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WASTEWATER TREATMENT IN CONSTRUCTED WETLANDS

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Constructed wetlands are an alternative and economically reasonable way for the wastewater from dispersed development treatment. Existing systems showed that the effectiveness of this treatment is high. The whole treatment process depends on many factors such as time of operation, type of filling, temperature. Constructed wetlands with proper construction and operation are safe for the environment and users.

Keywords: constructed wetlands, hydrophytic wastewater treatment plant

1. INTRODUCTION

Constructed wetlands as a technology of wastewater treatment was developed in Poland from early nineties of the twentieth century, mainly due to low construction cost and maintenance-free operation [9]. The simple design and cost much lower in comparison with conventional construction of wastewater treatment plants resulted in their wide application [11] .

Constructed wetlands is based on many different processes such as sorption, sedimentation, evapotranspiration, chemical properties of wastewater, biological activity of microorganisms and plants (bioaccumulation and biodegradation) [8, 14, 17, 18].

The aim of this paper is a brief discussion of wastewater treatment solutions on constructed wetlands.

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2. THE MECHANISM OF WASTEWATER TREATMENT IN CONSTRUCTED WETLAND

Each wastewater treatment plant should be based on at least two-step purification. The first one should be mechanical f.e. septic tank and the second one – biological [15]. Individual system of wastewater treatment begins in a septic tank. Debris, during the sedimentation process, creates bottoms where facultative and anaerobic bacteria lives. Anaerobic digestion leads to a partial liquefaction of the sediment. As a result of the bacteria more stable organic compounds and gases are formed. Gases from the fermentation are discharged through the ventilation system. Hydrogen sulfide combine with metals contained in the sludge and form insoluble sulphides, which significantly eliminates odors.

This first step in the sewage treatment process in a septic tank takes 2 to 3 days. After this step clarifier effluent with significant decrease content of fat and slurry flow to wetland.

Wastewater treatment in constructed wetland is a biological process that occurs through the involvement of heterotrophic microorganisms and hydrophytes. Porous tissue present in wetland plants supply the reservoir whith atmospheric oxygen, which creates around rhizomes and hydrophytes roots aerobic zones surrounded by anaerobic and anoxic zones [14, 17]. This combination of aerobic and anaerobic zones is settled down with a whole range of various microorganisms. Favorable conditions improve the efficiency and effectiveness of wastewater treatment [17].

3. REQUIREMENTS FOR CONSTRUCTED WETLANDS TREATMENT PLANTS

Hydrophytic treatment plants, due to specifics of their construction, are regulated on three main factors: pollution reduction, location and space.

2.1. Pollution reduction

The maximum values of pollutants at the outlet of the wastewater treatment plant is shown in Table 1. According to Minister of Environment Regulation [6] indicator of pollution, such as BOD_5 must be reduced to 20% and total suspended solids to 50%.

Table 1. The maximum values of pollutants at the outlet of the wastewater treatment plant

Nr.	Indicator, $mg \cdot dm^{-3}$	The maximum allowed value of the indicator for the system below 10,000 PE
1.	BOD_5	40
2.	COD	150

3.	Total suspended solids	50
4.	$N_{tot.}$	30*
5.	$P_{tot.}$	5*

* only in the wastewater discharged directly into lakes and to the artificial water reservoirs

2.2. Location of the septic tank

Location of the septic tank must comply with the conditions defined in [4, 5]:

- it should be located at least 5 meters from the windows and doors fo the inhabited building.
- The tank can be placed in the immediate vicinity of the building, however the venting from the tank will be constructed at least 0.6 meters above the upper edge of the external doors and windows.
- At least 2 meters from the border. It's possible to build it at the border itself, however it must be adjacent to a similar device on a neighboring plot.
- At least 30 m from the wells with drinking water, and 1.5 m from the highest aquifer utility.
- At least 1.5 m of gas pipeline gas.

2.3. The need for space

Area required for the construction of the treatment plant depends on the amount of sewage inflow. Many authors indicate the values from 2 to 20 m^2 for PE [8, 14, 17]. It is assumed that the minimum area requirement for the root system with horizontal flow, is approximately 5 m^2 for PE, which should ensure that the effluent BOD_5 value of 30 $g \cdot m^3$ [16].

2.4. Problems of economic and location

Choosing the right treatment system depends on the type of building and economic aspects. The dispersed development should force the designers and investors to effective, reliable and relatively low-cost technology solutions for the treatment of small quantities of wastewater [12]. Individual sewage treatment systems, the cost of the operation is much lower then in traditional systems and depends on these factors [2]:

- type of wastewater treatment system,
- efficiency of wastewater treatment,
- chemical properties of pollutants.

4. THE CONSTRUCTION OF THE PLANT-SOIL FILTER

The right part of the treatment plant (plant-soil filter) performs several functions [14, 17]:

- it is an environment for the biological treatment processes,

- it is an environment for the development and growth of plants,
- provides a surface for the growth of microorganisms,
- can be a decorative element.

Construction of the tank should be seald. Protection against water infiltration into the soil and ground water can be provide as a seal with an impermeable material such as geomembrane [14].

The minimum thickness of the filter layer should provide free plant growth, however, should not be greater than 1.5 m. The typical thickness of the filter vary from 0.60 to 0.80 m [14].

According to [14] the filter can be divided into the following zones (fig. 1):

- Inflow zone. It's built of stone, Ø 40 to 80 mm, total length of 2 m.
- Zone I - 2 m (30% of the total length of the filter). It is composed of particulate material which the filtration coefficient of 1% of the rate of filtration of pure material.
- Zone II - 4 m (70% of the total length of the filter). It is made of a material having a grain diameter of 20 to 30 mm, the rate of filtration is the filtration rate of 10% pure material.
- Outflow zone , with a length of 1 m. It's built (same as inflow zone) of stone with grain sizes 40 to 80 mm.

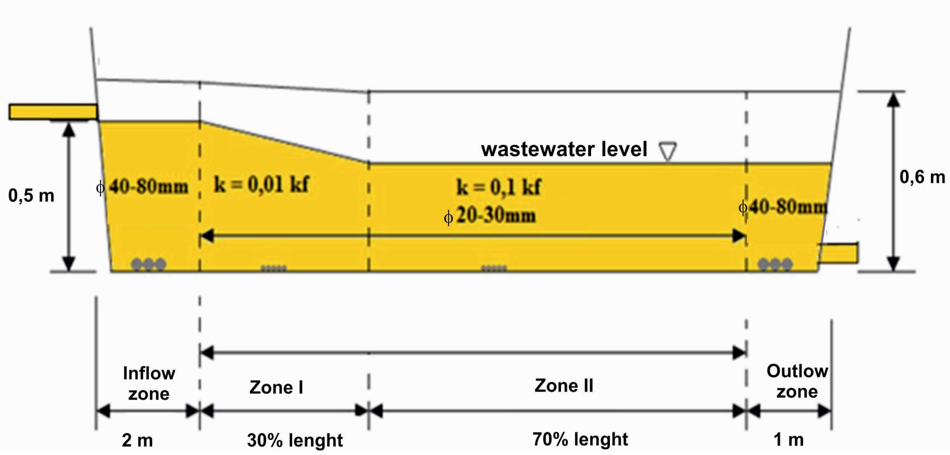

Fig. 1. Selected zones in the constructed wetlands [14]

5. PLANTS

Plants growing on the constructed wetlands are supplied with simple substances by microorganisms. Efficiency of this process reaches 10-15% [17]. In addition to partial assimilation of nutrients, plant also:

- ensure the delivery of oxygen to the microorganisms,
- clears the filter and prevent clogging,
- use water in the process of evapotranspiration.

For soil-plant filter strongly recommended are plants characteristic of wetland ecosystems. They should have the following characteristics:

- vigorous growth throughout the year,
- easily adapt to the environment and climatic conditions,
- resistance to pests,
- developed root system.

The most commonly used plants include *Phragmites australis*, *Glyceria aquatica*, *Typha latifolia*, *Iris pseudoacornus* and *Salix viminalis*.

6. THE EFFICIENCY OF EXISTING SYSTEMS

The efficiency of wastewater treatment systems in constructed wetlands for indicators such as BOD_5 and COD is very high and vary from 80% to 90% [1]. High pollution reduction confirm the publications of other authors [10, 15]:

- BOD_5 - 75 to 97.5 [%]
- COD - 73.2 [%]
- suspended solids - 55 to 83 [%].

Studies carried out in the initial phase of treatment plant (1997-1999) showed average efficiency of BOD_5 and total suspended solid reduction. It was of 60.8% for total suspended solids and 87% for BOD_5 [10]. Decress of the efficiency is the result of the accumulation of organic and inorganic substances in the filter, which reduce water flow and the contact time with the biofilm [7]. Clogging phenomenon does not occur as often in filters filled with gravel, in which the removal efficiency of organic matter is stable in the first years of life [3].

Better effects of pollution reduction can be achived if the vegetation will not be truncated before winter. Plants will form a layer of thermal insulation and space for bacterial flora growing on macrophytes root system [13, 12].

7. CONCLUSIONS

Based on the presented results it can be concluded that:

- hydrophytic wastewater treatment plant for at least 10 years of service, ensure the removal of organic matter from wastewater at the required level.
- The effectiveness of the wetlands systems decreases with time. This is due to clogging of the filter.

– Due to the high demand of the area this solution is recommended to the stand-alone buildings, inhabited by a small number of residents.

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OCZYSZCZANIE ŚCIEKÓW W OCZYSZCZALNI HYDROFITOWEJ

S t r e s z c z e n i e

Oczyszczalnie hydrofitowe są alternatywnym i ekonomicznie uzasadnionym, sposobem na oczyszczanie ścieków pochodzących z zabudowań charakterze rozproszonym. Literatura oraz badania istniejących systemów ze złożem gruntowo roślinnym pokazują, że skuteczność oczyszczania ścieków jest wysoka. Na skuteczność wpływa wiele czynników tj.czasu eksploatacji, rodzaju wypełnienia złoża, temperatury. Hydrofitowe oczyszczalnie ścieków przy odpowiedniej budowie i eksploatacji są bezpieczne dla środowiska oraz użytkowników.