Enabling Transboundary Cooperation & Integrated Water Resources Management in the extended DRIN RIVER BASIN

GEF/UNDP/GWP-Med Project "Enabling Transboundary Cooperation and Integrated Water Resources Management in the Extended Drin River Basin

In the framework of the Memorandum of Understanding for the Management of the Extended Transboundary Drin Basin

Pilot activity "Preparation of Wastewater Management Decision Support Tool"

Wastewater management solutions in the Shkodra city

Annex 3: Constructed Wetlands

The Coordinated Action for the implementation of the Memorandum of Understanding for the management of the Drin basin (Drin CORDA) is supported by the GEF Drin Project. Thus, the latter constitutes an institutional project implemented by the United Nations Development Programme (UNDP) and executed by the Global Water Partnership (GWP) through GWP-Mediterranean (GWP-Med), in cooperation with the United Nations Economic Commission for Europe (UNECE). The Drin Core Group (DCG), being the multilateral body responsible for the implementation of the Memorandum of Understanding serves as the Steering Committee of the Project. GWP-Med serves as the Secretariat of the DCG.

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1 Introduction

The world's rapid transition to urbanization increased the volume of wastewater to the extent that it exceeds nature's capabilities to process the pollution. Lack of sewage collection and wastewater treatment is a serious health and environmental hazard. Vast volumes of untreated wastewater are dumped directly into our water resources, threatening human health, ecosystems, biodiversity, food security, and water resources sustainability. Wastewater treatment is more than a local problem; it is a global challenge. Affordable and effective domestic wastewater treatment is a critical issue in public health and disease prevention worldwide, particularly in developing countries, where financial and technical resources necessary for proper treatment facilities are insufficient[1].

The entire country, including Shkodra Municipality, has a poorly developed collection and treatment of the wastewater from settlements.

Untreated domestic wastewaters are already contaminating the sources of drinking water, deteriorating the water quality of streams with organic content, ammonia, macroelements (N, P, etc.), and represent a health risk inhabitants and aquatic ecosystems in Shkodra Region.

The centralized, water-based sewer systems were applied to attain considerable public health improvement in urban areas of industrialized countries. However, the cost of such a sewer-based system is enormous and is unaffordable to many of the developing countries. Centralized systems require conventional (intensive) treatment systems, which are technologically complex and financially expensive. Many communities of the developing countries cannot afford the construction and operation of conventional treatment systems. For these communities, alternative natural treatment systems, which are simple in the construction and operation, yet inexpensive and environmentally friendly, seem to be appropriate[2]. For listed reasons, constructed wetlands have gained worldwide popularity in the last decades. CW is a nature-based solution, and for such technologies, apply "lower energy input needs – bigger area required" (Figure 1).

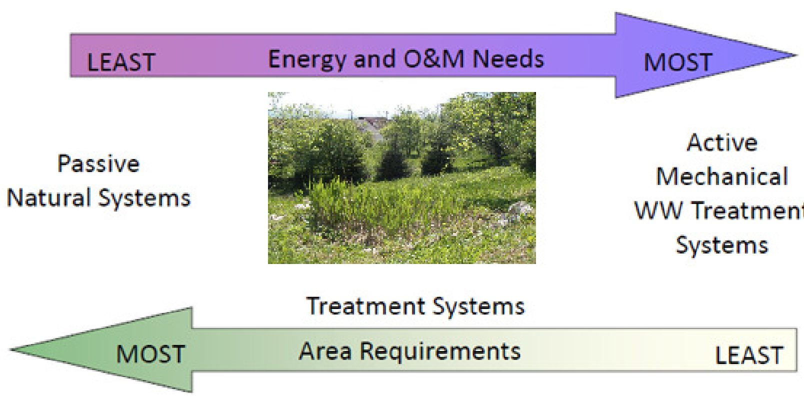

Figure 1: Energy needs vs area requirements

2 General description of constructed wetland

Constructed wetlands are artificially designed wetlands in which we create conditions for wastewater treatment processes. It is an ecological solution for the treatment of wastewaters. The operation of constructed wetlands is based on the imitation of nature's self-cleaning capacity. The water is treated to the required standards through physical and chemical processes by microorganisms and wetland plants. Numerous scientific research shows that constructed wetland enables efficient

[1] Mara, D., 2004. Domestic Wastewater Treatment in Developing Countries. London, Sterling. Earthscan, 310 p.

[1] United Nations Human Settlement Program: Constructed Wetlands Manual, 2008, 89 p.

wastewater treatment in terms of removing suspended solids, organic matter, nutrients, fecal and other bacteria, heavy metals, and even persistent organic pollutants[3].

Basic processes happening in the WWTP are adsorption, mineralization, aerobic and anaerobic decomposition. Bacteria do the main part of the treatment process. Plants bring into the substrate oxygen, thus creating aerobic zones. In so evenly spread areas of oxygen and no-oxygen zones, decomposition of substances in polluted water, and incorporation into a microbial mass of bacteria occur. The plants' role lies in their root system, where bacteria is thriving and is most relevant for the up-take of mineralized matter (for ex. phosphates, nitrates, and many toxic substances) in the plant tissue.

Imitating natural water ecosystems' natural processes, constructed wetlands represent a complex system in which interaction among water, plants, animals, microorganisms, and environmental factors contribute to a significant improvement in water quality. With the combination of physical, biological, and chemical processes within a constructed wetland, pollutants are removed from wastewater.

Constructed wetlands are primarily used for the treatment of municipal wastewater from smaller communities, but can be successfully adapted for the treatment of industrial wastewater, stormwater, landfill leachate, etc.

Most of the constructed wetlands in Europe are subsurface flow wetlands. There are two main types, depending on the course of the flow of wastewater through the substrate, being:

- constructed wetland with the vertical subsurface flow and
- constructed wetland with the horizontal subsurface flow,
- hybrid constructed wetlands represent a combination of the two or more interconnected plant beds with different types of constructed wetlands.

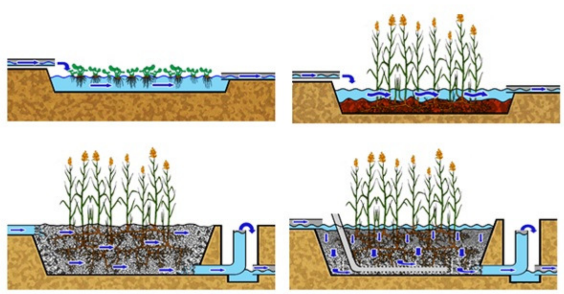

Figure 2: Different types of constructed wetlands: free water surface wetlands with floating vegetation (top left) and emergent vegetation (top right), subsurface flow wetlands with horizontal (bottom left) and vertical (bottom right) water flow[4].

Advantages of constructed wetland:

- High buffering capacity - they can quickly adapt to fluctuations in pollutant concentrations and hydraulic loadings;
- Typically no electricity and machine elements are needed for their operation (if water flows gravitationally through the system);
- Simple construction involving local construction/ companies;
- Low costs of construction, operation, and maintenance, especially if compared with costs of conventional technologies;
- Possible and simple enlargement if/when required;

[3] Kadlec, R., Wallace, S., 2009. Treatment wetlands. Second edition. Taylor & Francis group, Florida, USA, 1016 pages.

[4] Brix, H, 2011. Use of wetlands in water pollution control, Ph.D. Course. Aaarhus Univeristy, Denmark.

- Landscape attractiveness;
- Representing green areas with additional functions as habitats and source of biomass;
- Design can be adjusted to the area available;
- Very efficient removal of COD, BOD5 and other parameters, such as nitrogen, phosphorus, heavy metals, and other toxic substances;
- They effectively reduce the number of fecal and other bacteria (90–99 %);
- The ability of tertiary treatment (removal of N and P from the treated water);
- Multipurpose use of treated water (irrigation, firefighting, etc.): reducing overall consumption costs, increasing quality of life, food security, mitigation of climate change.[5]

Disadvantages of constructed wetland:

- A need for a relatively larger surface area than conventional wastewater treatment plants (2 to 5 m2 for one PE);
- Can become clogged (wrong selection of substrate, not appropriate construction and maintenance), therefore experienced designer and constructor should be hired;
- Harder to control operating systems compared to conventional systems, but yearly monitoring of discharge water gives reliable information on the operation
- Social and health risks related to water reuse: may be high distribution and storage costs, weak economic justification, a threat to public health in cases of illegal and unhealthy wastewater reuse practices, social tensions in non-acceptance, and can cause additional pressure onto the aquatic environment[6].

[6] Mediterranean Wastewater Reuse Report, 2007. Mediterranean Wastewater Reuse Working Group, 47 p.

3 LIMNOWET® treatment steps

The basic scheme of constructed wetland (CW) following LIMNOWET® technology is shown in the figure below.

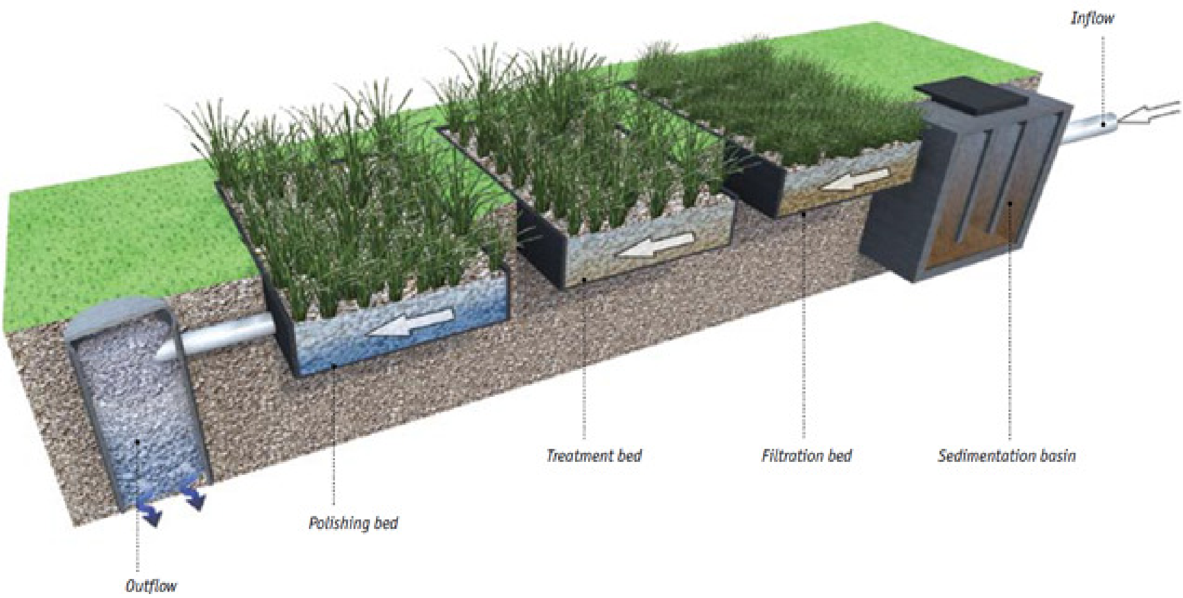

Figure 3: Scheme of LIMNOWET® constructed wetland operation

Wastewater treatment plans consists of the following steps:

- Primary (mechanical) treatment:
  - Coarse Screens (only needed for agglomerations)
    The screens' role is to remove all coarse and inert material from wastewater, which is big enough to cause clogging and/or deposit problems in the rest of the treatment system.

  - Sedimentation tank
    Sedimentation tank consists of chambers for sedimentation of suspended solids, sludge accumulation, and digestion.

- Secondary treatment:
  - Filtration bed
    Filtration bed is the first in the CW and, therefore, the most loaded. Its function is the retention (filtration) of suspended matters and others, which have escaped the sedimentation tank.

  - Treatment bed
    The treatment beds' function is retention, accumulation, and subsequent uptake of the nutrients into plant and microbial biomass. A reduction of all bacteria of human and animal origin is taking place in the beds, including reducing pathogenic bacteria.

  - Polishing bed

  The function of the polishing bed is an effluent polishing (advanced treatment) prior the disposal.

4 Cost analysis

4.1 Investment costs

The estimated costs include:

- Costs of project (design) documentation;
- Costs of construction;
- Costs of supervision

The indicative initial investment costs in constructed wetland systems are presented in table below.

Table 1: Investment costs for constructed wetlands

CW capacity (PE)	*Investment costs (EUR)	*Price per PE (EUR/PE)
10	6.-8.000	700
50	22.000-25.000	470
100	45.000-50.000	470
250	90.000 – 105.000	390
500	145.000 – 155.000	300
750	160.000 – 170.000	220
1.000	215.000 – 230.000	220
1.500	325.000 – 345.000	220
2.000	420.000 – 450.000	215
3.500	700.000 – 750.000	205

*Land acquisition costs are not included.

4.2 Operation and maintenance costs

Operating costs include all the costs to operate and maintain (O&M) constructed wetland.

Typical O&M costs of RBs include regular and periodic maintenance. **Regular maintenance** is a set of measures and actions that have to be carried out regularly throughout the year, to maintain the effective sludge treatment and technology / technical correctness of CWs. **Periodic maintenance** includes a set of maintenance works necessary due to ongoing technology improvements and predicted lifetime of CW parts. Periodic investment works ensure sustainability and increase the effectiveness of the treatment plant.

The main points include:

- Regular removal of the accumulated sludge;
- Regular removal of solids from the coarse screen;
- Regular visual inspections of the site and all units;
- Regular plant harvesting - cutting wetland plants every fall.

The O&M costs include:

- Labour work (public utility) – costs of employee visiting the WWTP site;
- Electricity consumption (only if needed! Systems can work without electricity if water can flow gravitationally.) – working hours of pump distributing wastewater on the system;
- Removal of accumulated sludge from sedimentation tank;
- Replacement costs and repairs – the life expectancy of the system is 30 years and more (only pumping station has a life expectancy of 10 years)
- Wastewater analyses – required by legislation.

Table 2: The main O&M activities

CW capacity (PE)	**Inspection (employer visiting site)**	**Sludge emptying**	**Accumulated sludge volume (m^3/year)**
10	Once per week	Once per three years	1
50	Once per week	Once per year	7
100	Once per week	Four times per year	14
250	Once per week	Four times per year	36
500	Once per week	Five to six times per year	71
750	Once per week	Five to six times per year	107
1.000	Once per week	Five to six times per year	143
1.500	Once per week	Six times per year	214
2.000	Once per week	Six times per year	286
3.500	Twice per week	Six to eight times per year	500

Every WWTP produces sludge, which has to be disposed of. The costs of removal and final disposal can present from 10 to 60 % of O&M costs. CW creates less sludge than other conventional technologies because the sedimentation tank accumulates only primary sludge (CW do not produce excess sludge) and has lower costs of sludge disposal.

Cost estimation of O&M costs for CW with capacity with 1.000 PE is shown in the table below.

Table 3: Typical annual O&M costs for CW (1.000 PE)

O&M	**Costs (EUR/year)**
Labour costs (2h/week; 5 EUR/h)	520
Sludge emptying (143 m3/year; 10 EUR/m3)	1.430
Plant harvesting (5 days; 4 workers; 5 EUR/h)	800
**Pump service (once per year)*	*100*
**Electricity (30 EUR/month)*	*360*
TOTAL:	3.210

* Only if needed due to terrain characteristics. CW can work without mechanical and electrical equipment.

5 Conclusions

Constructed wetlands (CW) are especially well suited for wastewater treatment in dispersed settlements (small rural areas). They present an attractive solution because of simplicity and low operational costs (the investment may be comparable to traditional/conventional plants). Moreover, the local contractor can build them using local materials, and public utility can easily operate them. They do not require equipment and service from abroad. They imitate the treatment process in nature and thus do not need any chemicals or added microorganisms. Even without continuous inflow, organisms survive in the system (role of plants and substrate) and efficiently treat wastewater. Therefore, they are also suitable for tourist homes and settlements (hotels, camps, etc.). However, they require large areas (2-2,5 m2/PE) and are usually implemented where land is cheap or owned by the Municipality.