARES – water reuse practices in Europe, but also as a guide supporting organisation of next study visits. Therefore the contents of the document are related to both substantive as well as to the organisational issues.

Considering the study visits' participants – this input paper describes the main goals of the project, its undertaken activities and their expected impact. Also the background information on the current water status in the European Union illustrated with some statistics (e.g. water exploitation index) is provided, as well as water reclamation, reuse and monitoring technologies and reclaimed water applications in Europe.

The core part of this document is dedicated to the water reuse related case studies in Lodzkie region. The most successful water reuse stories from Lodzkie voivodeship are presented with the reference to the possible applications of the reclaimed water: public sector, industry, agriculture, sport and recreation. The presented success stories are the key themes of knowledge transfer and exchange between the study visit participants.

Considering the study visits' hosts – this document provides technical and organizational guidelines to AQUARES partners organising further study visits. The guidelines have been developed by Lodzkie on the basis of experience collected during the AQUARES events preparation as well as while participation in SCREEN and GPP4Growth projects.

Finally, this input document includes the study visit agenda. Agenda defines precisely the scope of the study visit as well as gives detailed information on the date, hours and place of the meeting. It is important to notice that according to the agenda, some of the case studies listed in this document will be not only described, but also presented to the event participants in real-life conditions.

AQUARES project assumptions and water status in the Europe

Water is an essential resource for human health, agriculture, energy production, transport and nature, but securing sustainable management of water remains one of the key challenges of our time in Europe. The main aim of EU water policy is to ensure that a sufficient quantity of good-quality water is available for both people's needs and the environment. According to the latest report assessing European waters delivered by European Environment Agency[1], the state of surface, ground and coastal waters in the European Union is getting better, however, it still needs to be improved. Over the past 30 years substantial progress has been made - improvements in water efficiency and management of water supplies have resulted in an overall decrease in total water abstraction of 19 % since 1990. The observed improvement has been achieved mainly thanks to EU rules, in particular the EU's Water Framework Directive, the Urban Waste Water Directive and the Drinking Water Directive. It seems that the greatest impact can be attributed to the Water Framework Directive, which came into force in 2000 and established a framework for the assessment, management, protection and improvement of the quality of water resources across the EU. Following the Water Framework Directive requirements, Member States have made marked efforts to improve water quality or reduce pressure on water resources.

Despite the progress achieved, European Environment Agency points out in the report that issues of water status and protection should be included in various areas of activity, and not only in the so-called water policy – a more integrated approach was recommended, where the importance of ecosystems and the role of economic and social sectors would be taken into account.

Although 72% of the Earth's surface is covered with water, less than 3% of this water is suitable for uses like drinking and irrigation. Across the EU, water shortages and droughts have increased dramatically in recent decades. These phenomena are likely to become more frequent and more severe in the future not only because of the climat change, but also because of the growing needs of populations and overabstraction. Water demand across Europe has steadily increased over the past 50 years, partly due to population growth. This has led to an overall decrease in renewable water resources per capita by 24 % across Europe.[2]

Nowadays, water scarcity affects at least 11% of the European population and 17% of the EU territory. Unfortunately, there are forecasts predicting that by 2030 water stress and scarcity will probably affect half of Europe's river basin. What is important, the water scarcity is not limited to a few corners of Europe, but the phenomenon is fast becoming a concern across the whole EU. The most difficult situation is in the Mediterranean region (Spain, Portugal, the Italian peninsula, Southern France, Cyprus, Greece and Malta), where approx. 20% of the population lives under constant water stress, while during summer the percentage of the population affected by water stress is even 50%. Water scarcity is also becoming an issue in northern regions, including parts of the United Kingdom and Germany. Agricultural areas with intensive irrigation, popular tourist destination and large urban agglomerations are deemed to be the biggest water stress hotspots.[3]

The table below gives an overview of water stress conditions in Europe including the most recent data available for particular countries. The water stress is expressed with Water Exploitation Index (WEI). The indicator presents the ratio of the volume of annual water consumption to the volume of water resources obtainable. The minimum period taken into account for the calculation of resources possible to obtain is 20 years. The warning threshold of 20% for this indicator distinguishes a non-stressed from a water scarce region, with severe scarcity occurring where the WEI exceeds 40%.

[1] European waters, Assessment of status and pressures 2018, European Environment Agency (2018)
[2] https://www.eea.europa.eu/signals/signals-2018-content-list/articles/water-use-in-europe-2014 (available 7th October 2019)
[3] Ibidiem

According to the presented data, countries where the water consumption rate exceeds 20% of reserves are Spain, Malta and Cyprus (in the last two WEI exceeds even 40%). Importantly, in many European countries the value of this indicator remains at the dangerous limit value of 20%, above which it can be expected that there will be a water shortage.

Table 1 Water exploitation index in Europe (%)

Water exploitation index	
Country	Indicator value (year)
Belgium	15,2 (2015)
Bulgaria	5,6 (2017)
Czechia	10,2 (2017)
Denmark	4,5 (2016)
Germany	13 (2016)
Estonia	14,5 (2017)
Ireland	:
Greece	15,6 (2016)
Spain	**28,1 (2016)**
France	13,9 (2016)
Croatia	:
Italy	:
Cyprus	**67,4 (2017)**
Latvia	0,6 (2017)
Lithuania	1,3 (2017)
Luxembourg	2,7 (2016)
Hungary	3,4 (2016)
Malta	**51,2 (2017)**
Netherlands	8,7 (2016)
Austria	:
Poland	17,7 (2017)
Portugal	6,6 (2017)
Romania	17,1 (2017)
Slovenia	2,9 (2017)
Slovakia	0,7 (2017)
Finland	:
Sweden	1,2 (2015)
United Kingdom	4,2 (2014)
Iceland	:
Norway	:
Switzerland	:
North Macedonia	:
Serbia	3,1
Turkey	:
Kosovo	86,4

Source: ASM-Market Research and Analysis Centre on the basis of EUROSTAT (':' means lack of data)

In order to reduce the negative environmental impact of water shortages, the water resources must be managed more efficiently. Treated wastewater is one of the key effective alternative water supplies. Reusing water after appropriate treatment extends its life cycle, thereby preserving water resources.

The important statistic is that in EU more than 40,000 million m3 of waste water are treated every year, but only 964 million m3 of this treated wastewater is reused.[4] It shows extremely great potential for further uptake: Europe could use 6 times the volume of treated water that is currently used.

In response to Europe's growing problem of water scarcity, the AQUARES project has been established to support the efficient water management on the continent through water reuse. Especially, AQUARES overall objective is to support ten project partners representing nine European countries to transfer the lessons learnt on water efficient use & management into their regional policies and action plans. In detail, the AQUARES expected impact is as follows:

- increased capacity of 200 staff of public administrations to effectively support water reuse,
- 10+ million € investments unlocked to support projects on water efficiency and to improve the management of water bodies,
- increased awareness and consensus building among water providers, the workforce, and citizens, to support measures for water reuse (over 1000 individuals).

In order to meet these ambitious goals, the project team planned a set of various activities to be performed during the project lifetime. In general, the project activities are focused on facilitation of policy learning, sharing of knowledge, and transfer of good practices between regional and local authorities and other project's stakeholders. Particularly, within the frame of AQUARES, the following actions will be undertaken to gain the maximum of the expected impact:

- 9 action plans will be prepared for each country represented in the project to improve the relevant policy instruments, benefiting managing authorities and beneficiaries,
- 3 interregional workshops, 3 study visits and 10 bipartite site visits will be prepared to foster capacity building among partners and stakeholders,
- 1 online toolkit on the evaluation of water reuse investments for regions promoting water efficiency will be delivered,
- 5 joint thematic studies and analyses reports on territorial needs and opportunities for water reuse pathways will be released.

Apart from capacity building activities dedicated to the professionals, AQUARES important goal is to increase awareness on water reuse needs and possibilities among the general public – the public dialogue between citizens is being initiated and promoted by the project team.

Goals of study visits as well as technical and organizational guidelines

A study visit is a short organized meeting (usually 3-5 days) to exchange experiences and to show institutions, organizations, projects, and ventures. Such meetings usually take place in a small group (10-20 people) specialists or other people interested in the theme. The study visit programs include

[4] https://ec.europa.eu/environment/water/pdf/water_reuse_factsheet_en.pdf (available: 8th October 2019)

visiting the most interesting and valuable local places from the point of view of the main topic of the meeting. It can be said that during study visits, local leaders show invited leaders projects that are worth seeing in a given region.

One of the key knowledge and experience sharing events planned within the AQUARES project are study visits.

In total, three study visits are planned within AQUARES project: Lodzkie will organise the 1st study visit in Łódź, Poland, in Autumn 2019 i.e. during semester 3, the 2nd study visit will be organized by Regional Development Agency of the Pardubice Region (Czech Republic) during semester 4, and the 3rd study visit will be organized by Ministry of Environment and Energy, Special Secretariat for Water (Greece) in semester 5.

The Polish study visit will be a two-day event that will take place October 16-17, 2019. All AQUARES partners will participate in the study visits, and what is more, project external stakeholders from partner regions will be also invited. The profile of meeting participants (both project partners and external guests) can be defined as experts / professionals dealing with water management / reclamation issues. Participants of the study visit represent the public sector, the business sector and the academic community. All The expected participants number per each study visit is approx. 20.

The main reason why these events are organized is the interregional exchange of experiences on water reuse implementation and monitoring issues between participating regions, i.e. AQUARES success stories. Consequently, the key themes of study visits are as follows: innovative water reuse monitoring practices, adaptation of efficient funding models and policy measures to regional needs, etc.

The general structure of study visits includes a few key elements indicated below:

- a substantive introduction aimed to familiarize the event participants with the specific of hydrological status of hosting region – its water resources and management issues,
- practical activities (visits to institutions, facilities, buildings) to learn how different model solutions related to the water reuse eco innovations work in reality,
- evaluation sessions during and after the visit aimed at gathering opinions and recommendations of participants (internal debriefing meetings).

The summary report will be elaborated by the study visit host – Lodzkie Region, and apart from the most important substantive conclusions, also the logistics and organizational issues will be covered in the report. Knowledge and experience acquired during the event will be further disseminated by the meeting participants among their fellow-workers – each AQUARES partner (10) will organize internal debriefing meeting within own organization to share the lessons learnt during the study visit.

Preparing a study visit is quite a challenge for the organizers, because it requires the involvement of many resources (human, financial, etc.) on many levels. A very useful tool for planning and managing the preparation of meetings is a checklist, which contains a list of activities (both organizational and technical) necessary to perform a specific task (in this case - the organization of a study visit). Using the checklist, we can be sure that none of the necessary actions has been missed and that the meeting has been prepared with due diligence. In addition to the list of activities, it is also worth determining who will be responsible for the implementation of a given task and determine the deadline by which the task must be completed.

The below checklist might serve as a set of proposed recommendations supporting the preparation of successful study visit. They have been developed by Lodzkie on the basis of experience collected during the AQUARES project as well as while participation in SCREEN and GPP4Growth projects.

Table 2 Checklist supporting the preparation of study visits

CHECKLIST ACTIVITIES TO PERFORM	YES/ NO
Arranging the date of the visit with project partners	
Confirmation of the number of participants from the project team	
Determining the profile of meeting participants from outside the consortium and their number	
Determining the persons responsible for recruiting participants from outside the project (e.g. each partner should invite 1-2 experts)	
The recruitment process of external participants	
Confirmation of the number of participants of a study visit outside the project	
Establishing the study visit program (program elements: presentations, discussion part, trips to selected case studies + their duration)	
Providing a meeting place (e.g. conference room) isuitable for the number of participants	
Determining the language of the meeting and, if necessary, providing interpreters	
Providing the person / persons running the event (e.g. opening speech etc.)	
Provision of speakers	
Providing additional assistance / service during the event (registration of participants, delivery of information materials, serving meals, etc.)	
Appointment of a person responsible for preparing the meeting minutes / meeting summary report	
Providing transport with a sufficient number of places for event participants	
Determining the number of meals including information on restrictions in the participants' diet	
Providing meeting participants with practical tips (recommended hotels, dress code - if e.g. an open-air visit, driving directions, etc.)	
Preparation of gadgets and information materials for meeting participants (e.g. notebook, pen, badges, meeting agenda)	
Preparation of promotional and communication materials (e.g. posters, leaflets about the project, organizer or region in which the visit takes place)	
Considering the need to promote the event - if so, by what means (press release, radio, social media, etc.) and on what scale (local, national, European)	
BUDGET PROVISION FOR IMPLEMENTATION OF ALL TASKS (planning and controlling expenses within the available budget)	

Subjects of study visits

The subjects of study visits concern mainly the technologies of water recovery and reuse applied in the Lodzkie region. The study visit was planned in such a way that the event participants could learn about good practices implemented in the region within various sectors: sport, recreation, industry, agriculture and public applications. Examples of good practices from the Łódź Voivodeship are discussed in detail in the next chapter of this document. Due to time constraints, not all of the case studies described in this report can be reached during the visit. The topics of study visits will also raise the issue of models for co-financing projects aimed at implementing water reuse mechanisms. Availability of effective co-financing models play critical role in Resource Recovery and Reuse projects as the funding sources support to overcome the main barriers hindering such projects: high up-front costs and long payback time.

The available financial support models include public-private partnership and the use of financial resources from structural funds: the European Regional Development Fund (ERDF), the Cohesion Fund, the European Agricultural Fund for Rural Development (EAFRD), the European Maritime and Fisheries Fund (EMFF). All these funds are managed independently by European Union countries on the basis of partnership agreements with the European Commission, in which the allocation of funds (e.g. support for water resources management projects) during the current financing period is established.

The rationale why public-private partnership might be successfully deployed in water reuse projects as well as its different models applicable for water management are in detail presented in AQUARES report *Input study on how to unlock public and private investments in water* issued by Energy and Water Agency Malta in March 2019. Additionally, a comprehensive list of public-private partnership case studies relating to water reuse in Europe has been provided in the mentioned deliverable.

Among the projects from the Lodz region described in this document, in most cases of the selected investments, they were carried out with investors' own funds and without external financial support. Sometimes these investments were implemented as part of large modernization projects, for which financial support was received, but the funds were not specifically dedicated to the implementation of water reuse solutions (it was the beneficiary who decided to include this goal in the available budget). The exception is the Janis dyeing plant - in 2014 the company received funding from the European Union under the Lodz Regional Operational Program and the state budget (name of the investment: Increasing the company's competitiveness through the acquisition and implementation of the results of R&D works to build a recovery system and recycling of technological water). The total value of the project is PLN 3.1 million, of which the ERDF co-financing amount is PLN 765.0 thousand PLN. In the case of investments from the agricultural sector described in the document, the owners of farms did not bear the investment costs, but only shared their property, as the projects being implemented there are part of research programs conducted by universities in Lodz.

In general, according to the opinion presented in the document "17 challenges for Poland - 17 answers. What companies in Poland can do to achieve the Sustainable Development Goals? ”Poland lacks good water management at all stages of its use, and one of the biggest challenges for our authorities, apart from preparing good legal regulations, is preparing financial support mechanisms. Until now there law quality and scope were not satisfactory enough, but fortunately this is being changed now as the Polish authorities take action in this direction. However, there is certainly a lack of financial support and widespread education in the use of water.[5]

Coming back to the topics of study visits, in addition to the presentation of examples of technologies for purifying and reusing water in the region and the financing aspect of this type of projects, participants of the meeting will also be acquainted with the hydrological characteristics of the Lodz region. This characteristic of each region is crucial to identify the needs for water reuse and matching relevant technologies. Each region has its own specificity and different water management problems, therefore different solutions require popularization in a given region.

The criteria that should be taken into account when selecting the most effective solutions supporting water reuse are undoubtedly the natural features of the region that condition its water resources: precipitation, field evaporation and runoff (surface and underground), which result from a variety of factors such as climate, land cover, topography, geological structure and soil type. Natural conditions, in particular climate features, hydrological regime, terrain and flora are natural factors affecting water resources. However, their proper assessment is possible only after taking into account demographic and urbanization processes as well as factors related to human activity, including but not limited to industrial development, mining processes and agriculture.[6]

An important criterion in the identification of regional needs in the field of water reuse is also information on the volume of water abstraction taking into account its purpose in specific regions. Based on such data, it is not only possible to identify those sectors of the economy that collect water on a large scale in a given region, but equally important - it is possible to design dedicated activities for these most absorbent sectors to improve the efficient use of water (technologies appropriate for a given sector, co-financing model, etc.).

The map below presents the distribution of water intake in the economy sectors in individual voivodships in Poland. The proportions of water use in the Lodzkie Voivodship are as follows: 48% water for the operation of the water supply network, 33% water for the production industry, 19% for irrigation in agriculture and forestry as well as filling and completing fish ponds. Considering the above information, it can be assumed that in the Lodzkie region the most effective solution increasing the efficiency of water use would be the implementation of technologies and procedures as well as co-financing models supporting water reuse for all activities related to with the operation of water supply networks.

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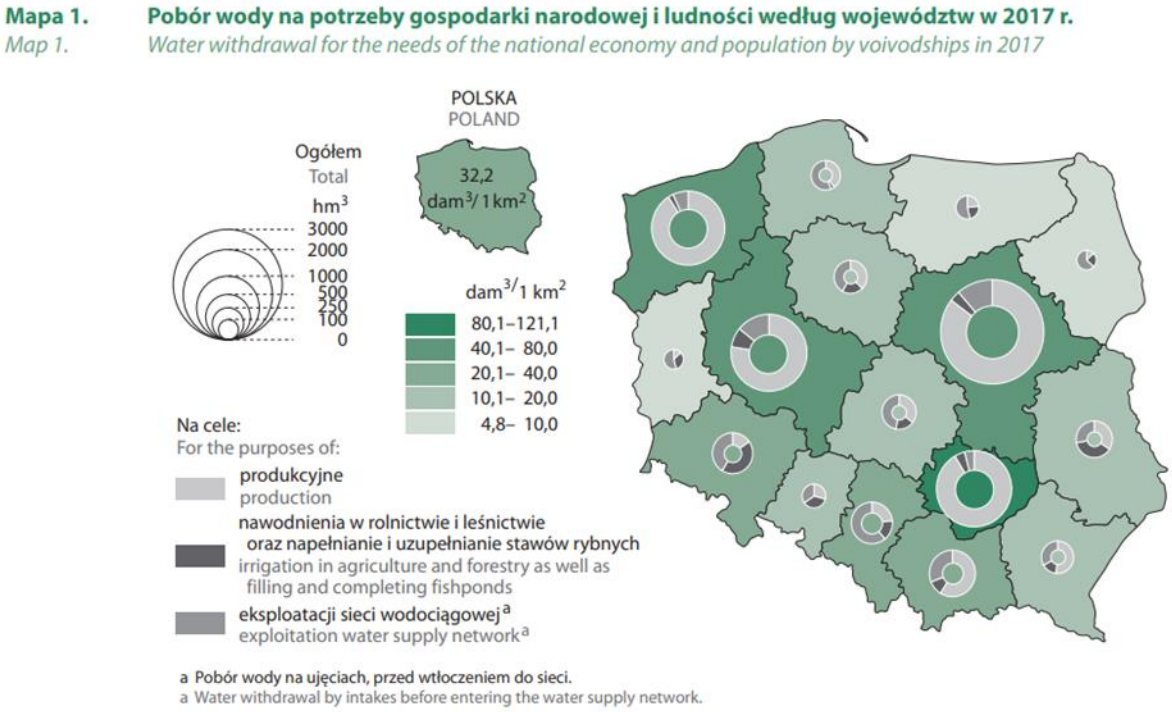
[5] 17 wyzwań dla Polski – 17 odpowiedzi. Co firmy w Polsce mogą zrobić dla realizacji Celów Zrównoważonego Rozwoju?, Forum Odpowiedzialnego Biznesu (2018)

[6] https://circabc.europa.eu/webdav/CircaBC/env/wfd/Library/framework_directive/implementation_documents_1/information_consultation/poland/rwma-poznan/B-SWMI-PL-RWMA-Poznan-pre-consultation.pdf

Map 1 Water withdrawal for the needs of the national economy and population by noivodships in 2017



Source: ASM-Market Research and Analysis Centre on the basis of Statistics Poland [7]

In the course of work on this document, it also turned out that it is difficult to find advanced examples in the Lodzkie region for water reuse in the agricultural sector, despite the fact that the sector plays a significant role in the economy of the voivodship, and agricultural land accounts for over 48% of its area. Although this sector does not absorb the largest amounts of water in Lodz, rapid actions are needed to increase the efficiency of water resources management (e.g. support for water reuse technology), mainly due to the increasingly frequent problem of agricultural drought in the region. According to the latest report of the Institute of Soil Science and Plant Cultivation, the Lodzkie Voivodship was one of those areas in Poland where the largest water deficit was recorded in May-July 2019 - drought was found in all 177 municipalities of the Lodzkie Voivodship .

Water recovery & reuse technologies and monitoring technologies in the European Union by sector

Reclaimed water is most often used for **agricultural irrigation**. The possible agricultural irrigation uses are: food crops both commercially and not commercially processed, pasture for milking animals, fodder, fibre, seed crops, ornamental flowers, orchards, hydroponic culture, aquaculture, greenhouses, viticulture. The potential uses in urban areas might be described as **public applications**: roadsides and street cleaning, fire protection systems, vehicle washing, toilet flushing, etc. The reclaimed water might be as well efficiently applied in **the industry sector** – it might be used as processing water, cooling water, recirculating cooling towers, washdown water, etc. Finally, the reclaimed water are being used in both sectors of **sport and recreation**. **Sport applications** consider

[7] Ochrona środowiska 2018, Główny Urząd Statystyczny (2018)

irrigation of courses/pitches (e.g. golf courses) and other applications in sporting facilities. Possible recreational uses are irrigation of public parks and other green areas, and even snowmaking.

When it comes to **the technologies for recovery and reuse of water**, an additional advanced treatment apart from the standard wastewater treatment is necessary in order to minimise health and environmental risks and ensure its quality. Such additional treatment is called reclamation treatment and its main objective is to remove pathogens and chemical contaminants. Reclamation technologies can be classified as intensive (conventional) and extensive technologies (non-conventional) – their overview is presented in the below table[8].

Table 3 Intensive and extensive reclamation technologies

Intensive technologies	Extensive technologies
Physical-chemical systems (coagulation-flocculation, sand filters)	Waste stabilisation ponds (maturation ponds, stabilisation reservoirs,...)
Membrane technologies (ultrafiltration, reverse osmosis, membrane bioreactor, ...)	Constructed wetlands (vertical-flow, horizontal-flow,..)
Rotating biological contactors	Infiltration-percolation systems
Disinfection technologies (ultraviolet radiation, chlorine dioxide, ozone, peracetic acid, ...)	

Source: ASM-Market Research and Analysis Centre on the basis of Water Reuse in Europe

Intensive technologies require large quantities of energy, but minimum space. What is important, to be efficiently operated they need highly specialised operation and maintenance personnel. On the contrary extensive technologies require a large amount of land because they use environmental matrices and rely on natural processes for water treatment (processes occur at almost natural rates). The energy requirements of extensive technologies are rather low. These technologies also do not require advanced levels of operation and maintenance. In practice, a combination of two or more technologies is used to achieve the required water quality levels. The selection of the relevant reclamation technology is based on the following criteria: the quality and the quantity of the water to be reclaimed, the final quality required for the specific use, the economic cost, and the environmental impact.

The next sections give the brief overview of water reuse applications in the following sectors of the European economy: industry, agriculture, sport and recreation, public sector.

Golf courses are important users of reclaimed water when **sport applications** are considered. In general, the average 18-hole golf course covers about 54 ha of land - it means that golf courses require a considerable amount of open surface that potentially could be used as wildlife habitat. Moreover, potential problems associated with golf course construction and maintenance include soil erosion and pollution; surface and groundwater depletion; etc. As a result, in recent years there has been a considerable demand for golf courses to adopt environmentally sustainable strategies in design, construction and management. Water consumption on a golf course depends on its dimension, local climate, water retention properties of substrata and water requirements of turf and can therefore vary from zero (in rainy seasons) to 2,500 m3 /per day in a dry, hot season. Average

[8] Alcalde Sanz L., Gawlik B.M. ,(2014), Water Reuse in Europe Relevant guidelines, needs for and barriers to innovation, p.40

water consumption on a standard 18 hole golf course (with an irrigated surface of 54 ha) can be estimated at around 0.3 Hm3 per year.[9] The increasing cost of water and proecological social moods have pressed golf course management to reduce water consumption. What is more, water authorities in several countries (e.g. Spain and Portugal) are enforcing by law the irrigation of golf courses with alternative water resources, mainly reclaimed water.

There are several strategies to obtain water for the irrigation of golf courses. As in conventional agricultural practices in arid climates, water can be obtained from nearby water courses or from underground aquifers. Another solution is the use of non-conventional resources - reclaimed water is usually the preferred one. No matter what the origin of the water, the technology used in irrigation practices is almost always based on the use of sprinklers. Reclaimed water obtained in compliance with reuse standards should be of a high enough quality to reduce risks to an acceptable level. Due to the differences between regulations in different countries, there are no uniform water reuse monitoring methodology and its analytical control worldwide or on European level . Often, the water reuse in golf courses apply mainly the same procedures that were established for agriculture, albeit considering that the end-users (golfers) should not enter into contact with reclaimed water.

The main mechanisms for controlling the quality of purified and reused water include capturing features or signs that may indicate malfunctioning of the entire system or parts of it by trained personnel. The condition of turf, soil, soil, lakes and streams can be used as an indicator, especially if golf course staff know their standard characteristics. Thera are also most scientific ways to detect problems on a golf course- three types of analysis can be performed:

- preventive - aimed to discover problems before they appear: grass, soils and water are periodically sampled and analyzed either in situ or in a laboratory;
- regular – aimed to detect the needs of the system (e.g., nutrient contents in soil, water and plants), support to manage the facility adequately, with the additional benefit of obtaining savings on fertilizers, pesticides, etc.
- legal – compulsory if the course is irrigated with reclaimed water; the main types of analysis are physical, chemical and biological, but those performed to comply with legal requirements when using reclaimed water refer mainly to the microbiological characteristics.

Apart from the golf courses irrigation, Spain delivers a few other applications of reclaimed water - a large-scale strategy to use recycled water for park irrigation (**recreational application**) and street cleaning services (**public application**) was implemented in the Spanish capital – Madrid[10]. Not surprisingly, in 2018, Spain was classified as the country with the highest rates of wastewater reuse from the European Union and it belongs to the top ten worldwide.[11] Replacing the potable water currently used to keep parks and gardens green and to wash down streets and pavements was one of the most important goals of the Madrid Water Re-Use Plan. Under the Plan the municipal waste-water treatment plants of Viveros, La China, Las Rejas, Valdebebas and La Gavia were managed and

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[9] Miquel Salgot, Gerda K. Priestley and Montserrat Folch, Golf Course Irrigation with Reclaimed Water in the Mediterranean: A Risk Management Matter, (2012)

[10] https://ec.europa.eu/regional_policy/en/projects/major/spain/keeping-madrid-clean-and-green (available: 7th October 2019)

[11] Antonio Jodar-Abellan, María Inmaculada López-Ortiz and Joaquín Melgarejo-Moreno, Wastewater Treatment and Water Reuse in Spain. Current Situation and Perspectives (2019)

as these facilities used the most modern tertiary waste water treatments, the recycling of treated waste water was possible. As part of the project, the water supply network was expanded and modernized in order to deliver the reclaimed water to the application areas. At the moment, across the European Union there are 6 countries where water reuse policies and regulatory tools are in place at national level: Cyprus, France, Greece, Italy, Portugal, Spain. The irrigation of parks is perceived as one of the intended uses of reclaimed water as it is included in the standards of the Member States mentioned above.[12] Importantingly, Spanish legislation is the only one that includes the use of reclaimed water for the irrigation of private gardens. However, authorisation for this use is only given provided that a marked dual circuit is implemented, i.e. a water pipe system with dedicated and separated lines for drinking water and reclaimed water.[13]

Madrid example of water reuse application in the street cleaning services is a consequence of the inclusion of such possible intended use into the Spanish standards. Apart from Spain, the street cleaning with reclaimed water is also defined in the standards of Italy and Greece. Spain, Italy and Greece also included into their national standards **another public application of reclaimed water - fire hydrants supply.**

One of the best known example is the **industrial application** of the reused water is Kalundborg symbiosis in Denmark, where several companies mutually provide and recycle wastewater. The Kalundborg Eco-Industrial Park is the first full realization of industrial symbiosis - a number of industrial companies from very different sectors exchange waste and resources with each other in an elaborate network of pipelines. Among the participants are a refinery, a power plant, an enzyme producer, a producer of insulin, and a manufacturer of gypsum board - these companies send waste from their production process on to other companies in the system, which can then use this as valuable input for their process. Steam, sludge, fly ash or hot water are some of the resources exchanged.[14] The symbiosis project in Kalundborg dates back more than fifty years. The first exchanges took place back in 1961, and at the time it was prompted by a lack of access to water. Since then, the system of exchanges has gradually been extended. Today, it includes 30 different material, water and energy streams between 13 different companies and a range of farms and municipal institutions. Water reuse schemes have also been developed within Kalundborg[15]. Statoil pipes deliver 700,000 cubic meters of cooling water per year to Asnaes (power plant), which purifies it and uses it as "boiler feed-water." Asnaes also uses approximately 200,000 cubic meters of Statoil's treated wastewater per year for cleaning. The 90 °C residual heat from the refinery is not used for district heating due to taxes. Instead, heat pumps are used with the 24 °C waste water as a heat reservoir.

It seems that the highest number of water reuse project is related to the **agricultural applications**. One of the largest irrigation projects in Greece is located in Thessaloniki plain which is one of the biggest agricultural areas of Greece[16]. The irrigation water is transported water from the Axios and

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[12] Alcalde Sanz L., Gawlik B.M. ,(2014), Water Reuse in Europe Relevant guidelines, needs for and barriers to innovation, p.24

[13] Ibidiem, p. 25

[14] http://we-economy.net/case-stories/kalundborg-symbiosis.html (available 7th October 2019)

[15] https://en.wikipedia.org/wiki/Kalundborg_Eco-industrial_Park#Material_Exchanges (available 7th October 2019)

[16] Andreas Ilias, Athanasios Panoras and Andreas Angelakis, Wastewater Recycling in Greece: The Case of Thessaloniki (2014)

Aliakmon Rivers to the fields with extended open canal irrigation networks. During dry years, at the peak of the irrigation period (July–August) the flow of the two rivers is getting low and additional water resources are needed in order to meet the demand. Effluent from waste water treatment plants (WWTP) is an alternative water resource that was implemented in order to catch up with the demand. As a result, wastewater effluent of 165,000 m^3/day from the Thessaloniki WWTP is mixed with river water from the Axios at maximum ratio 1:5 and reused to irrigate approximately 2500 ha of rice, corn, alfalfa, sugar beet and cotton. The exact percentage of wastewater in the mixture depends on the quality of the effluent and especially its salinity, and is decreased if higher than usual salinity values are measured. The Land Reclamation Institute is in charge of the surveillance of the system, checking the quality characteristics of the effluent delivered to the irrigation network and the possible effects of its use. In order to eliminate the negative impact on the environment, appropriate management practices were adopted, including the selection of suitable irrigation methods, soil cultural practices, soil drainage, and selection of salt-tolerant plant species. Two of the substances of concern in recycled water are nitrogen (N) and phosphorus (P) and they are both monitored in Thessaloniki case.

Additional measures in the Thessaloniki reuse project include the restriction of effluent application to crops that are consumed raw by humans while, in the case of horticultural crops, irrigation must cease at least two weeks before harvesting. Farmers are encouraged to use trickle irrigation to minimize the contact of crop and humans with recycled water, while the use of sprinklers is prohibited. Moreover, notices should be placed in the effluent-irrigated fields and effluent (mixed water) conveying canals.

Case studies in the Łódź Voivodeship

Pursuant to the case study guidelines, the task was to elaborate on 10 examples of water reclamation and reuse success stories in Lodzkie voivodeship (with 2 examples per each of these sectors: industrial, recreation, public use, sports, and agriculture). The report includes also examples of solutions targeted at reduction of water losses, applications of water retention, and water contamination reduction.

For each of the sectors, examples are given of good water reclamation practices for resource conservation:

a. Industrial: Farbiarnia Bilińscy; Janis
b. Recreation: Arturówek; EC1 Miasto Kultury
c. Sports: ZATOKA SPORTU ŁÓDŹ (ŁÓDŹ SPORTS BAY)
d. Public use: Sieradz City Water Supply and Sewerage (Miejskie Przedsiębiorstwo Wodociągów i Kanalizacji Sieradz); The Cluster Sewage Treatment Plant of the City of Łódź (Grupowa Oczyszczalnia Ścieków Łódzkiej Aglomeracji Miejskiej)
e. Agriculture: organic manure platforms' applications at two farms – Kobyla Miejska (Szadek municipality) and Mikołajów (Rokiciny municipality).

There were no viable examples of water reclamation and reuse at sports facilities in the Lodzkie voivodeship (no real-life solutions were located during the research or by expert consulting), a specification of an innovative solution's PoC (proof of concept) by Cybercom was included (in agreement with the Employer).

Due to the lack of examples of recovery and reuse of water in sports facilities (outside of ZATOKA SPORTU ŁÓDŹ), it was not possible to identify this type of solutions in the Łódź Province both in the course of research and in consultation with experts. Therefore, another example of innovative practices in region was included into the report (in consultation with the Principal) - a description of an innovative solution of Cybercom company - Proof of Concept (PoC) was added.

FARBIARNIA BILIŃSCY (Biliński Textile Print)

Farbiarnia Bilińscy is a private industrial plant located in Konstantynów Łódzki with nearly 300 employees. Farbiarnia Bilińscy's core business is dyeing, bleaching, upgrading and digital printing of woven and knitted textiles. Over 50% of production is sold to export destinations, primarily in the Nordic countries, followed by Baltic states and the Czech Republic, Slovakia, Germany, the United Kingdom, and Italy.

The sewage treatment and closed water cycle project for Farbiarnia Bilińscy was completed in compliance with BAT (Best Available Techniques) for the textile industry (European Commission, 2003).

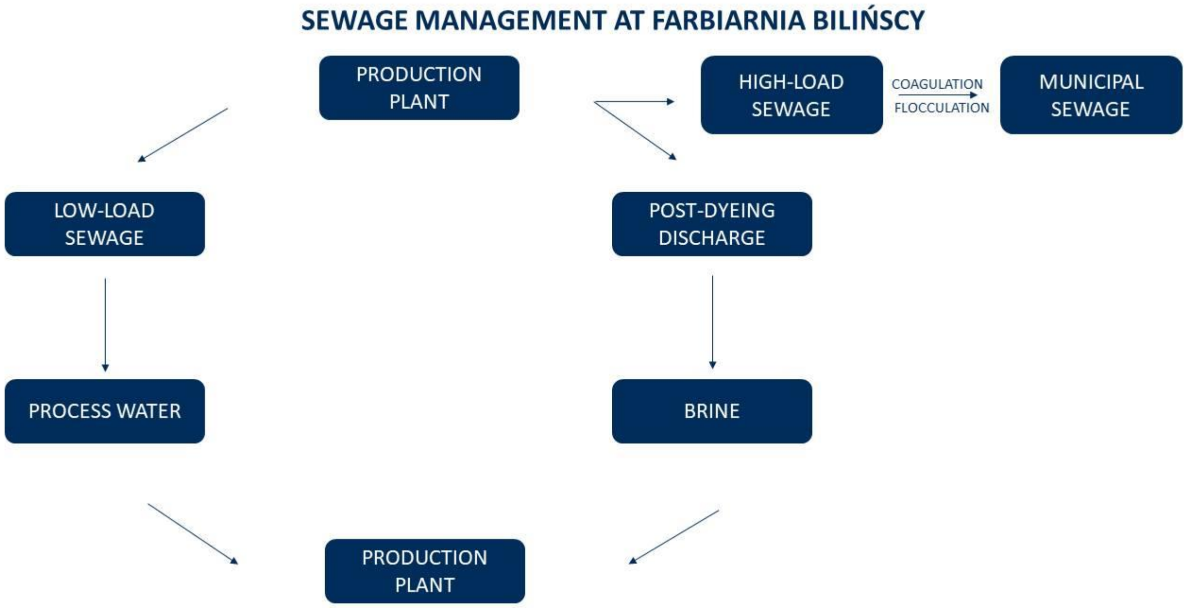
The BAT guidelines determine the following stages of project work:

1. characterization and classification of sewage into streams by biodegradability;
2. design of a treatment system for the relevant sewage streams;
3. investigation into the feasibility of treated water use in manufacturing processes.

Two main sewage streams were identified on site:

1. biologically treatable sewage;
2. hardly biodegradable sewage, directed to treatment plants using chemical methods.

Figure 1 Sewage management at Farbiarnia Bilińscy



Residues of dyes, detergents and processing aids imbue the sewage from the site with intense colours, high pH values, and high salinity; the sewage often has a BOD_5/COD (biological to chemical oxygen demand ratio) unfavourable to biodegradability.

Low-load sewage (which are backwash water) are diverted for biological treatment. This water is treated to achieve the minimum purity level required by on-site processes and recycled to the manufacturing processes at Farbiarnia Bilińscy. Hence, approximately 40-50% of the original water consumption is recycled. The sewage unsuitable for reuse by negative impact on the biological STP are pretreated by coagulation and flocculation, followed by discharge to the sewerage system. The latest project completed at Farbiarnia Bilińscy involved separation of post-dyeing sewage, which is characterised by high salinity (at up to 80 g/ml in salt contents), a very high pH value, and a significant colouring (which makes the sewage impenetrable to light). By application of suitable physical and chemical treatment, the purity level of the sewage facilitates reuse in the dyeing processes. Although the share of this sewage is the lowest in the operations of the site, they are most heavily loaded with contaminants. Moreover, the load includes chlorides which are compounds difficult to remove. If discharged to a combined sewer system, the sewage could not be eliminated by GOŚ (the Łódź Cluster Sewage Treatment Plant); only dilution would be viable.

The chemical-biological sewage treatment plant has been designed as a system of sequenced treatment stages: filtration, heat exchange, pH adjustment, coagulation, biological treatment and ultra-filtration, and ozone treatment. The sewage treatment plant was also equipped with an oxygen stabilization system for excess sludge. The first stages of processing at the treatment are mechanical filtration and heat recovery. The raw sewage enters an expansion tank with a service capacity of 10 m^3, in which irregular sewage discharges are contained and averaged. Next, the sewage is pumped to a self-cleaning filter screen, called a drum interceptor. The drum interceptor separates solids up to

0.2 mm in diameter, which reduces approximately 75% of solid contaminants, approx. 10% of suspended organic contaminants and approx. 10% of BOD_5, with removal of grease, sand particulates, and fibres (which are a major pain point for dyeing operations). The downstream module is a 60 m^3 tank in which the quality of sewage is averaged and sewage temperature is equalized before discharge to the heat exchanger. This tank is operated in cycles of filling and discharge to achieve optimum mixing of sewage.

Figure 2 The BCSTP (biological and chemical sewage treatment plant) systems at Farbiarnia Bilińscy

The call for implementation of the water reclamation technologies were driven mainly by cost efficiency desired by the increase in the costs of media (including the sewage).

The owners of Farbiarnia Bilińscy admitted that while they had sought inspiration in water reclamation and reuse in textile plants, they never saw a such a comprehensive solution. The water reclamation and reuse system installed at Farbiarnia Bilińscy was implemented in cooperation with the Textile Research Institute and the Technical University of Łódź. The owners also admitted that there are no laws in Poland to regulate the characteristics of industrial textile processing sewage, which are currently eligible to the criteria applied to commercial and household sewage.

Before the implementation of the water reclamation and reuse system, Farbiarnia Bilińscy had had an infrastructure extensive enough to warrant an adaptation to the project only. Hence, the implementation required no specific official permits. The reclaimed water is subject to ongoing manual quality monitoring by laboratory workers who test the water parameters and monitor the performance of biological and chemical sewage treatment plant, which includes testing of pH, redox, oxygen levels and miscibility. An array of probes and meters is operated in an automatic water measurement system.

JANIS

Janis is an enterprise which provides services in dyeing, bleaching and general upgrade of a variety of textiles. Janis was established in 1989 and currently employs a staff of 120. The main sales market is domestic (Polish).

Already 6 years ago, as a result of a manufacturing costs analysis and challenged by the growing costs of sewage disposal, Janis decided to act and optimise its water consumption and reclamation. In

2014, Janis was awarded EU funding under the Łódzkie Regional Operational Progamme and the Polish state budget (for the investment titled *Improvement of company competitiveness by acquisition and implementation of R&D work outcomes to build a process water reclamation and recycling plant*). The overall project value was 3.1 MPLN, of which the ERDF subsidy was 765.0 kPLN.

Figure 3 Underground pumping plant for filtered water

Figure 4 Membrane system installed at Janis

Figure 5 Averaging tank installed at Janis

The processing infrastructure of the water reclamation and reuse system was developed from 2014 to 2016, and is functioning well.

The post-dyeing water reclamation system at Janis comprises this sequence of processes:

1. waste water pumping to collection tanks (by the pumping plant);
2. waste water heat recovery by a plate heat exchanger (the recovered energy heats the raw process water);
3. two-stage (coarse and fine) mechanical filtration;
4. water cooling and delivery to an averaging tank for pH adjustment, coagulation and flocculation;
5. repeated mechanical filtration to remove the contaminants separated by the treatment process;
6. ionite filtration (removal of colour and remaining soluble fractions);
7. post-filtration by a multi-stage membrane system.

The water reclaimed in this process remains saline and slightly contaminated by detergents; however, it is still viable for recycling into the dyeing process (with dark colour only). Janis has contracted a third party (under National Center for Research and Development grant) to separate the reclaimed water streams into purified water and brine.

In line with the project specifications, the implemented dyeing water recycling process recovers 40-60% of the original input. The reclaimed water quality is not monitored, as it is not required by the applied dyeing technology.

The implementation of the water reclamation and reuse system at Janis required no official permits; the system used the pre-existing infrastructure that only needed adaptation.

ARTURÓWEK

The water reservoirs in the town of Arturówek are among the most popular rest and recreation areas of the citizens of Łódź. Not unlike other water reservoirs in urban settings, they are exposed to considerable contamination which significantly reduces the quality of water. Under an EU project titled LIFE + and "Eco-hydrological Remedial", the years 2010 and 2011 saw actions completed to identify the sources of contamination by an analysis of threats and opportunities and an assessment of the balance of contaminants flowing to and from the Arturówek water reservoirs. The data gathered from the actions helped to develop a mathematical model, a foundation of the Arturówek water reservoir remedial concept in 2012. The documentation collected from this work enabled completion of capex projects in 2013 Q1 do Q4 and comprising:

- Construction of buffer zones and floating vegetation mats in 3 of the water reservoirs to reduce the influx of biogenic substances to the basin;
- Eco-hydrological adaptation of 1 water reservoir to intensify the sedimentation and spontaneous treatment of its water;
- Construction of a Sequential Biofiltering and Sedimentation System (SBSS) for 1 pond at Arturówek to retain and pretreat the rain water received from Wycieczkowa Street;
- Eco-hydrological adaptation of low-volume water reservoirs to intensify spontaneous water treatment of the upstream river section;
- Hydraulic engineering modification of the damming structures to reduce flooding hazards;
- Removal of bottom sediments to reduce the internal supply of the water reservoirs with biogenic substances.

The project site was a 3.54 km long stretch of the Bzura River, with 56.6% of the stretch occupied by man-made water reservoirs (lower tank, middle tank and upper tank).

The actions completed under the project reduce the inflow of contaminants from the Łódź urban basin to the reservoirs and the Bzura. The operating principle is an integration of engineering and biological solutions derived from the operating concept of the SBSS. The SBSS comprises three zones:

1. the sedimentation zone, where the water flow is decelerated by which a significant fraction of the entrained suspension precipitates;
2. the biochemical zone, where a dolomite and lime structure reduces the phosphoric compounds dissolved in water;
3. the biological zone, where phyto-fermentation processes reduce nitrogen compounds dissolved in water.

Figure 6 Sedimentation zone: treatment of water for sediment removal at a part of the system settling tanks

Figure 7 Rain water treatment layer for the inputs from low-usage land; it is filled with rocks and features water plants

The solutions installed at the Arturówek primary water reservoir improve the quality of water and the biological diversity, providing habitats for fauna and flora. However, urban ecosystems requires efficient polishing of rain water and must be integrated with engineering solutions; here, the solutions include underground (buried) systems of separators and settling tanks which support pre-treatment and retention of rain water.

To reduce the negative impact of the runoff waters from road, bike and foot pavements on the Bzura River, the system of street gullies routes the waters from hard-paved ground to the underground treatment equipment (a swirl concentrator and a coalescing plate separator). The equipment filter out the suspension and eliminate petrochemicals. Next, the water is passed to the SBSS with a service surface area of 300 m^2 and installed in a pond near the street. By the effect of biological processes (which involve floating plants), the water is polished and discharged directly into the river).

The rain water from the hard-paved areas in direct vicinity of the Arturówek water reservoirs is discharged by curb drains and a system of gullies to the underground pre-treatment equipment (a swirl concentrator and a coalescing plate separator). Once pretreated, the water is released to a separated reservoir zone (with a service area of 120 m^3) for physical polishing (by sedimentation), geochemical polishing (with a layer of dolomite and rock) and biological polishing (by the action of water plants).

Figure 8 Geochemical filter: eliminates biogenic compounds by a geochemical structure (the underwater gabion zone filled with dolomite, limestone, and coconut fibre mats)

The system also treats the rain water drained from soft surfaces of the ground. The structure includes a swirl concentrator (integrated with the rain sewer system) which captures the sand, gravel, leaves and other debris entrained by water, and the SBSS, installed in the dome of the reservoir.
The project includes support operations:

- restriction of human feeding of aquatic birds, which otherwise result in additional loads of nitrogen and phosphoric compounds introduced to the water reservoirs;
- reduction of excessive use of bait feed by fishermen and anglers;
- regulation of the fish complex (with a 30% share of predators);
- management of the reservoir banks with shore plants;
- mechanical removal of muck from the reservoir bottom.

Since 2014, the system has been undergoing continuous optimisation and monitoring to assess the efficiency of the applied solutions.

EC1

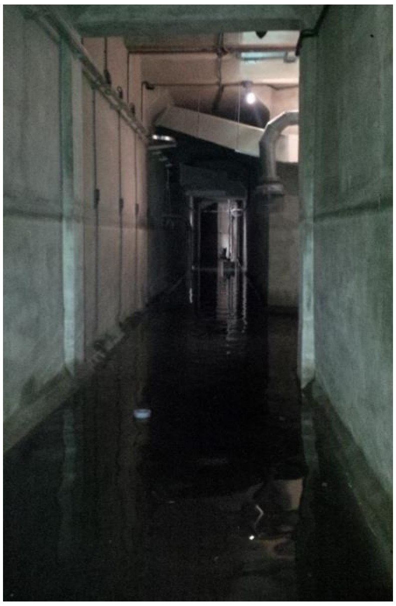
EC1 Łódź Culture City (*EC1 Łódź – Miasto Kultury*) is currently an arts, cultural and education hub operating in the converted and refurbished facilities of the once-largest heat and power plant in Łódź. The EC1 was converted and refurbished in effect of the act passed by the Łódź City Council in 2008. The project that followed the decision was 265 MPLN, of which more than 82 MPLN were subsidized by European Regional Development Fund. The conversion, refurbishment and conservation work preserved the entire volume, form and most of external features of the industrial buildings. The project was divided into two milestones: EC1 West and EC1 East (currently, the third part of the project is in progress and titled “EC1 South East”).

Given the surviving post-industrial facilities of the former heat and power plant (including the tanks and ducts), it was decided to preserve and repurpose them at the design engineering stage of EC1 West. This brought an idea for managing rain water with a system of pumps and tanks. The closed cycle of the system feeds grey water to toilets (through the flushing cistern supply subsystem at the Switchgear Building). The rain water collected from hard paved areas and roofs is pretreated (in hydrocyclones), released to tanks and pretreated further by their filtering layers, followed by pumping to the flushing cisterns. The piping and a part of the tanks are buried. The system comprises an arrangement of water tanks and pumping plants with:

- pumping plant P2 at water tank ZB2 (an underground tank, a surface tank, and a hydrocyclone unit);
- pumping plant P3 at water tank ZB3 (the slag quenching tank with rains and filtering layers);
- pumping plant P4 at water tank ZB4 (the cooling tower bowl with filtering layers);
- pumping plant P5 at water tank ZB5 (the water canal) and a pressure booster plant which can force water with the main pumps offline;
- pumping plant P6 at water tank ZB6 (at the Switchgear Building);
- tank ZB8 (filled with filtering material and vegetation).

Here, the main water tanks include the water canal (ZB5, ca. 350 m^3) with the pressure booster tank at pumping plant P5, the cooling tower bowl (ZB4, ca. 600 m^3), the prism tank ZB3 (the decommissioned slag quenching facility, ca. 300 m^3), and ZB2 (ca. 70 m^3). The water canal is a decommissioned process water tank operated to treat the water for the former heat and power plant. It is supplied with the rain water collected from the adjoining land and rooftops of the Boiler House, the Pumping House, the Engine Room, and pumping plant P6 (with the hydrocyclone pretreatment). In the north-western outdoor part of the complex (and next to the Engine Room), an oil separator is installed. Once petrochemical contaminants are removed, the water is discharged to the water canal. The water canal (ZB5) capacity is rated at approximately 350 m^3. The water from the canal is drawn with the pumps to the following locations:

Figure 9 Water canal: tank ZB5



a) to the top storey of the Switchgear Building, where a system of 2x2 tanks (with a total of 8 tanks) is installed in a technical area);
b) and to the remaining on-site tanks.

Figure 10 Water supply tanks at Level 4 of the EC1 Wess Switchgear Building

The Level 4 water tanks can feed the flushing reservoirs of the toilets in the Switchgear Building and tank ZB8. The cooling tower bowl tank is located underneath a structure which mimics the actual cooling tower operated at the HPP. Inside there is a system operated for the EC1 West Science and Engineering Centre (*Centrum Nauki i Techniki*) as a demonstration facility, showcasing the fill packs of the cooling tower. It is difficult to determine the exact service capacity of the cooling tower bowl, which is circular (with an approximate radius of 20 m) and concave to the centre. The bowl bottom is located approximately 1.8 m below the bowl edges (and under the current filtering layer), as the reference documents state. Tank ZB8 is fed directly by the drain pipe of the roof gutters of the Switchgear Building and from the water tanks inside the same facility.

Figure 11 Green roofs at EC1

The entire pumping plant system is under automatic control.

The water tanks and pumping plants include a garden hydrant for drawing water for maintenance and overall upkeep. EC1 operates separate blackwater and rain water systems; still, both are discharged to the combined sewer system under Tuwima Street.

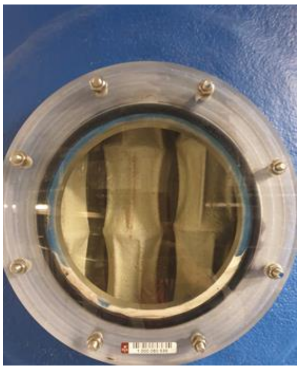
The Extension Building and Water Softening Plant Building at EC1 West feature parts of green roofs. The green roofs are home to mixed varieties of vegetation, crossed by foot pavements. The roof garden vegetation does not require watering for the most part of the year, unless dry periods are too long (which is especially true on hot days).

ZATOKA SPORTU ŁÓDŹ (ŁÓDŹ SPORTS BAY)

The TUL Sports and Education Centre's Sports Bay (Zatoka Sportu) is an interfaculty unit of the Technical University of Łódź (TUL). It is a sports campus with two basic parts, a swimming pool and a ground athletics area. The swimming pool includes two facilities:

1. an indoor 50x30 m Olympic pool with 10 lanes and a fixed depth of 2.5 m;
2. a 30x25 high jump pool with an adjustable bottom (which can be positioned anywhere between 0 to 5 m of depth).

Figure 12 Diatomic earth auger filters



The swimming pool water quality is monitored online and meets the Polish Regulation of the Ministry of Health dated 9th November 2015 and concerning the requirements for swimming pool water, i.e.:

- olympic swimming pool water — ref. Test Report no. 8581/ZL/18 of 10 July 2018;
- high jump swimming pool water — ref. Test Report no. 8581/ZL/18 of 10 July 2018;
- whirlpool water — ref. Test Report no. 8581/ZL/18 of 10 July 2018.

Figure 14 Filters system

Both pools reuse water by operation of closed-cycled water overflow. Each pool has overflow gutters by which the water splashed out of the pool volume is returned to a tank in the pool basement. The pool basement tanks are covered to prevent evaporation of the contents. The water in this closed cycle is disinfected and filtered with positive-pressure auger filters that comprise a total of approximately 200 cartridges. The water is fed into the filters under positive pressure and treated while passing layers of diatomic earth deposited on the fabric which surrounds the filter auger part. Downstream of the filters, the water is chlorinated with a chlorine compound produced on site with an electrolyser, which forms a salt bridge and chlorine gas from NaCl; this form of delivery is much more efficient than liquid chlorine compounds. Next, the chlorinated water is passed under an UV lamp. The UV lamp provides photo-oxidation-driven disinfection, which efficiently neutralises and inhibits the growth of bacteria, viruses and other microbes. Finally, the water is recycled back to the pool via a system of piping and pool bottom inlet nozzles (with a total number of approximately 100 units). A pool with a total service capacity of 3,300 m^3 has 3 to 4 full water changes a day.

Figure 13 Pool basement tank which receives the water from the overflow gutters at the Łódź Sports Bay

The water lost by evaporation, carried out on the bodies and splashing amounts to approx. 100 m^3 a day is replenished from the district mains; this make-up water is already treated (pursuant to the Polish Regulation of the Minister of Health concerning the water supply for indoor pools). The district mains water is not additionally tested. The Łódź Sports Bay pool systems test the water at later stages.

The swimming pool water quality is monitored online.

MPWIK SIERADZ

Miejskie Przedsiębiorstwo Wodociągów i Kanalizacji Sieradz (MPWiK , Sieradz City Water Supply and Sewerage) is a business which provides services related to water supply and sewage systems for customers in the agglomeration of Sieradz, spanning the City of Sieradz and the adjoining rural lands in Sieradz municipality. There is water reclamation in effect at two water treatment stations owned by MPWiK Sieradz and located in the towns of Górka Kłodzka and Męka. The water intake to the water supply system passes two-stage treatment (iron and manganese removal) in DynaSand filters. This produces backwash water. The technology applied at the water treatment stations purify the backwash water by separation and densification of sediments. Supernatant water is recycled to the filters. Hence, the backwash water is stripped of heavy pollutants, and a part of the water reclaimed in the process is recycled for treatment. It is estimated that the technology will reduce the consumption of backwash water by approximately 10%. At Męka Water Treatment Station, the water losses from the formation of backwash water during water intake treatment were minimised to 1.5%. At Górka Kłodzka Water Treatment Station, the loss on backwash water were estimated at approximately 5%. The remaining backwash water that cannot be reclaimed are discharged to a combined sewer system. A future objective of MPWiK Sieradz is to further minimise the loss of water on intake treatment and increase the water reclamation rate of the backwash water.

Figure 15 Water intake treatment at MPWiK Sieradz: DynaSand filters

Figure 16 Clean water pumps feeding the water supply main of MPWiK Sieradz

The reclaimed water is recycled back to the water intake treatment process, so its biochemical quality is not separately monitored. The quality monitoring of reclaimed water is a part of an online quality control of the treated water supply distributed to consumers via the water main.

Since no statistical data existed, no volumes of water reclaimed from backwash water were disclosed during the case study visits.

GOŚ (CLUSTER SEWAGE TREATMENT PLANT) IN ŁÓDŹ

Figure 17 Process water pumps

The Cluster Sewage Treatment Plant of the City of Łódź (*Grupowa Oczyszczalnia Ścieków Łódzkiej Aglomeracji Miejskiej*), or GOŚ, is one of the largest sewage treatment plant (STP) installations in Poland. GOŚ, the adjoining land with its facilities and the protective buffer occupy 366 ha, of which 41.3 ha is the core operations area. The core operations area of GOŚ is located in the western part of Łódź and at the boundaries of the following gminas (municipalities): Łódź, Pabianice, and Konstantynów. GOŚ receives sewage from the urban Łódź, the adjacent towns and the nearby gminas.

GOŚ recycles approximately 2-3% of water from treated sewage for reuse. In 2018, 63.2 Mm^3 of the treated sewage discharged to the local river included 1.5 Mm^3 of water recycled for operation of the GOŚ facilities. The reclaimed and recycled water is used for internal consumption only: cleaning of machines and equipment. No external regulations exist for water reclamation by STP (the Urban Wastewater Treatment Directive 91/271/EEC, which is currently under revision, specifies that water reclamation should be attempted whenever feasible and cost efficient). Hence, GOŚ uses the water reclaimed from sewage treatment for internal processing, as a measure of care for the environment and the business budget. If the reclaimed water was replaced with tap water, its estimated consumption costs would be around 6 MPLN.

The water reclamation and reuse infrastructure of GOŚ was developed between 2007 and 2008, and fully funded by the owner's corporation. The infrastructure comprises two sand filters and a plant of four pumps (with 2 installed and 2 converted) which supply the water via pipelines to the fire hydrants installed throughout the GOŚ site.

Figure 18 Process water pumping and fire hydrant system

The monitoring of reclaimed and reused water is the same as the overall monitoring of treated sewage quality and condition. The treated water is monitored with a system of various sensors and an internal accredited lab operated at GOŚ. The GOŚ has no separate monitoring system for the reclaimed and reused water.

The reclaimed water is recycled to support operation of the on-site plant, flushing of conveyor belts in continuous operation (which include sludge dewatering equipment), occasional cooling of selected pumps, and extinguishing of foam in bio-reactors.

AGRICULTURE

With a task of reducing the spread of man-made pollution (limited to agricultural activities in this case) and to protect the quality of surface and ground waters, and the quality of human environment, a team at the UL Faculty of Biology and Environmental Protection[17] and its partners[18] created an innovative technology of an organic manure platform, designed to contain spot sources of pollution. The organic manure platform (OMP) features an innovative structural design procedure based on a system of modules (in the form of jute packaging units with an engineered carbon substrate, inoculated with select strains of denitrification bacteria). The modular design helps quickly adapt the OMP bed size and apply OMP beds of varying thickness, both in horizontal and vertical arrangement.

[17] Agnieszka Bednarek, PhD; Sebastian Szklarek, PhD; professor Joanna Mankiewicz-Boczek; Liliana Serwcińska, PhD; Katarzyna Dziedziczak, PhD; Bogusław Kowalski, MSc; Jerzy Mirosław Kupiec PhD; professor Maciej Zalewski

[18] Mikronatura Środowisko Sp. z o.o.; Zielone Oczyszczalnie

The OMP was implemented at two farms located in the Lodzkie voivodeship:

1. Kobyla Miejska, municipality of Szadek
2. Mikołajów, municipality of Rokiciny

Figure 19 Horizontal modular OMP bed with the carbon substrate

Source: Photo by Markiewicz-Boczek J., provided by courtesy of Agnieszka Bednarek, UL Faculty of Biology and Environmental Protection

Figure 20 OMP vertical beds in the way of leachates running from a manure heap

The structure of the organic manure platform (OMP modules) enables storage of solid animal faeces (manure or bird droppings). The OMP modules provide conditions for storage without any risk of detriment to environmental indicators (of water and soil quality) and an optimized process of manure conditioning, which maximizes the manure value as a fertilizer.

As a consequence, the ammonium nitrogen present in faecal leachate from farming operations is oxidized (by nitrification) to form nitrates. The nitrates already found in the leachate and formed by nitrification of ammonia are denitrified further to nitrogen gas. The time to full nitrogen pollution reduction and biochemical balance of a new OMP installation is 1.5 months. An OMP is protected against the risk of prolonged drought (where excessively long overdrying of the OMP bed is a hazard to denitrification performance and the microbes in the bed) by installing the OMP beds in a layer under the manure heap (this provides an horizontal OMP bed) while forming a barrier to the outflow of the polluted ground waters (this provides a vertical OMP bed). An application of an additional bacterial pool (an engineered inoculum based on denitrification bacterial strains of autochthonic origin) to an OMP bed exposed to the effects of drought promptly restores its optimum performance (with the reduction of up to > 90% of nitrates).

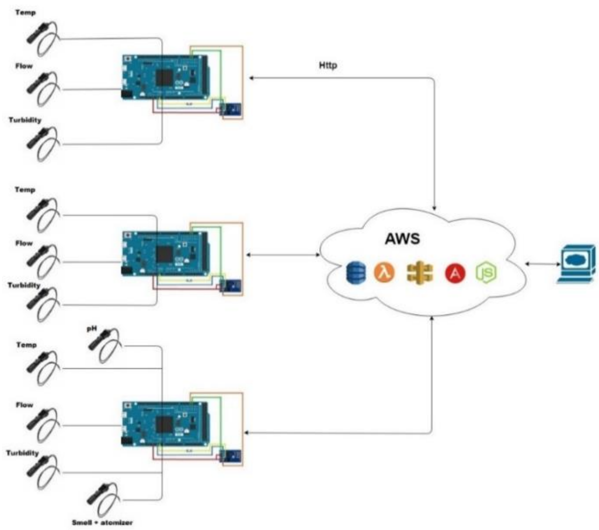
Numerous research projects from animal farms suggest that the concentration levels of nitrates in the manure leachate entering ground water may exceed as much as 2,000 mg dm^{-3}. This concentration is an extreme hazard to ground waters in immediate vicinity of manure heaps. This also markedly increases the risk of failure to meet the Nitrates Directive (91/676/EEC) and contribution to euthrophication of surface waters. Hence, the application of the OMP technology becomes indispensable in many cases. The innovative OMP technology has also a low cost of substrate production and installation, requires no official building permits for deployment, facilitates easy disposal of the OMP bed without any environmental impact, and has a long service life.

DIGITAL WATER. THE PROOF OF CONCEPT (POC) OF A SOLUTION FOR DETECTION OF CONDITIONS FAVOURABLE TO INFESTATION OF WATER WITH E. COLI

The PoC project for an online monitoring of water conditions was developed in response to a request from an STP (sewage treatment plant). The problem defined by the STP in the request was a missing ongoing source of information about the quality of network water. The turnaround time for the output of water quality data from manual testing was long (an average of one day from sampling to test report) and a small number of quality testing locations. The STP defined a goal of having an online monitoring and assessment of the actual network water conditions, determined by multi-point testing and providing a continuous stream of data about the potential presence of conditions favourable to infestation of water with E. coli.

The processing solution designed by Cybercom in response to the request by the STP is based on an array of sensors which test temperature, pH, water turbidity, flow rate and odour (the water odour is tested by application of ultrasonic detection; no sensors exist which would enable any assessment of the odour of liquids). The PoC system solution features a Wi-Fi module which outputs all water quality test results to cloud (AWS). A pump delivers water to the array of sensors.

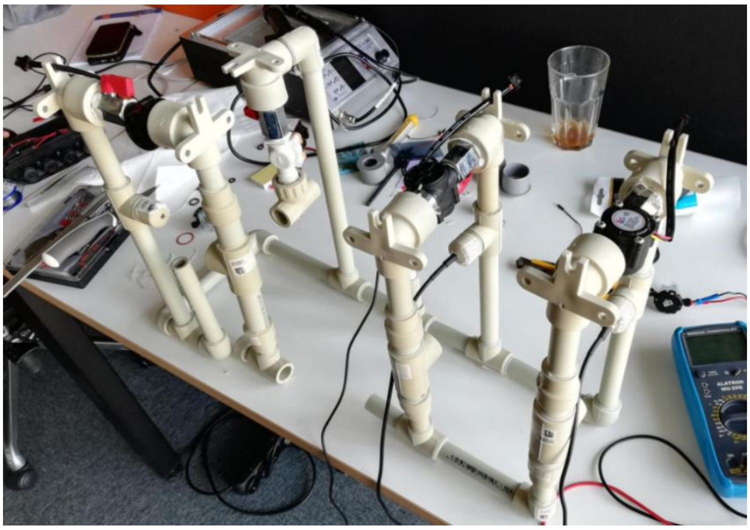
Figure 21 Diagram of Cybercom's PoC of the system for online water quality monitoring to detect conditions favourable to infestation by Escherichia coli (E. coli)



Source: Cybercom Group

Cybercom based its solution on a *predictive maintenance* approach: to detect the conditions which are likely to favour infestation of water by undesired bacteria.

Figure 22 Cybercom's PoC of the system for online water quality monitoring and E. coli detection



Cybercom's core business is technological consulting. The company helps its clients improve the competitive strength by the use of opportunities provided by the world of digitally connected devices, people and organisations. Cybercom's experts combine technological expertise with insights into business needs.

Digital Water is an example of the PoCs completed at Cybercom's Innovation Zone in Łódź.

Meeting agenda

AGENDA

October 16th, 2019

08.45 – 09.30	**Arrivals and registration/ Welcome coffee (Plenary Hall 104 Piłsudskiego 8, 1st floor)**
09.30 – 09.50	**Welcome speech and outlining the study visit plan**
09.50 – 10.10	**Presentation of the hydrological characteristics of the łódzkie region - European Regional Centre for Ecohydrology of the Polish Academy of Sciences in Łódź**
10.10 – 11.10	**Transfer to the water treatment plant in Sieradz**
11.20 – 11.50	**Presentation of applied water filtering and treatment technologies in Sieradz - AWP Nordic Products** Example of urban application of water reuse technologies
11.50-13.00	**Visiting the Water Treatment Station Sieradz Męka and Górka Kłocka**
13.00-15.00	**Networking lunch**
15.00-16.00	**Transfer to Konstantynow to Biliński textile factory**
16.00- 18.00	**Introduction of participants to methods of decolorisation of textile waste water in industrial conditions and tour of the plant** Example of industrial application of water reuse technologies
18.00-18.30	**Return to Łódź (Piłsudskiego Avenue 8)**
19.30-21.30	**Dinner in Łódź**

October 17th, 2019

09.00-09.30	**Transfer to the Conference Centre of the University of Łódź**
09.30-10.30	**Presentation of the University of Łódź**

	Presentation of Arturówek reclamation and applied water treatment technologies Example of recreational application of water reuse technologies
10.30-12.00	**Outdoor presentation of Arturówek**
12.00-12.30	**Transfer to the Zatoka Sportu (Gulf of Sport)**
12.30-13.30	**Networking lunch**
13.30-15.30	**Presentation of the technology of swimming pool water treatment and reuse – Lodz University of Technology** Example of recreational application of water reuse technologies
15.30-16.30	**Cybercom Poland - innovative solutions for monitoring water quality** **Politecnico di Milano - research on water reuse** **Technologies for water reuse in various sectors in Lodzkie Region - Lodz University of Technology**
16.30-17.00	**Discussion** **Final remarks**
17.00-17.15	**Transfer to Piłsudskiego Avenue 8**

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