http://www.iwlearn.net/experience YYYY-XX

INTERNATIONAL WATERS EXPERIENCE NOTES

Constructed wetland to reduce the impact of polluted water: a demonstration project in Azerbaijan

Abstract: In Azerbaijan several small towns and rural villages discharge their untreated sewage into the environment, contributing to the pollution of surface and groundwater. Conventional wastewater treatment plants are not the right answer to solve the problem cause they require relevant Operation and Management costs and skilled personnel not always available in remote areas. Nature Based Solutions such as constructed wetlands (CW) are perfectly fit for the use. A demonstration CW treating an estimated population of 325 inhabitants discharging their untreated sewage into the Hajiqabul lake has been built by the Kura II. The preliminary results are encouraging: the system appears very effective in removing organic matter (BOD and COD) and ammonium, showing removal rates ranging between 85% and 98%..

Giulio Conte, River Ecology Expert
UNDP-GEF Kura II project
https://kura-river.org

Constructed wetland to reduce the impact of polluted water: a demonstration project in Azerbaijan

Experience of the GEF - sponsored

UNDP GEF/IW: Kura II: Advancing IWRM across the Kura river basin through implementation of the transboundary agreed actions and national plans

GEF- ID: 5325

PROJECT DESCRIPTION

The Kura II Project was developed to address the priority needs in the ministerially endorsed Strategic Action Plan (SAP) through implementation of the SAP and national Integrated Water Resources Management Plans to strengthen and harmonize coordinated conjunctive transboundary ground and surface water management. It comprised five components: Support for institutional governance protocols; professional development and capacity building for water managers across sectors; stress reduction measures in critical areas; stakeholder education and empowerment; and, enhanced science for governance.

The Strategic Action Program (SAP) and the UNDP-GEF Kura II Project Document expressed the importance of introducing the concept of river ecological restoration and support the two countries in applying this concept in pilot areas.

THE EXPERIENCE

Issue

In Azerbaijan several small towns and rural villages discharge their untreated sewage into the environment, contributing to the pollution of surface and groundwater. Conventional wastewater treatment plants are not the right answer to solve the problem cause they require relevant Operation and Management (O&R) costs and skilled personnel not always available in remote areas. Nature Based Solutions (NBS) such as constructed wetlands (CW) are perfectly fit for the use.
An area for the implementation of a demonstration plant has been identified by the Kura II project in Shirvan, a village by the Ajiqabul lake.
Currently, the Hajigabul lake is threatened by pollution due to the untreated sewage released from a village of summer houses located near the town of Shirvan. A significant part of the village, in fact, is not equipped with a sewage system and discharges the wastewater coming from the houses in a network of drainage ditches flowing into the lake.

Addressing the Issue

Before starting the design of the system, a few samples from the outflow discharging into the lake were taken and analyzed. Information was also collected on the number of people living in the settlement and discharging wastewater into the ditches that fed the outflow.

According to the results of the investigation an estimation of the wastewater to be treated in the constructed wetland has been provided and used for the sizing of the system.

Daily flow:	260 m3/day
COD Concentration:	150 mg/l
BOD5 Concentration:	75 mg/l
N Concentration:	10 mg/l

SST concentration:	120 mg/l
E.Coli:	10^4 UFC/100 ml
COD daily load: 39 Kg/day	
Load in P.E.:	325 P.E. (assuming 1 P.E. = 120 grCOD/day)

After the field survey and preliminary analysis, the detailed design was delivered in spring 2019.
The general lay-out of the proposed treatment wetland can be summarized as follows:

- **Preliminary treatment and polluted water diversion**: a manual screen in envisaged to block coarse solids along the existing outflow and a small weir, about 20 cm high that feeds a pipe to extract part of the flow (maximum around 10 l/s) and directs it to a pumping station that diverts the flow into the CW.
- **Constructed Wetland:** the CW is composed by one single stage: Free Water Surface System (FWS): fully vegetated with emergent plants; total area of the bottom 4350 m^2, total area of the water surface 5480 m^2.
- **Gravity discharge** into the lake.

The chosen solution achieves a high degree of biodegradation of organic load, suspended solids removal and pathogen reduction and presents very limited Operation and Maintenance (O&M) requirements and costs. The estimated removal efficiencies allows the effluent to **fully achieves** the proposed standard limits (compliant with the EU wastewater Directive 91/271) related to the urban domestic discharge in surface water.

After the bidding procedure that took place during the summer of 2019, the construction company was selected in October 2019, and in November 2019 the company visited the construction site for the first time. During the winter of 2019/2020 a few minor changes to the design were provided by the consultant to bypass the problems encountered by the construction company. In the spring of 2020, the main basin of the future constructed wetland was excavated.

The works proceeded slowly, due to the restrictions linked to the COVID 19 epidemic, however in the summer of 2020 the impermeable liner was correctly lied down and the gravel and stones sections put in place. In October 2020 the new constructed wetland was built and the vegetation planted.

To be fully developed it will take probably two years, so the wetland will be fully vegetated in the summer of 2022. To have an idea of what the wetland will look like in the future in the following pictures a graphic simulation is provided.

RESULTS AND LEARNING

Summary of work and outputs

On January 22, 2021 the inlet and the outlet of the wetland were sampled. The results of the analysis are reported in the following table.

Pollutants	Water Quality (mg/l)		Removal rate
	Inlet	Outlet	%
pH	7,20	8,10	
Suspended solids	143,00	63,20	56%
Biological Oxygen Demand	135,60	3,00	98%
Chemical Oxygen Demand	339,00	7,50	98%
Ammonium ion, NH_4^+	5,45	0,83	85%
Nitrate ion, NO_3	0,10	9,11	-100%
Orthophosphate ion, PO_4	0,40	0,40	0%

Considering that the system is not yet colonized by aquatic vegetation, the results are encouraging. The removal of the suspended solids is presently lower than expected but still over 50%. One of the reason why the sediment removal is lower than expected may depend on the feeding system that send to the system more than the exptected 260 m^3 per day. Since the CW is not fed by the envisaged pumps but by gravity, it's more difficult accurately control the inflow volume.

The system appears very effective in removing organic matter (BOD and COD) showing a removal rate higher than expected and near to 100%. However the most surprising result concerns the removal rate of ammonium (85%). The constructed wetland object of the present report is a free flow (FW) system, a typology that generally shows a lower removal rate for ammonium. Such an high removal rate could be transitory and due to the diffuse presence in the system of aerobic conditions. With the growth of vegetation, however, and with the increase of the content of organic matter, anaerobic sites will establish in the system, reducing the availability of aerobic sites for nitrification (the oxidation of ammonium).

The excess of aerobic condition is the reason why the content of nitrate (NO_3) increases inside the system. The degradation of organic matter and the oxidation of ammonium generates nitrates. To remove the nitrate from the system by *denitrification* (the reaction transforming NO_3 in N_2), anaerobic sites and availability of organic matter are needed. Such conditions are presently lacking and therefore nitrates could not be removed from the system and we find them in the outlet flow.

Phosphate concentration in the inflow is lower than estimated, therefore the removal rate could not be expected to exceed 20/30%. Phosphates in CW are removed by uptake by the vegetation and by absorption on the plants surface. In the next months, with the expected vegetation, we will certainly observe an increase in the phosphate removal activity.

REPLICATION

The restoration project will demonstrate the effectiveness of the Nature Based Solutions, such as constructed wetlands, in reducing water pollution. CW technology is still poorly known in Azerbaijan and the implemented "demo" project will be an opportunity to test the affordability of a "nature based" technology that could be easily replicated in the country.

The most important drawback of CW technology is in fact that, being an extensive technology, it requires larger areas compared to "grey" treatment technologies, such as activated sludge wastewater treatment plants. The population density in Azerbaijan, however, is much lower than in most European countries, and the lack of available land is not a constraint, particularly in the rural context and in isolated villages. Restoration of wetland habitats throughout the country by replicating the demo project in other location in Azerbaijan is therefore recommended.

SIGNIFICANCE

The most interesting feature of the CW for wastewater treatment is their very low operation and management (O&M) costs. In chapter **Ошибка! Источник ссылки не найден.** an estimate of O&M costs is provided that show that – even envisaging some energy costs due to the use of the pumping station that was installed but presently is not in operation, being the wetland fed by gravity – the cost is lower than 1 US cent per treated m^3. The present "demo" project deals with diluted wastewater, thus a very simple treatment scheme was applied (a single free water basin): that's why the O&M costs are so low.

For more complex CW, however, O&M costs are still very competitive compared to conventional treatment systems. A recent paper showed that a complex CW (ad "hybrid" vertical subsurface flow "French system" + free water flow) show O&M costs 1 order of magnitude lower than activated sludge treatment plant (Rizzo et Al.2018).

REFERENCES

https://kura-river.org

- Langergraber G., Dotro G., Nivala J., Rizzo A. Otto R. Stein O.R. 2019. Wetland Technology. Practical Information on the Design and Application of Treatment Wetlands. IWA Publishing ISBN: 9781789060171 (eBook)
- Rizzo A., Bresciani R., Martinuzzi N., Masi F. 2018. French Reed Bed as a Solution to Minimize the Operational and Maintenance Costs of Wastewater Treatment from a Small Settlement: An Italian Example. Water 2018, 10, 156; doi:10.3390/w10020156

KEYWORDS

- Nature Based Solutions
- Constructed wetlands
- Wastewater treatment
- Ecosystem restoration
- Ecosystem services