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Implementation of sustainable sanitation in rural areas: Integrated approach

Case study Hostětín village (the Czech Republic)

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Introduction, scope of the study

Natural (extensive) methods treat wastewater from individual settlements and small communities aby imitating the natural self-cleaning processes that may take place in the soil, water or wetland environments. The issues regarding these wastewater treatment methods are detailed in Wallace and Kadlec, 2009, and Vymazal, 2009. Kadlec et al., 2000 also details the design of these methods. A freely available handbook detailing the use of natural wastewater treatment methods was published by the GWP in 2013/2014 (http://www.gwp.org/en/GWP-CEE/gwp-cee-in-action/publications/regional-publications/).

The advantages of natural wastewater treatment technologies are the low construction and operation costs compared to conventional (activated sludge) wastewater treatment systems (Liu et al., 2012). In Europe, the implementation costs for the natural wastewater treatment technologies amount around €170 per person, and the operation costs are averaged to €7 per person, per year (Masi, 2012). In the Czech Republic, the implementation costs range between 20,000 - 30,000 CZK per person (own survey, 2012), and the operation costs are averaged to 385 CZK per person, per year (Kriška, 2012; own survey, 2012), including the costs of maintenance, waste disposal, etc. Thus, a final prize for inhabitant reaches 100 CZK/person/year. The construction cost forms the largest demand of workload, and represents around 50% of the investment costs. The material costs represent the most significant portion second to construction costs, representing approximately 30% of the total investment. These materials are preferably sourced from local sources (gravel, concrete and building materials). The smallest stake in the investment costs are the manufactured material (mechanical pre-treatment, piping, valves and electrical equipment), representing roughly 20% of the total costs (Newton and Wilson, 2008).

The disadvantages of these natural wastewater treatment methods (NWWT) are the large demands on surface area, overall treatment effectiveness, dependence on climatic conditions, low control of the processes, sediment extraction from the waste stabilization ponds, implementing constructed wetlands, and soil filters clogging.

The NWWT methods are mostly used for individual homes and recreational facilities, to municipalities of 2,000 population equivalent (p.e.), small industrial plants, and farms (exceptionally effective for larger systems). The use of these methods also depends on the availability of affordable land. For small settlements, older sewer systems, often locally built, conducts both sewage and storm water, and sediments of various origins. The proportion of ballast water constitutes more than 50% of the flow even during the dry weather periods. The water in these systems meets basic indicators of water quality criteria given for outlets; however, bacterial contamination, phosphorus and nitrogen content might fluctuate. For this reason, it is necessary to equip the systems with additional measures. Storm water and runoff can be problematic, as the local wastewater treatment plants cannot handle their volume without the reconstruction of the sewer system to accommodate separate flow. Construction of a new separate sewage system with activated sludge WWTP is economically unattainable for many small settlements. This is an opportunity to implement the affordable natural technologies of wastewater treatment, which can ensure adequate cleaning of water, including water from combined sewerage systems.

The NWWT methods utilize naturally occurring self-cleaning processes taking place in the soil, aquatic and wetland environments. Vegetation is directly involved in the cleaning process, particularly the creating favourable conditions for the development of micro-organisms involved in the purification process, and utilizing the released nutrients to the formation of biomass.

Currently, NWWT technologies are not only linked to historical tradition, but are continuously being improved to develop methods of purification at a higher water quality. In the European Union countries, the focus is to establish smaller sewage plants that use natural wastewater treatment for 1,000-2,000 p.e., although these are in operation next to larger facilities, focused on tertiary treatment. In the Czech Republic, technologies based on natural methods are frequently used in communities up to 500 p.e.. These are methods suitable for settlements with irregular inflow of wastewater, such as holiday homes, cottages, and recreational facilities. The most commonly used technologies are single-stage and two-stage biological tanks (waste stabilization ponds) which may include mechanical pre-treatment. Constructed wetlands with horizontal subsurface flow filters are a close second. The least used technology is the soil filter method.

This case study focuses to analyse and assess wastewater treatment produced in a small village (up to 2000 pop.) in Central and Eastern Europe. The study has all technical and technological details; however, these would not be possible to implement without a broader aspects – to analyse the water cycle in a holistic way. In addition, the study assesses complex issues ranging from legal, administrative, economic and social aspects; these aspects are frequently abandoned when designing alternative approaches to water quality problems. Important aspects of the capacity to involve the local community and other stakeholders, choosing suitable and sustainable solutions are discussed.

An important motivation of the study was the use of NWWT methods, which may serve as an exemplary solution of a typical problem for rural areas of Central and Eastern Europe, which can be solved using tools of sustainable sanitation.

Locality description

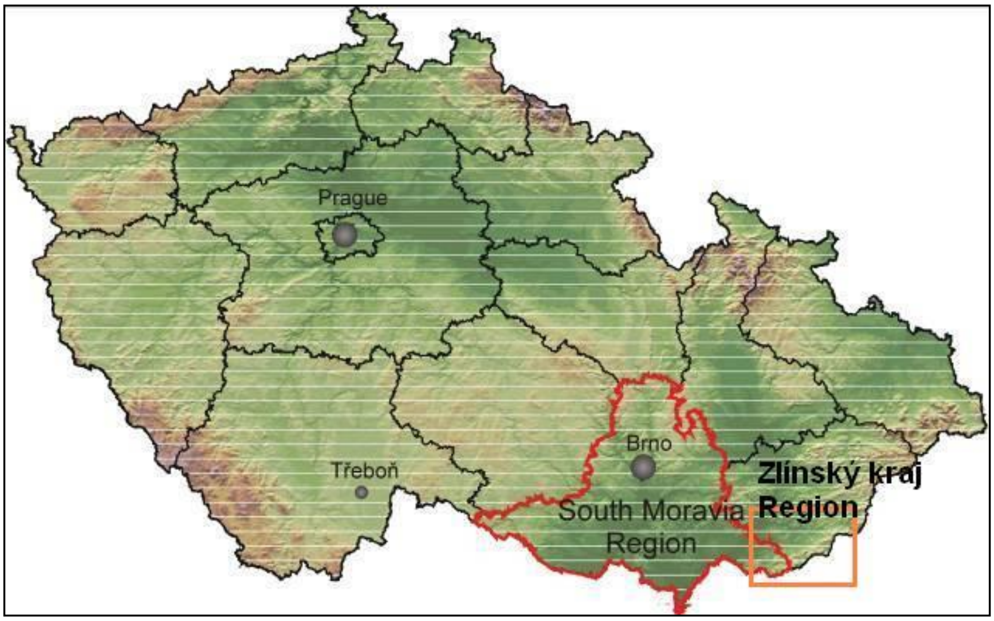
The scope of the case study is the village Hostětín, in Zlínský Region of the Czech Republic, which borders the White Carpathian Mountains. The White Carpathian Mountains region is facing a number of problems such as a marginal position in the Czech Republic (has highlighted the emergence of Czech-Slovak border since 1993), and unfavourable economic situation in the region. Employment in the industry since the 1920's concentrated in arms production and shoemakers; both these industries have been affected in the 1990's by a transformational crisis. In this period, unemployment in the region has increased greatly. There has been significant restructuring and intensive agricultural production of socialist management to accommodate for extensive cattle breeding. Due to reduced agricultural and industrial production, this lead to the second half of the 1990's dwindling job opportunities.

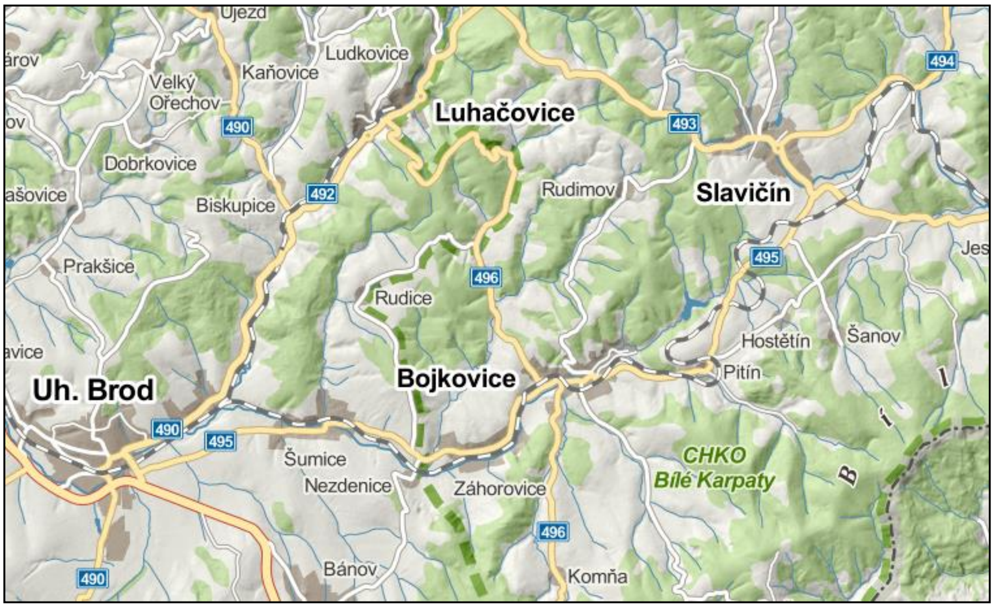
Rising unemployment in the area urged residents to seek work elsewhere; the migration from the area has led to a significant loss in population density (60.2 people / km2), the average population density for the whole country being more than double, i.e. 130 persons/km2. A driving force to hamper unfavourable situation was to introduce the concept of sustainable development of the region; it has started with a small number of citizens who began to cooperate with civic associations, members of local authorities; later cooperation included local small entrepreneurs, and foreign investors to actualize a number of local projects and initiatives. A practical application of the idea of sustainable development was attempted in several layers such the application of economic self-sufficiency of the region, rebuilding a regional identity of locals, reviving the traditional crafts and technologies, involving more people community and regional events, promoting of environmentally friendly lifestyles, strengthening social ties, and restoring local communities (Štětka, 2000). This approach may not solve all the relevant problems of the region, but it can certainly contribute to their solution (Uhlířová, 2008).

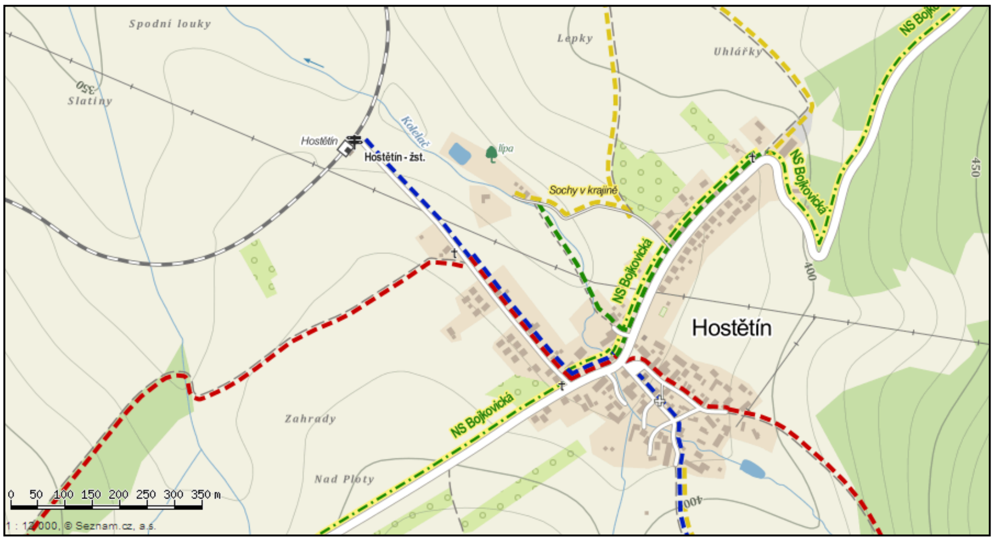
A small village Hostětín (238 inhabitants, as of 31/12/2006) become to be a pioneer in the sustainable development approach. In the last twenty years, the village has managed to conduct several pilot projects, such as constructed wetland based wastewater treatment plant, biomass district heating, developing factory for production of cider with organic production, and centre focused on education on sustainable development, which is also an example of ecological construction. At the end of the nineties, Hostětín became a centre of self-sustainable power generation by installing solar systems en masse. The area has also implemented energy saving and ecologically-friendly public lighting, minimizing light pollution and saving electricity (Uhlířová, 2008).

The village lies in the catchment of the Bojkovice water reservoir, which was built in 1966 and originally intended for the abstraction of industrial water; it currently serves as the reservoir for drinking water supply. Cadastral of the Hostětín is located in the 2nd external sanitary protection zone of the reservoir. According to current legislation, some of the land of Hostětín cadastral was designated to 2nd protective zone of water reservoir Bojkovice. Land close to the stream Kolelač creek, into which the Hostětín WWTP discharges, were designed to be a protective zone along watercourses – infiltration zone.

The following charts show the localization of the Hostětín in the Czech Republic.







Hostětín is the only settlement in the reservoir catchment. Its development was limited/prohibited by the legislation. The only solution for the village to grow was to establish a water supply system, safe sewer system and wastewater treatment plant. The former sewer system, built in the period of socialism in the 1950's, was a combined sewerage system, draining away both domestic wastewater and storm water, as well as runoff from any connected springs and other difficult to identify sources of groundwater and surface water. Its various branches were connected and discharged in the local Kolelač creek, which flows into the reservoir at 2.5km downstream. This was not anymore feasible solution to upgrade the existing system.

At that time the reservoir had have big problems with the water quality, especially during dry periods due to the lower dilutions of sewage. To remove all sources of pollution in the catchment of the reservoir Hostětín, being the only settlement that lies in the catchment, suffered from resulting construction prohibition which limited the the development of the village.

Decisions and Actions Taken

Local authority decision making

In 1990, after the fall of the communist regime and the first social changes in Czechoslovakia, the municipality decided to solve the sewerage in the village by removal of existing infrastructure to incorporate a sewage treatment plant. The most appropriate solution was chosen in order to maintain the wastewater treatment plant operation costs less than the costs for cleaning, due to its environmental character and position of the village in the White Carpathians protected area.

Local authority plan

In an effort to address this situation, the municipal authority commissioned a simple conceptual study to summarize and evaluate the proposals eligible. The following options were proposed:

1. Build a "traditional" (activated sludge, mechanical-biological) water treatment plant with a discharge of effluent into the creek Kolelač,

2. Build extensive reed bed (constructed wetland) wastewater treatment plant with a discharge in to the creek Kolelač,

3. Build a wastewater treatment plant (the previous two variants) in the village and treated water pumped downstream of the water reservoir,

4. Pump sewage to the neighbouring village Pitín lying downstream below the water reservoir, and utilise their upcoming municipal WWTP and connecting sewer systems to Bojkovice.

The alternatives had already taken into account the construction of a sewer system, and were evaluated by the available technical solutions, existing built-up areas, available land and their prices, and treatment efficiency and cost. For the implementation of wastewater, it is necessary to consider the concentration of pollution in sewers, water dilution and implementation of new separate sewer if at all possible, to assume effective water purification for the characteristic influent load.

Decision about resolution

The environmental impact assessment favoured to complete the sewer system and construct the tertiary wastewater treatment plant. At that time authorities did not recommend to seek alternative (and cheaper) solutions, such as constructed wetland (CW) treatment, due to lack of experience with these types of WWTP in the Czech Republic in the 1990's.

It should be noted that reservations to alternative technical solutions still perceive and are very common in the Czech Republic – in summary, the opinions of individuals in decision-making positions in government are being the limiting factor, rather than the overall experience. The approaches are also regionally different at the district level, as municipalities with extended powers, regional river administrations, etc., can unpredictably react with smooth approval of the appropriate and applicable concepts and extensive application of technology, but can also categorically reject the proposals regardless of the presented concepts and documents.

The same happened in the case of Hostětín: the EIA study reasoned that "... from a health perspective, the location of the sewage treatment plant in Hostětín is highly recommended to include a tertiary final treatment at a filter. Realization alone CW WWTP in the area of water management is not recommended or tolerated due to operational unreliability cleaning effect." It was clear that the views of the professional community at the given time considering that the extensive technology was fundamentally different.

The local authority decided in collaboration with members of NGO Veronica in Brno to organize a seminar that would help illuminate the situation the water quality in the whole catchment of the Bojkovice water reservoir (including upper part of the Olšava river basin, down to the town Bojkovice, as well as other municipalities in the area that are faced with the problem of sewage and water quality of streams). The seminar discussed the observed situation, possible solutions, the use of natural (extensive) technology, and selecting the appropriate option for the village Hostětín.

Activities to implementation the decision about water treatment solution

The seminar facilitated by local NGO, entitled "Horní (Upper) Olšava" focused on the issue of water pollution, its relationship to the landscape and possible remediation strategies. The seminar was specifically designed to incorporate mayors, civil officers, workers whose activities affect water management, but also invited other interested parties, e.g. members of civic associations, including fishing associations. The aim of the seminar was to acquaint participants with various indicator methods of water pollution monitoring (chemical and hydro-biological analyses), the limits of these methods with regard to hydrological conditions, and the current state of biota in the watershed. The seminar turned to three days training when the participants were engaged in water sampling, mapping of pollution sources and be present in laboratory analysis.

The seminar should support the interest of the general public to be mindful of their environment, in this case being the watercourses in your neighbourhood, whose pollution is a critical factor. The end goal of the seminar was to influence the behaviour of consumers living in the catchment area with regards to minimising their share of the water pollution. Municipal and village authorities held a seminar to help better understand the issues associated with the pollution flows in the water management of the affected watershed, and to decide on the construction of wastewater treatment plants.

The seminar proved that alternative solution (CW treatment method) should be seriously considered. The survey demonstrated that the creek self-purified approximately 95% of organic contamination before reaching the water reservoir. However, unlike in 1993, the attention today focuses on nutrients and microbial contamination.

In April 1995, project documentation was completed. The construction of the plant started in July 1095 by a local construction company. It should be noted that expertise of the contractor is an important; especially root filters, which even in its simplicity, require careful implementation to ensure sealing insulating layers and dispatch to the correct filtration materials and precise positioning of manifolds. The CW system started its operation in 1997.

Today, more than 20 years experience shows that a decision to implement the CW method with pre-treatment facilities, and tertiary treatment of water by a waste stabilization pond was a sustainable solution.

In the next two decades, this catchment, and in particular projects implemented in Hostětín and surroundings, became the basis for education and training of environmental protection, sustainable development, presentation and environmentally friendly technologies, sustainability solutions of small settlement. A leader of these activities was a local NGO Veronica who initiated the established of eco-centres, workers cider, association “Tradice Bílých Karpat” and friendliness of the local community and the municipality (Uhlířová, 2008; links to leaflets and publications Veronica).

Thanks to the local village near the border between the Czech Republic and Slovakia, Hostětín has become a place of cross-border meetings and exchange of experiences with the implementation of projects. There are regular "apple festivals” in the cider factory, attended by large numbers of people, which allows the involvement of volunteers and enthusiasts to present completed projects and disseminate the ideas of sustainable development and environmental protection among the general public, across and beyond Hostětín and Zlínský Region.

A similar seminar was organized in the Upper Olšava basin ten years later in 2004, which aimed to create a repeating survey of surface water pollution. The control functionality has already been built into the sewers and sewage treatment plants, which presents the results to stakeholders from government staff, administration offices, river basin authorities (management of watercourses), general public, and NGOs and associations. The outcome of the seminar was a collection of contributions from experts, basin managers, and administration involved in the survey.

In 2004, under the umbrella of the eco-centre in Hostětín, a conference on "Rural Landscape" was organized to host the presentation of work, with significant involvement from university students. The students prepared the work under the guidance of experts in fields associated with the landscape, the environment, water, landscape, etc. During the workshop, students presented suggestions for resolving problems associated with land erosion, water quality, crucial local habitats, in the cadastral municipalities in the Upper Olšava basin.

In 2006, funding allowed NGO Veronica to further the survey of the state of the surface water pollution, as well as construct a detailed monitoring plan of the WWTP in Hostětín in response to changes in the use of detergents with phosphates[1]. The project also included a survey of buyers in virtually all types of shops in the basin of the Upper Olšava and awareness.

In the next part of this case study the results of the Hostětín WWTP operation are presented. These findings come at a time when many similar plants have been implemented in Central Europe, including the Czech Republic. These experiences have been active for roughly twenty years, having been built in the nineties of the 20th century with the intention of extending the lives of treatment plants, especially with the addition of CW filters.

The village Hostětín is a representative subset of municipalities, where runoff from septic tanks and sewage system reflected various qualities and ages with different ratios of diluted ballast water (both surface water and groundwater). The collection, removal and treatment of sewage in Hostětín in the early 1990’s was typical for most small and middle-size communities. Most houses had their own septic tanks, or a drainage pit discharging into local waterways. The overall waste load from the village had the character similar to diffuse pollution, discharging anaerobically pre-treated wastewater from numerous sources. The sludge was often irregularly exported and processed on nearby farmland. According to a survey done by GWP in 2012 (Bodik et al., 2012 - link), the situation in the Czech Republic and other CEE countries is the following: a septic tank and a cesspool is predominantly used in some countries, even though extensive technology can be available.

Description of realized WWTP

Combining the WWTP with natural wastewater treatment technologies is used for treating wastewater from Hostětín. The wastewater influent to the WWTP comes from the combined sewerage system, which means that it can have a high proportion of storm water in addition to the wastewater. The sewerage consists of connected overflows of wells and drainage systems of houses.

Technological line of the WWTP includes:

1st stage of mechanical pre-treatment – overflow structure, storm water retention tank, standardized grit chamber with a fine screens and an additional modular settling tank (type KMN) with lateral sludge digestion chambers

[1] Due to the ban on the sale of phosphate detergents except factories, i.e. industrial laundries

2nd stage of the biological treatment - two horizontal subsurface flow filters (constructed wetlands). Vegetative cover consists of Phalaris and Phragmites. In drier areas, other ruderal nutrient-requiring species, e.g. nettles, can be used.

3rd stage of the final treatment stage - shallow low-loaded waste stabilization pond (biological tank) with prevailing aerobic conditions.

A more detailed description of each object is given below.

The WWTP was designed and modelled for organic pollutant and suspended solids removal (see Vymazal, 1995; Kadlec et al., 2000; Šálek, Tlapák, 2006; GWP CEE guidebook, 2014).

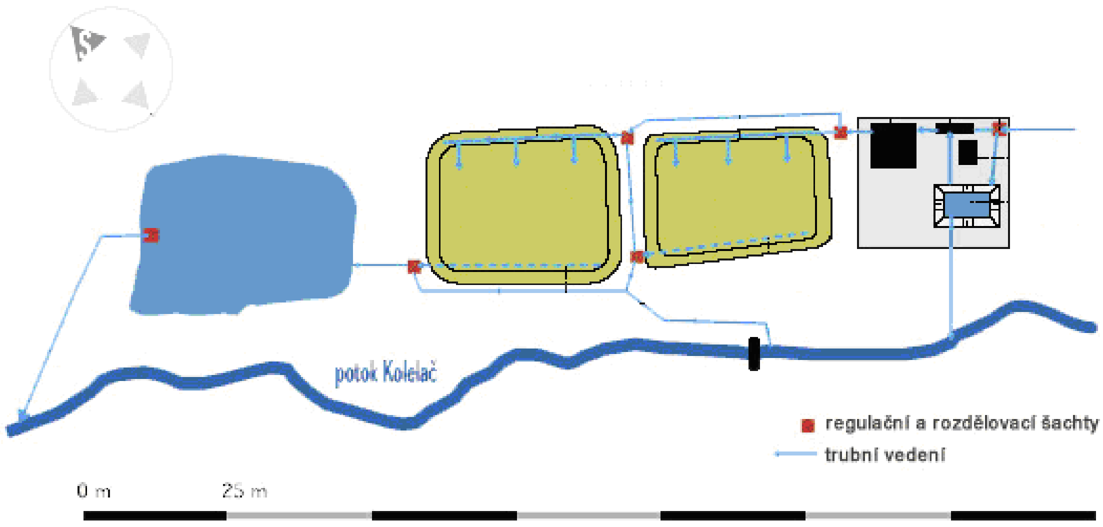
Design data WWTP are:
capacity 280 p.e.
concentration BOD5 212 mg/l, in influent
average daily flow Q 0.55 l/s (47.6 m3/day)
maximum flow Qmax 4 l/s
mass loads BOD5 15.12 kg/day
mechanical pre-treatment efficiency -expected about 30% (outflow to the biological purification stage 148 mg/l BOD5)
value of the reaction constant KBSK 0.1
surface filters area 1,240 m2 (4.4 m2/1 p.e.)
final purification pond surface area 940 m2

The design values, e.g. hydraulic and mass load of constructed wetland filters in the inflow, are shown in Table 1. Calculated loading is based on actual values observed by monitoring between 2010 and 2012.

Table 1. Load of the Hostětín WWTP constructed wetland filters – average values

Profile	Hydraulic load	BOD_5	COD	TSS	$N\text{-}NH_4^+$	Ptot
	m^3/ (m^2 filters per day)	g / (m^2 filters per day)				
Designed						
Inflow	0.04	5.7	---	---	---	---
Calculated by the measured values						
Inflow	0.18	5.7	13.0	0.5-6.5	2.9	0.24

The WWTP schematics are shown below. Photo documentation of individual objects can be found in the appendix.



The following satellite images depicts the WWTP area in 2003 and 2009.

In detail, the entire process flow consists of the following objects:

Objects of mechanical pre-treatment:

• Overflow structure
Module used to limit excess inflowing to within maximum inflow capacity of WWTP, as to avoid hydraulic overload.

• Storm water retention tank
Tank to retain storm water from separate sewer systems. Water is pumped after the rain subsided into the sand trap and purified, or after the settling of the suspended solids discharged into the stream.

• Sand trap (grit chamber)
Coarse floating debris (sand and gravel) is removed from the influent wastewater in the grit chamber utilizing fine screens. The waste material is deposited on a dumping place.

• Shallow combined settling tank
Water flows from a sand trap to a settling tank, which is used to separate finer particles contained in the wastewater. The removal of suspended solids and organic contaminants occurs through binding to these particles, which doubles as protection constructed wetland and the pond from rapid clogging. This kind of settling tank contains a lateral chamber for settling particles (sludge) digestion.

Digested sludge is taken out once or twice a year and transported by a sludge removal truck to be used as fertilizer. It can also be transported to a larger wastewater treatment plant for further processing.

The biological purification stage represents constructed wetland – two filters.
Two constructed wetland filters are filled, forming aggregates that are 4-8 mm grain size, distributed in 50-120 mm fractions. The total area of the filters is 1,240 square meters. The filters are operated in parallel with the possibility of a serial operation.

Their layout and design enable serial, parallel and alternating operation modes.

The first filter has a 580 m2 surface area, with dimensions 26x22 m. The thickness of the filter layer is 1 m, and the slope of the banks is 1: 1.5.

For the first filter, the influent wastewater from shallow combined tank is fed to the first filter by PP pipeline DN160. Two pipelines are operational - one at the surface of the filter, for operation during summer, and the second one is installed deeper on the broad side of the filters, in the middle of the filter thickness, used during winter. The outflow pipeline is joined to a perforated PVC drain DN 200, mounted on the bottom at a gradient of 1%. The bottom of the filter is constructed from the inlet edge toward the outflow edge, at a gradient of 1.5%

The second filter has a 660 m2 surface area , with dimensions 30x22 m. The thickness of the filter layer is 1 m, and the slope of the banks is 1: 1.5. The inflow and collection of waste is handled in the same manner in the first filter, as described above.

• Filter bed of constructed wetlands
The filter beds are filled with coarse aggregate (50-120 mm) and finer fractions (gravel grit 4-8 mm). The total thickness of the each filter is 1 meter. The bed is insulated with PVC foil and geotextiles. Reed canary grass and common reed were planted on the filters. Filters are yearly mowed, and the material is composted.

• Collection and regulation shaft
This serves to regulate the water level in the filters. For this purpose, wooden plank walls acts as sluices by which the water level is maintained at 10 cm below the top.

• Distribution shaft
The distribution shaft is situated between the septic tank (or settling tank) and the biological treatment facility (CW, WSP). It distributes the tank wastewater in approximately equal quantities through all the treatment units, or percolation pipes leading from it. It also enables the control of the flow to each filter.

• Bypass pipeline
This pipeline is set up to allow withdrawal of one of the filters of operation for inspection, and to clean the filter filling material. The bypass pipeline later dischargesinto the final purification pond.

The polishing stage in the WWTP consists of the wastewater stabilization pond, which is a natural basin for the treatment of water flowing from the constructed wetland. The main objective is to reduce the content of nutrients in the water discharged from the plant, and thus reduce the risk of eutrophication in the recipient water body. The inflow can be recharged from the creek Kolelač in addition to the wastewater influent from the CW filters. Normal level corresponds to the maximum level.

Current state:

- Specific surface level of water	97.80 m above datum.
- Surface water level at a specific level / maximum level	835 m2
- Capacity at maximum level	630 m3
- Elevation of the dam crest	98.40 above datum.
- Water depth at maximum level	0.60 m to 1.40 m

The surface area of the pond is 830 m2, with a capacity of 800 m3. The average depth is 1.25 m. The mean residence time was designed to be 16.8 days.

Objects at final purification pond

• Water intake structure

The inflow can be supported by inflow from the Kolelač creek. The creek bed is in the vicinity of the structure, reinforced with quarry stone. Any bacckwater flushing of the creek can be secured by sluice plank wall, for which they are embedded in the creek banks. There are separate concrete diversion structure installed with screens, followed by pipeline of DN 300. This module was not originally a part of the treatment plant in operation.

• Head inflow structure

The pipeline transports wastewater to the pond from last regulation and collection shaft. The inflow structure consists of PVC piping, with DN 300, discharging into the pond at an edge. The pipe is submerged and follows the bed of the creek. The dimensions of the piping bottom - 97.70 m of relative high.

• Outflow structure

It is a semi-closed gullet with one wooden sluice plank wall. The sluice plank is used to regulate the water level in the pond and its eventual release. A separate sluice plank wall is supplemented with concrete baffle, which serves to constrict the inflow in case of overflow. The upper edge is 0.8 m below the upper edge of the gullet. Water outflow runs by the bottom outflow pipeline beneath the scum board. This water outflow set-up should ensure the collection of eutrophic zone, and thus eliminate the pollution of water by algae biomass during summer period. In the current configuration and depth, algae biomass reproduce at certain times of the year throughout the water column, thus causing unwanted pollution of Kolelač creek, which receives some of the discharge.

The perimeter of the concrete structure gullet at the height of a normal water level is severely damagable by freeze-thaw erosion and by fluctuation of purified water.

The acceptable mass loads of the pond were calculated 25.16 kg BOD5 per ha-1 day-1, and by the treatment efficiency of the CW 80% to 33.32 kg BOD5 per ha and day. Normal water level corresponds to the maximum level. The bottom of the ponds are without reinforcement, as well as the slopes. During the growing season, floating macrophytes can be seen in the pond. The riparian vegetation of the pond is made up of both herbal and wetland communities, as well as trees (mainly salix sp.). Currently, wetland vegetation and trees are growing into the pond. Comparison of development of riparian vegetation can be seen from the photos in Appendix 1.

Due to the presence of trees in the vicinity of the pond, including its banks, this leads to loss of leaves into the aquatic environment of the pond, which can suggest that the decomposition of leaves affects the water quality, with regards to its oxygen demand, organic matter content, nutrients, and other substances (e.g. Taylor et al., 1983; Hai, 2005). The influence of water quality characteristics, however, has not been evaluated.

WWTP monitoring, given outflow limits

The following water quality requirements at the outflow (discharge) of the wastewater have been set, resulting from water management decisions. The limits were established during the term of Government Regulation no.61 / 2003 Sb. as amended by amendment no. 229 / 2007 Coll. and amendment No.23 / 2011 Coll .:

Limits for the sources of up to 500 p.e. (values in mg/l):

COD	"p" 150	"m" 220
BOD5	"p" 40	"m" 80
TSS	"p" 50	"m" 80
N-NH4 +	"p"	--- "m" ---

The minimum number of samples of discharged wastewater is four. The type of sample is prescribed as a two-hour sample mixed from 8 partial samples of the same volume every 15 minutes. The sampling time determines the local water authority so as to best characterize the activity of the monitored plant.

Limits for discharges from wastewater by water management decisions (values in mg/l) for the WWTP Hostětín:

COD	"p" 70
BOD5	"p" 20
TSS	"p" 25
N-NH4 +	"p" not determined

Sampling description

Throughout 2003-2013, regular monitoring was carried out by the accredited laboratory of the Water Research Institute, Brno. The water samples were sampled according to laboratory procedure (technicians in question were certified no. 389 dated June 28, 2010 and valid until June 30, 2015). These samples determined the COD through accredited procedures. The samples were stored in a cool place until further analysis and processing. The analyses were performed by accredited procedures (technicians in question were certified no. 389 dated June 28, 2010 and valid until June 30, 2015).

The water samples were taken at the following points of the WWTP:

1. At WWTP inflow - the influent to the wastewater treatment plant (following the last outflow structure, before a reaching a tributary to the sand trap)

2. At WWTP outflow - the discharge of water from the polishing stabilization ponds into the Kolelač creek, through a drain pipe.

These sampling points were monitored and sampled in addition to other important water profiles of the WWTP, such as below stormwater tank, below settling tank, outflow from the each of CW filters, and the aquatic environment of the final purification pond.

The range of performed analyses included determining basic indicators of water quality:
1. total suspended solids dried at 105 ° C (TSS).
2. biochemical oxygen demand (BOD 5)
3. chemical oxygen demand (COD)
4. ammonial nitrogen (N-NH4 +)
5. total phosphorus (Ptot)

As well as additional indicators necessary for plant operation:
6. water temperature
7. water electrical conductivity
8. pH
9. dissolved oxygen concentration
10. oxygen saturation

The set of parameters also included soluble parts of phosphorus, other forms of nitrogen, total and dissolve organic carbon, chlorides, and sulphates. From the aquatic environment of the pond, samples were taken to determine population of bioseston (phytoplankton). The mentioned parameters are not commonly determined in samples from such small WWTP. However, it was possible in this case thanks to many ongoing projects, and that the data adds to the Czech datasets for the wastewater treatment efficiencies of natural technologies.

Treatment efficiency

The annual average concentrations of organic pollution, expressed in BOD5, range from 26.3 to 95.2 mg / l. Compared to the design value of the treatment plant, 212 mg / l, it is less than half the amount. The treatment is able to normalise large fluctuations in the amount of waste water. During 24-hour periods, measurements were captured during in the hydraulic load spikes in the morning and evening rush in the weekdays, and weekend lunch spikes. The average annual inflow to the wastewater treatment plant is 14,000 m3 / year. The average value of daily discharges by point measurement of 2006 was 0.6 l / s at the inlet. In 2010, the continuous flow measurement showed a mean value of 3.4 l / s. The median values of the flow in that year was 1.8 l / s. However, the design value of average daily flow rate is only 0.55 l / s.

The waste water processes are occasionally hydraulically overloaded, especially during the period from November to March. For this reason, the proposed modification of the overflow chamber.

The mass load of the final purification pond is 3.1 kg / day (31 kg/ ha /day). The retention time of water in the tank is 5.1 days. These parameters meet the requirements for post-treatment ponds, as reported by Effenberger and Duroň (1984) and Šálek and Tlapák (2006). Further reducing the load is possible by improving overflow structure and increasing the efficiency of treatment modules in the mechanical pre-treatment. If the average flow at the design level, or level measurement in 2006 - 0,6 l / s can be expected to reduce the mass load of 10.6 kg BOD5 / ha / day.

Table 2 summarizes the results of long-term monitoring of the values of the selected indicators when in the operation of WWTP Hostětín (2003-2010). The final purification pond contributes significantly to the reduction of outflow concentrations of nitrogen and phosphorus from CW filters shown in the average and maximum values. However, TSS and organic compounds behaved as expected , showing higher concentrations as indicated by COD , caused by biomass production and decay of algae and other vegetation in the pond.

The WWTP values meets the prescribed concentration of the BOD and COD parameters of long-term monitoring; although in some samples, the values are higher than specified. In the case of performance indicators, TSS shows problematic performance, with the long-term average being higher than the discharge limit. .

A significantly lower mass load than anticipated in the design documentation is in case of the dissolved oxygen in the pond. Attention should be drawn to the harvesting of floating macrophytes biomass, or to make minor adjustments to the outflow structure to allow for the movement levels and hindering further growth on the surface. These adjustments should be taken into account in maintenance and operating rules.

Table 2. Long-term values of monitored water duality parameters (values in mg/l)

Profile	Inflow to WWTP	Outflow from CW	Outflow form pond (from WWTP)
Parameter		BOD_5	
min	1	1.90	0.20
avg	64.9	16.69	13.21
max	195	68.00	28

Parameter		COD	
min	17	8	12
avg	142.8	42.27	44.54
max	588	78	109
Parameter		TSS	
min	8	1	8
avg	41.9	9.82	27.77
max	123	16	64
Parameter		$N\text{-}NH_4^+$	
min	2.79	1.27	0.09
avg	23.25	18.56	9.15
max	44.00	36.64	25.21
Parameter		P_{tot}	
min	0.57	0.23	0.24
avg	2.84	3.08	1.74
max	5.81	5.16	3.94

Sludge and sediment samples analysis

In 2006, after ten years of operation, a survey was carried out of the sediment content of the pond in Hostětín WWTP. It was found that the deposited sediments ranged of from 0 cm to 30 cm. Their depth grew along the pond, from the inlet pipeline to the outflow. The values around 30 cm were found practically only in the immediate vicinity of the outflow facility.

Table 3 shows the content of selected risk pollutants as analysed in the dry mass of sediment. The table shows also the limit values for monitored pollutants given by Czech legislation (Gov. Decree No.382 / 2001 Coll.). Analyses of microbial contamination (enterococci, thermos-tolerant coliforms) showed that the excess load samples meet the limits set by the mentioned legislation.

Table 3. Content of risk pollutants in sediments of WWTP pond (mg/kg of dry matter)

Parameter	Final purification pond sediment 2006	Final purification pond sediment 2013	Allowable limits (Gov. Decree No. 382/2001)
As	0.9	5.9	30
Cd	0.06	0.23	5
Cr	4.4	38.0	200
Cu	6.1	40.0	500
Hg	0.01	0.07	4
Ni	4.7	28.4	100
Pb	1.1	39.0	200
Zn	46	62.0	2,500
AOX	---	---	500
PCB	---	---	0.6

The sludge samples do not exceed the prescribed concentration limits for any of these pollutants. In terms of microbial contamination, the sludge complies with category II - sludge can be applied to agricultural land for cultivation of industrial crops, and other agricultural land with the exception of not using the land to grow fruit or vegetables until 3 years after sludge application, in compliance with the principles of occupational health and other provisions of the legislation.

In 2013, another survey of the sediment content in the pond of the Hostětín WWTP was carried out. The state of the sediments was reminiscent of the state in 2006: there as only an increased amount of sediment in the immediate vicinity of the outflow structure, reaching about 50 cm in thickness. Other larger accumulations of sediment was transported by the inflow pipe and subsided in its nearby vicinity; the specific sediment transported is the original bottom subsoil material. This area is also inhabited by macrophytes vegetation - mostly cattail (Typha sp.).

In a sample of sediment collected in 2013, microbial contamination was not found. When considering heavy metals, the sediment content does not constitute a risk for possible use on agricultural land.

NWWTP effectiveness assessment

The NWWTP is regularly monitored on a daily basis, and suggested adaptations to the water level in the CW filters are implemented and flow through the filter and pond adjusted. Based on the operation and the assessment of its functionality, the following recommendations were made:

1. Overflow and operation of mechanical pre-treatment facility

In 2012, a design flow was consolidated and resulted in a reduction of extreme values of the hydraulic load in the plant. The result was a limitation of the transport of sludge from the settling tank to the filters, and a limit on the development of clogging fields. It is therefore necessary to pay careful attention to the balance of deposits on sand trap, and the sludge from the settling tank.

2. Vegetation of the CW filters; clogging and anaerobic conditions prevailing in the filter medium of the CW

According to the project documentation, two CW filters were built as part of the wastewater treatment plant, which allow horizontal subsurface continuous flow through filters. The filters are filled by gravel and vegetation (common reed and canary grass). These filters are dominated by anaerobic aquatic conditions, which do not allow sufficient nitrification of ammonia to nitrogen. Vymazal (2009) showed that the efficiency of removal of ammonia nitrogen in the 53 WWTP outfitted with CW in the Czech Republic for the period 1989-2007 had an average of 34% of nitrogen removal. As a reason for the low efficiency, this indicates anaerobic conditions in the filters.

Previous research and monitoring of the operation showed that the plant roots can provide stable and sufficient removal efficiency of organic pollution and suspended solids, both during the growing season and during non-vegetation period when macrophytes vegetation are dormant, and does not participate in the cleaning process (Rozkošný and Mlejnská, 2010). The condition for this, however, is the availability of good mechanical wastewater pretreatment (Šálek and Tlapák, 2006; Rozkošný et al., 2010; Kriška, 2012).

Solutions given by previous research (Kadlec and Wallace, 2009; Kršňák and Douša, 2011) consists in changing the filters of the project design, thus continuously allowing flow through permanently water-saturated horizontal filters. The CW fields alternate between saturated and unsaturated environments, emptying the fields on a pulse. This requires implementation of a regulatory pit, and install the control objects on the device enabling the emptying pulse, and thus the alternating operation of CW filters.

Presently, denitrification process in the treatment plan works appropriately. In case of any future changes, it will be necessary to regularly empty the pulse filters and their operation in the unsaturated and saturated state. To do this, adjustments need to be made to the regulatory pit in order to ensure the completion of the pipeline with emptying functionality.

In the inflow zones, clogging of filter media was detected. Their cleaning or replacement the filter material is necessary.

The vegetation of CW filters is currently a mixture of many species, including weeds. Fundamentally, it does not affect the cleaning efficiency of the entire plant. However, it is recommended that regular mowing of vegetation and processing the biomass outside the filters through a suitable composting method.

3. The creation of secondary contamination in final purification pond due to the rapid development and subsequent death of phytoplankton biomass, in the growing and operating season

The result is an increase in the concentration of BOD, COD and TSS in the outflow. Possible measures for mitigation are presented below.

4. Final polishing pond

The polishing pond was designed for a point inflow and a point outflow structure. In terms of removing pollution, the entire volume of the pond may not be used due to the nature of the water flow. This one-point solution of the inlet placed in the corner of the pond is inappropriate, as it does not ensure the uniform distribution of wastewater. Preferential currents are formed in the pond. These are not effective for the entire width of the pond, and thus limits the treatment effects that it provides. Within the pond, “dead zones” may form, which provides an inlet duct manifold along the head of the reservoir.

The installation of a one-point inlet supports the formation of preferential streams, and areas where water stagnates and invites ongoing unwanted anaerobic processes. It would be desirable for the outflow to incorporate the manifold along the trailing edge of the pond. The installation of this pipeline could be combined with the filter to capture sediment and phytoplankton biomass in the pond.

Design of measures to operation and efficiency improvement, adoption in 2012 - 2014

Several measures to improve the operation and functioning of the plant impose only a low-cost investment from the local village authority budget. Some improvements in operation are possible by additional plant installations (such as pumps). These measures do not require changes in a project documentation, obtaining grants, or adding a larger burden on the budget of the village. The goal is to improve the state by which the WWTP meets the prescribed limits. The measures were proposed in a cooperation of the village government, operating personnel, ecological centre and WRI staff, who were able to assist by conducting research on the plant.

1. Adjustment to the facility in order to ensure overflow separation and mechanical pre-treatment, sludge stabilization and adjustment mode of sludge disposal

During 2012, the installation of the overflow chamber has been adjusted to give better control of water separation, and to reduce the hydraulic load of the wastewater. The measures could be effective, and hence fulfilled its purpose.

2. Adjustments of distribution shafts

The distribution shafts were cleaned and distribution lines complemented by knee joints, which allows water to flow to higher levels. This prevents the transport of sediment into the inflow pipe to CW field. At present, the shafts are operative.

3. Adjustments of regulation shafts

Regulation shafts were cleaned and outflow lines were complemented by knee joints, which allows water to outflow from higher levels. The sluice plank was also removed from the walls, as they lost purpose due to regulating levels in CW fields which have already been broken. The shafts were fitted with designed pipes allowing better control of the water level in the CW fields, through manually emptying the chambers.

A view into a regulation shaft after the reconstruction of the pipeline.

4. Maintenance of the CW filters

At the CW filters, there filtration medium stripes surrounding the inflow zones, around the inlet pipelines were cleaned. The material was also changed.

5. Pond sediment inspection

A survey on the amount of sediment in the pond was done in spring 2012. The bottom and slopes of the pond were inspected. A significant increase of sediment was not able to be proved compared to the situation in 2006. Since the total amount of sediment is relatively low, it is not necessary to empty the pond in order to dispose of the sediment.

6. Final polishing pond - outflow

In 2012, works have started to stabilize and improve the cleaning effect of the WWTP, focusing on polishing pond. A two-piece floating filter was thus fitted to outflow structure of the pond. The filter is able to absorb floating impurities, and allows the elimination of the phytoplankton biomass in the discharge. The filters will ensure the elimination of the peak values of BOD, COD and TSS in the wastewater treatment plant effluent. In the first phase, the survival of the wetland vegetation on floating filters was tested, using different types of plants Iris, Glyceria, etc., during their vegetative season and during winter. In the spring of 2013, the vegetation resumed growing again without damage due to the winter season, due to the partial freezing of the water.

Floating vegetation filters fitted before discharging water from the pond

A mixing island was fitted to the pond, which draws water from the bottom and directs it to the surface. The aim is to reduce stratification of water in the pond to homogenise the temperature and oxygen content. Stratification creates favourable conditions for the development of cyanobacteria, and hindering stratification promotes other types of algae and reduces the possibility of the development of floating macrophytes on the stagnant pond surface. The mixing of water serves to reduce the total amount of water freezing during the winter season, subsequently worsening the oxygen regime and cleaning performance. The following figures show some of the positive effects of freezing in mixing water. The island has been designed to drive mixing pump procured autonomous source of electrical energy, in this case solar energy.

Outcomes

Compliance of targets

Were the intended targets with regard to the situation in the village achieved? Essentially, yes. The base situation was that the village was not allowed to expand prior to implementation of measures in wastewater management. Traditional solutions to construct WWTP were expensive. Alternative solutions proposed by local NGOs in cooperation with enthusiastic water experts were challenged by obstructions given in the national legislation. An involvement of stakeholders – local farmers, eco-tourist volunteers, and committed local authorities – was a key to a success. Strategic partnership of the local authority comprised:

1) non-profit organizations, especially Veronica Foundation, “Tradice Bílých Karpat” and “Nadace Partnerství” (“Partnership Foundation”), which brought inspiration, expertise, international contacts, sources of financing, project management, personal commitment, and new partnerships e.g. the corporate sector, the embassies of European countries, etc.,
2) public administration (especially initially district authorities of the Uherské Hradiště district, later Regional Office of the Zlínský Region, State Environmental Fund, etc.).

Hostětín would not have become what it is today without the key players who were at the origin of individual projects, not allowing to themselves be deterred by the additional projects that managed to attract dozens of other professionals and concerned citizens.

It seems that it was the power of the initiators, which played one of the most important roles in the Hostětín project. Without them, the Hostětín projects would probably not exist. A similar situation can be observed elsewhere in the Czech Republic. The phenomenon of "project managers" and their current role as a catalyst for rural development (especially towards sustainable development) and rural sociology has not yet been systematically mapped (Uhlířová, 2008).

WWTP assessment

The Hostětín WWTP has been in operation since 1996. When comparing the design load, both hydraulic and mass, with long-term results of monitoring the plant, it is apparent that the mass load is much smaller than anticipated in the project, which is for the treatment plants connected to the combined sewerage system. The current situation is also influenced by a reduction in water consumption by population, change in diet, changes in the use of detergents in households, etc. The hydraulic load, on the other hand, has been in fluctuating over a long period of time, especially if snowmelt and at main precipitation events are high. The situation in the plant improved in 2012 after adjusting the overflow structure in the chamber, allowing for a higher design load. The hydraulic load needs further attention during the operation of the plant. Unlike the mass load, the hydraulic load is a limiting factor in connecting new sources, such as further households. For larger proportion of separate sewerage system in the village, the assumption lies that it may will also cause changes to the mass load, especially the increase of ammonia nitrogen and phosphorus.

The treatment design was for the removal of organic pollution and suspended solids. These indicators show that the effectiveness is high over the long-term, but concentrations of suspended solids, BOD, and COD can fluctuate during various parts of the year, which may lead to the development of phytoplankton biomass and vegetation in the pond. This can cause problems with failure to comply with the effluent permit. Therefore, it has been appropriate to install an intermediate trap of debris (leaves, branches, floating algae cakes) in the pond, or to actualize the outflow filter, and supplement its current impelementation with an investment project, and necessary project documentation.

Having high phosphorus removal can also provide conditions for better separation of suspended solids in the mechanical pre-treatment stage. It is recommended to pay attention to the age of the sludge, and to prevent bulk transport of sludge to the filters. According to an analysis of the material sludge or sediment from the tank biological was within acceptable limits for their use in agriculture. A prospective could be the treatment of sludge and sediments, along with vegetation from root filters through composting.

In terms of handling and operating the plant, it was necessary to make adjustments to the distribution and regulation shaft. The adjusted regulation shaft also allows the use of the pulse emptying filter, if it can be demonstrated that the removal efficiency of ammonia and nitrogen is presently insufficient. At present, however, there is not a prescribed limit for ammonia and nitrogen in the discharge. In case the objects can be removed through sorption, materials that support this for the removal of phosphorus would increase the efficiency of the removal of ammonium and nitrogen in the CW filters, which could reduce competition between ammonia nitrogen and phosphorus with respect to the sorption materials.

Stabilization of the final polishing pond has positive effects on a sufficient nitrogen and phosphorus removal. In addition, stabilizing the pond helps to remove suspended solids and organic pollution that occurs during the growing season in higher concentrations, expressed in terms of BOD5 and COD. However, these indicators present different characteristics than those of the substances in the sewage inflows, albeit legislation has not been evaluated when comparing the limit of the concentration in the runoff and the current achieved values. In the case of floating macrophytes in the pond, e.g. duckweed, it is necessary to periodically harvest biomass during the growing season. Regular harvest would eliminate conditions that also contribute to the depletion of oxygen in the pond. The total biomass of floating macrophytes, especially for larger ponds, is difficult to harvest and relatively time consuming. Therefore, it is preferable to ensure the continuous flow of water in the pond surface to prevent the occurrence of macrophytes, since their proportion of the nutrient uptake of water at the municipal sewage practically negligible (about 5%) and not necessary. From these results and analyses, it has been shown that the waste materials (sediments, sludge and biomass) from wastewater treatment plants do not pose a risk for the occurrence of specified pollutants. Conversely, it is possible to sort and separate the valuable resources, in terms of nutrient content. Their use can be found in agriculture as a fertilizer, and used as composting material.

Sustainable development components of the WWTP Hostětín project

Economic
1) the investment costs comparable with other types of wastewater treatment plants.
2) the low operating costs
3) the possibility of using the existing sewerage system

Social
1) cancelling of construction prohibition, and community development
2) education and awareness
3) job creation
4) a new type of public space

Environmental
1) sensitive integration of wastewater treatment in the landscape
2) the ability to absorb large variations in water flow
3) treatment ability even when high concentration of pollution
4) treatment ability of the vegetation outside the growing season
5) cost-efficient energy usage

Economic component – investment cost

In Table 4, there are mentioned for comparison given the capital (investment) and operating costs and other information about the WWTP in Hostětín and mechanical-biological treatment plant in the neighbouring village Šanov, which has twice the population and produces a similar type of contamination.

Table 4. Comparison of WWTP in Hostětín village and Šanov village

Type of the WWTP	Hostětín CW WWTP	Šanov Flexidiblok 100 m^3/day
put into operation:	July 1996	July 2002
the total cost of construction of the WWTP	about 1.9 (2.8) mil. CZK	about 5 mil CZK
the total cost of construction of the WWTP and sewage system	4.9 (7.1) mil. CZK	16.2 mil. CZK
surface area	2.740m^2	375m^2
the number of jobs created	0.1	1
p.e. design value of the WWTP	280	700
the number of inhabitants in the municipality (as of 31. 12. 2006)	238	503
the actual number of connected population	236	450
Investment costs for the WWTP (CZK per 1 p.e.)	8,051 (11,668) CZK	11,111 CZK
investment costs at full capacity utilization (CZK per 1 p.e.)	6,786 (9,835) CZK	7,143 CZK
energy costs in the year 2006	1,700 CZK	120,000 CZK
maintenance costs for the year 2006	14,100 CZK	15,000
the total annual cost of maintenance and operation (2006)	40,000 CZK	175,000 CZK
the ratio of the total annual cost of maintenance and operation of the WWTP to the annual municipal budget (2006)	2.6%	5.6%
Treatment efficiency	COD = 77 % BOD5 = 90 % TSS = 92 %	COD = 87 % BOD5 = 95 % TSS = 96 %

Source: website of the Centre Veronica Hostětín; Hostětín municipal office; Šanov municipal office; Machů, 2007; Uhlířová, 2008.

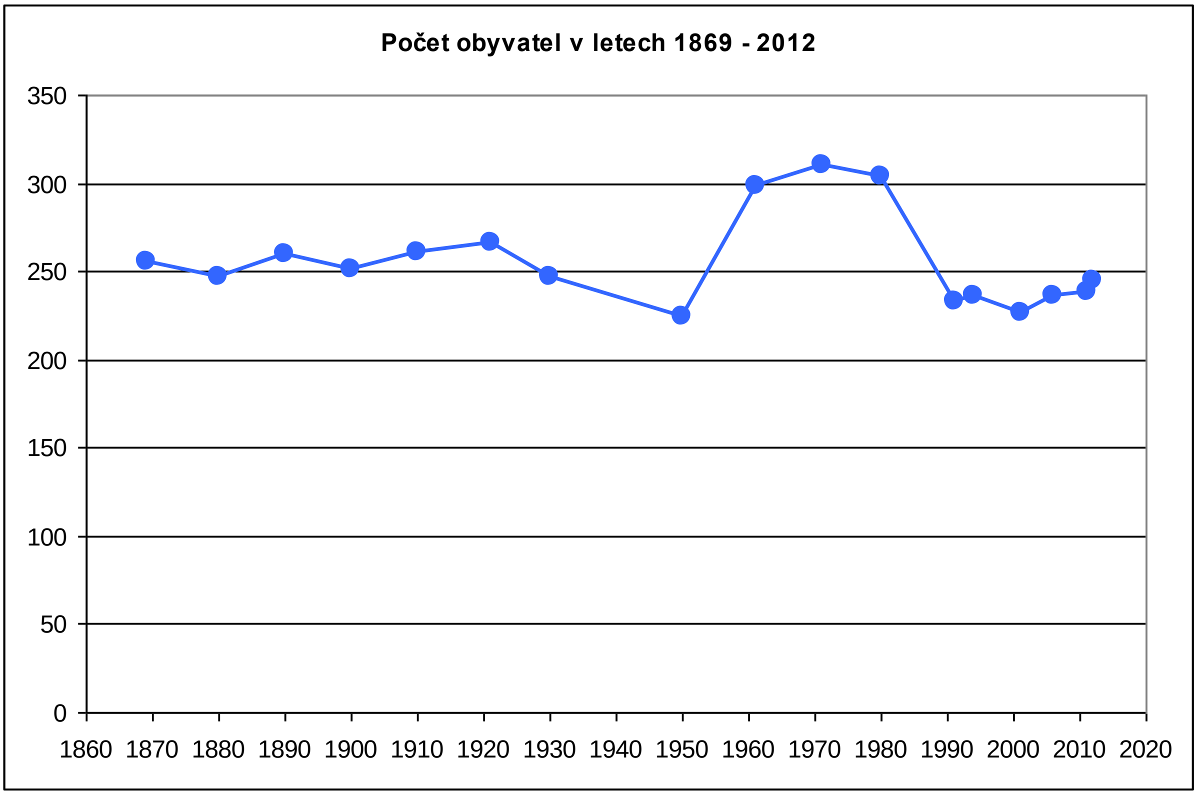
In addition to village Hostětín, the following institutions also contributed to the total investment costs:
- The district authority Uherské Hradiště paid about 92% of the total cost,

- the Ministry of Environment had contributed via the River Systems Revitalization Program 6.5% to build final purification pond,
- the village Hostětín subsequently invested less than 2% of the total investment cost from the municipal budget in the construction of the new plant and sewerage system.

The operation of NWWTP is inexpensive, and is not demanding to the regular disposal of sludge (1-2 times per year), checking the setting level of water in filters, visual inspection of manholes (1 per week), and mowing vegetation (1-2 times per year). The mayor of the village used to conduct the mowing himself until 2006. Now it has been providing by two members of the local authority staff. Of these two, one conducts mowing in the village, which covers all the public works, making the quantification of funding for maintenance not so easy. However, mowing the surrounding grass land and the macrophyta vegetation of the filters from the municipal budget costs about CZK 12,000 (2006). Reducing the plants biomass has been a case of composting on site within the WWTP. It is also necessary check the condition of the WWTP every other day, which takes about 0.5 hours. Once every quarter, samples must be taken of the wastewater. Sludge from wastewater has been used in the application to agricultural land, as sludge from the settling tank is anaerobically stabilized. To do this, the necessary analysis have been carried out, which so far have shown no excess loading by microbial contamination, heavy metals, or organic pollutants.

Social component – prohibition of construction override, village development

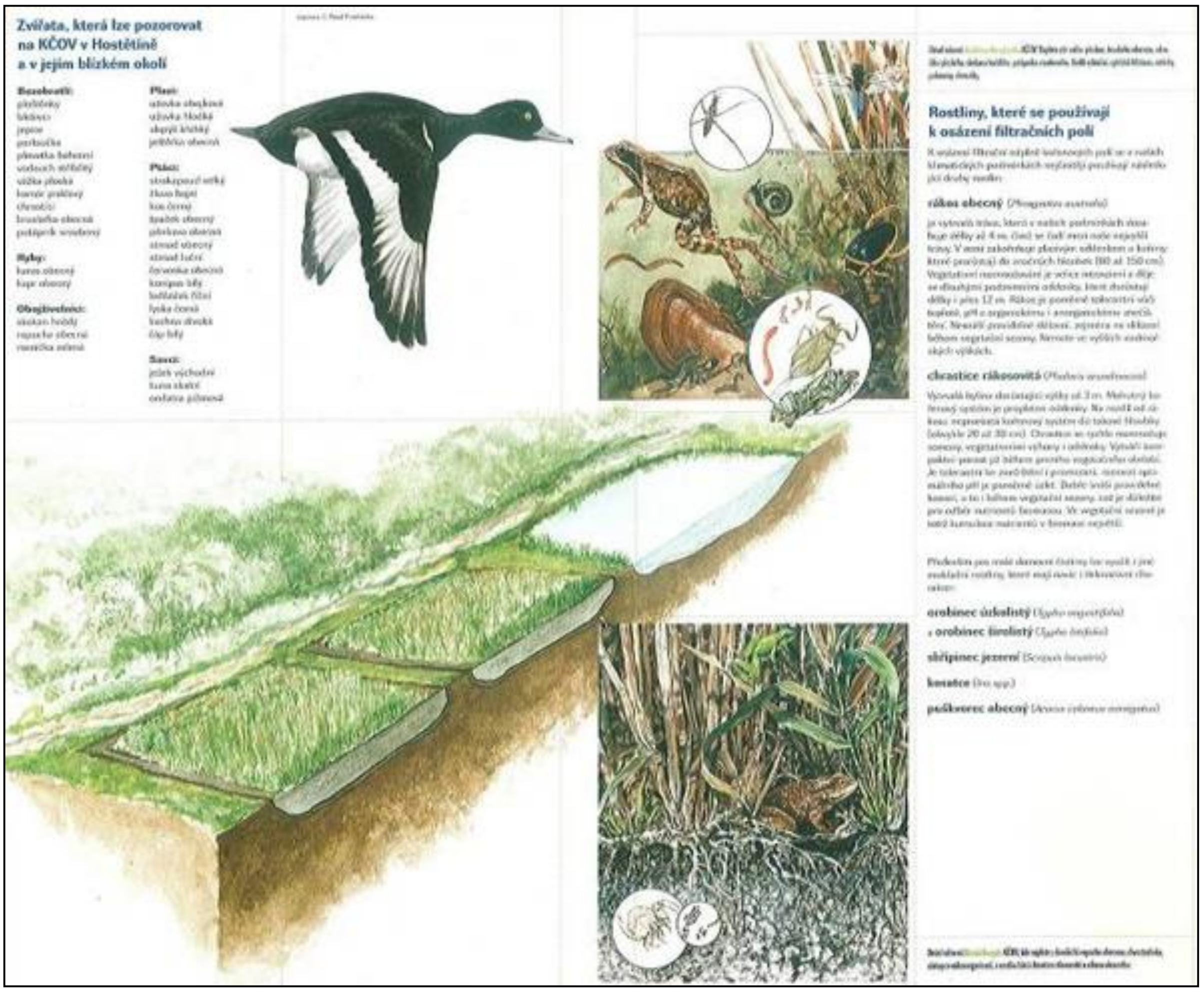
Construction of NWWT allowed to remove the ban on the expansion of the village. The following graph shows the progress on the number of inhabitants, and the impact of the drinking water supply reservoir construction and the construction prohibition over the last three decades of the 20th century. After the construction of the WWTP and the cancellation of the construction prohibition, some progress has been seen in the development of the village.



The village Hostětín inhabitants 1869 – 2012 development

Environmental component – electricity saving

Furthermore, other positive environmental impact of the project shows electricity savings within the operation of constructed wetland based WWTP (see table 3). Reducing the electricity usage reduces the carbon dioxide (CO2) emissions.



Environmental component – biodiversity advancement

The following figure is an example of publication showing the biodiversity of the WWTP area. The area of the WWTP became the target of biological surveys of fauna and flora. As documented in the photos in Appendix 1, the area has been gradually incorporated into the landscape and has since become an important refuge of wetland habitats and their local biodiversity, including protected species. The findings were summarized in educational materials, available on the web of the NGO Veronica.

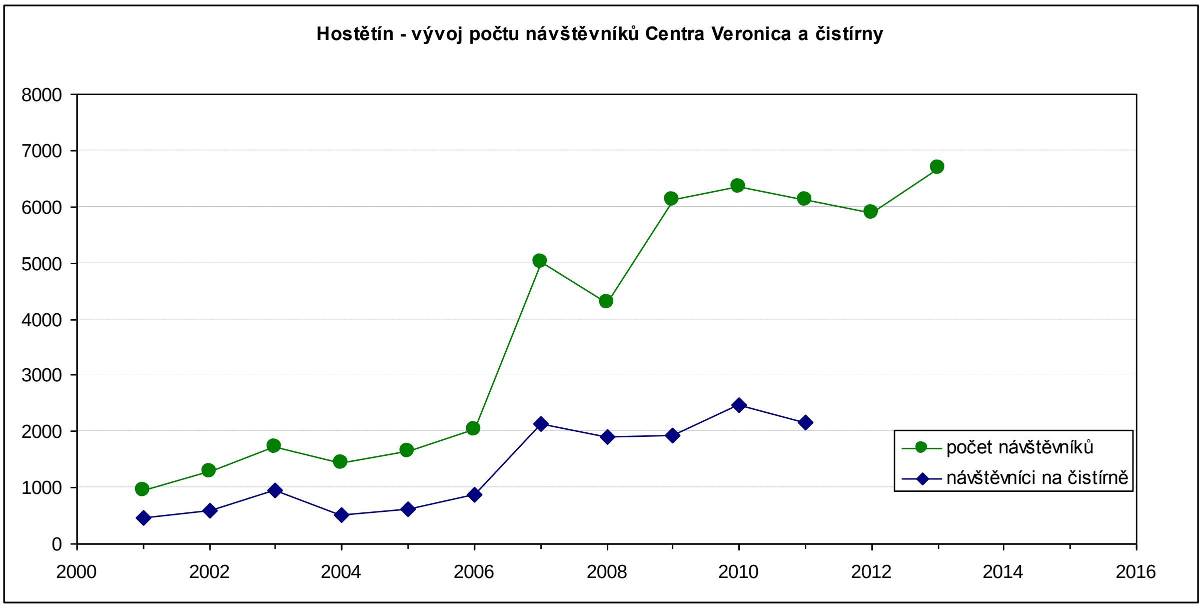
Lessons learned and replicability

One of the recommendations in the decision-making was process to address sewerage and wastewater treatment and general management of all waters within the territory of similar settlements. We must admit that it is definitely helpful to perform even simple concept study evaluating solutions at the specific time and place. Focus should be on legislative requirements, including the requirements for local development, environmental protection, biodiversity, and quality of life. More often than not, the valid legislation, especially for small sources (settlements), does not attach high requirements to solve pollution of water and aquatic ecosystems. As an exception, current requirements may not provide a satisfactory solution to the situation.

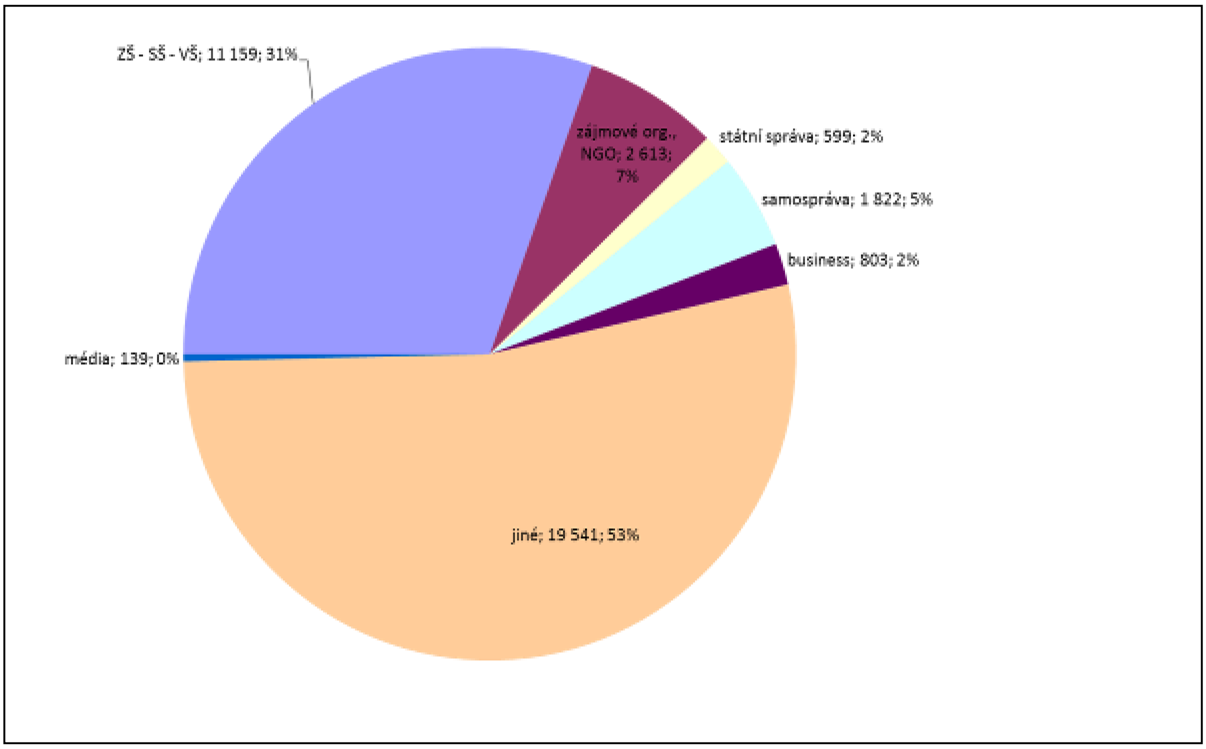
It is necessary to assess the implementation of the project through the capital costs, but also the operation costs, including operating costs, operation, maintenance, and replacement. At the present, investment funds can be procured from many different grants, but operating funds are always dependent on users, being the residents of settlements in this case. Therefore, even though it appears to be advantageous in terms of investments (including land prices), it may not be economically sustainable in the long term for the local community, or encumber it significantly.

A great advantage of the extensive treatment technologies are generally low construction and operating costs, in comparison to the conventional treatment technologies (activated sludge). The disadvantages of the extensive technologies are that it requires great demands on surface area, cleaning effectiveness also has a partial dependence on climatic conditions, low technological control of the processes, the need to extract sediment from the biological tanks (waste stabilization ponds), constructed wetland filters, and soil filters clogging. This does not indicate the disadvantages of low efficiency once installed, because the outcome is dependent on the correct use of these technologies and their design, including dimensions of all objects.

An emphasis was placed on the importance of education and the strengthening of co-responsibility of citizens, clubs and associations for deciding on a common environment and use of natural resources. As stated by the mayor of the neighbouring village Pitín, Mr. Juračka: "Only when I walked along the Olšava River with experts did I realize how rare the plants are here, that we are still growing, and what kind of animals live in water; that's all we need to preserve for future generations "(cit. Kundrata, M. in Podroužková, H. et al., 1993). The following figure shows the development of Hostětín ecological centre visitors, implemented projects focusing on the WWTP, and also the structure of visitors.



Number of visitors of the Hostětín ecological centre and WWTP.

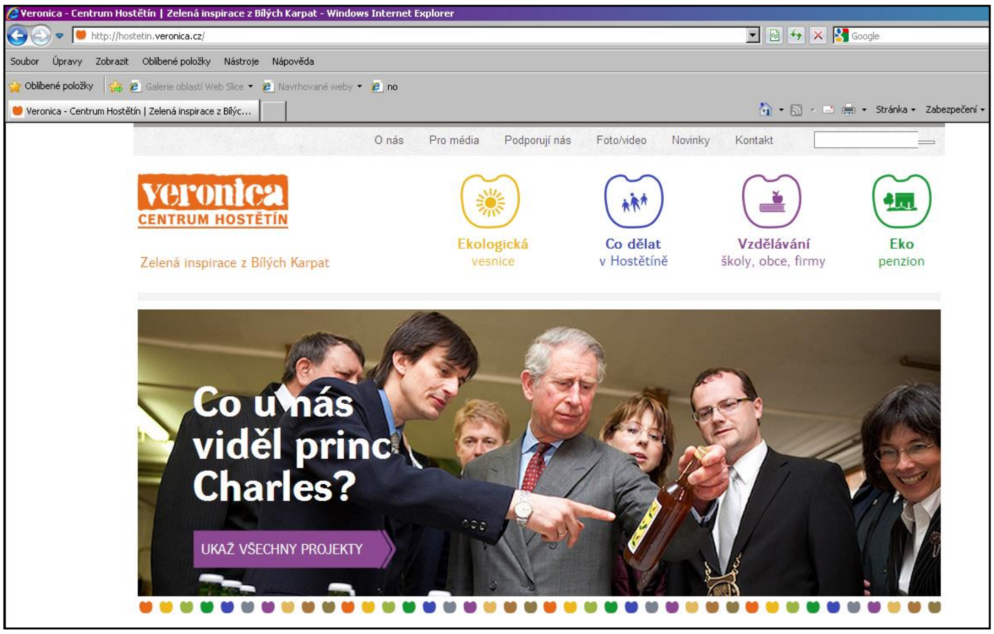


The distribution of the visitors to are the following: pupils and students, members of interest and non-governmental organizations, public administration officers, local authority officers, media professionals and the business community, not including tourism.

Out of about 38,000 registered visitors of the Hostětín ecological centre between 2001 and 2011, there were nearly 36,000 domestic and about 2,500 from abroad, mainly from Slovakia, which is also due to proximity of the state border, and cross-border activities.

Project publicity

A big event for publicity of the Hostětín projects and sustainable development was the visit of Prince Charles. The event has been also used for publicity, e.g. published on the website of the environmental centre (see the following photo)



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List of abbreviations

€	Euro
A, S	Area, Surface area
Al	Aluminium
AOX	Absorbable organic halogens
BOD_5	Biochemical oxygen demand (measured and calculated in 5 days)
BR	Biological reservoir
C, Co	Concentration
Ca	Calcium
Cd	Cadmium
CEE	Central and Eastern European countries
CFU	Colony forming unit
Cl	Chloride
CO_2	Carbon dioxide
COD	Chemical oxygen demand
Cr	Chrome
CSN	Czech technical guidance
Cu	Copper
CW	Constructed wetland
CTW	Constructed treatment wetland
ČSOP	Czech Association of Environmentalists (Český svaz ochránců přírody) – Czech NGO
DN	Nominal diameter of pipe
EU	European Union
FWS	Free water surface flow (filter or CTW)
GWP	Global Water Partnership
H_2O	Water (chemical abbreviation)
H_2S	Hydrogen sulphide
HF	Horizontal flow (filter or CTW)
Hg	Mercury
HRT	Hydraulic retention time
HSSF	Horizontal sub-surface flow (filter or CTW)
IWA	International water association
K	Potassium
lPE	Linear polyethylene (tube, pipe, pipeline)
Mg	Magnesium
N	Nitrogen
NH_3	Ammonia ion
NH_4-N	Ammonia nitrogen
Ni	Nickel
NO_3-N	Nitrate nitrogen
P	Phosphorus
p.e.	Population equivalent
PAH	Polycyclic aromatic hydrocarbons
Pb	Lead
PCB	Polychlorinated biphenyls
PCR-SSCP	Microbial community analysis method
PE	Polyethylene (tube, pipe, pipeline)
PE-H	High density polyethylene (tube, pipe, pipeline)
PP	Polypropylene (tube, pipe, pipeline)
PVC	Polyvinyl chloride (tube, pipe, pipeline)

Q	Flow
SBR	Sequencing batch reactor
SF	Soil filter
SS	Suspended solids
TN	Total nitrogen
TOC	Total organic carbon
TP	Total phosphorus
TW	Treatment wetland
UASB	Upflow anaerobic sludge blanket (reactor)
UV	Ultraviolet radiation
V	Volume
VF	Vertical flow (filter or CTW)
WSP	Waste stabilization pond
WWTP	Wastewater treatment plant
Zn	Zinc
ZO	Basic unit (in this study – of the NGO Veronica)

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Annex 1 – the Hostětín WWTP in pictures

A view of the WWTP – constructed wetland filters and fence area of mechanical pre-treatment stage

A view of the WWTP – constructed wetland filters and fence area of mechanical pre-treatment stage

Water intake structure at the Kolelač creek

Stormwater retention tank (2006): Well-grown vegetation of Typha sp.

Stormwater retention tank

Sand catcher (grid chamber)

Shallow combined settling tank with a lateral sludge digestion compartment

Shallow combined settling tank with a lateral sludge digestion compartment

A dam between second constructed wetland filter and final purification pond


Constructed wetland filter during vegetation period


Elevating of the water surface level within the constructed wetland filter in a spring time

Summer drying of the final purification pond

A view of the final purification pond from the constructed wetland filters


An excess biomass of floating macrophyta (Lemna sp.) during emptying period of the tank


A view of the final purification pond


A view of the final purification pond


Naturally occurred lithoral zone at the right bank of the final purification pond


Naturally occurred lithoral zone at the right bank of the final purification pond


Left bank of the final purification pond

Left bank of the final purification pond and a view of outflow part

Outflow structure – simple half-closed gullet with a simple sluice plank wall

Outflow structure supplemented by floating filtration islands with vegetation (2013)

One-point inflow to the pond close to an edge of its

A view of the final purification pond from the outflow structure point (2006)

A view of the final purification pond from the outflow structure point (2012)

Natural abundance of Iris pseudacorus at the right bank of the final purification pond


The Kolelač creek channel under the WWTP outflow structure (pipeline)