

Ročník 6.

2003

Mimoriadne číslo

# Acta horticulturae et regionotecturae

◆ ENVIRO Nitra 2002

◆ Zborník vedeckých prác

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Acta horticulturae et regiotelecturae – Mimoriadne číslo  
Nitra, Slovaca Universitas Agriculturae Nitriae, 2003, s. 96–98

## STRUCTURE OF COSTS OF CONSTRUCTION AND EXPLOITATION OF SMALL HOUSE WASTE WATER TREATMENT PLANTS

### ŠTRUKTÚRA NÁKLADOV NA VÝSTAVBU A PREVÁDZKU MALÝCH DOMOVÝCH ČISTIARNÍ ODPADOVÝCH VŮD

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The purpose of the paper was to analyse the structure of the construction and operational costs of the small house wastewater treatment plants, utilized presently in Poland. 15 typical alternative designs offered by 9 Polish and foreign firms were analysed. The highest participation in investments spent on the house wastewater treatment plants oscillating from 44-92% of the analysed costs use the devices. Their significant diversification results from various technological advances of the applied solutions.

**Key words:** small house wastewater treatment plants, investment expenditures, operational costs

Rural areas present a dispersed development system. The distances between farms measure from tens to more meters. The situation creates more favourable conditions for introducing technical systems of individual sanitation, properly selected in respect of suitable technical parameters rather than collective sewage systems. The investor will find it basic to choose proper installations also in categories of economy (Błażejowski, 1998).

Table 1 Yearly operational costs of household sewage treatment plant

No.	Sewage treatment plant name	Yearly exploitation costs (EURO)		
		Sludge disposal distance		
		5 km	10 km	15 km
1	Ecopart FG6	12	16	20
2	Wobet – Hydret	12	16	20
3	Sebico	18	24	30
4	Puriflo	12	16	20
5	Sotralentz – dreňaz rozsączający	12	16	20
6	Nevepox	18	24	30
7	Sotralentz – złoże biologiczne	12	16	20
8	MB/TK-4	39	41	43
9	Bio – Clear 8/2-20	22	24	28
10	Miniflo	133	137	141
11	BIOK-4	18	21	24
12	BD-5-Polaris	59	71	83
13	Turbojet EP-1	59	66	73
14	Compact FA 1	56	64	70

Tabuľka 1 Ročné prevádzkové náklady (náklady na vývoz čistiarenskeho kalu a náklady na elektrickú energiu) ocenené pre analyzované malé domové čistiarnie odpadových vôd pre 5 ekvivalentných obyvateľov

## Material and Methods

The purpose of the paper was to analyse the structure of the construction and exploitation costs of the small house wastewater treatment plants, utilized presently in Poland. 15 typical alternative designs offered by 9 Polish and foreign firms were analysed. The objects in focus are systems consisting of chapter tank and installations of the second stage of purification such as: leachlines, activated sludge chambers and biofilters (sprinkled, immersed, circular).

The paper was based on the data obtained from Polish distributors of the installations of foreign firms or agents of Polish producers. The paper also uses the Department's own calculations of costs (1 Euro = 3.80 PLN) according to average prices and rates in force in the first three months of 2002. The calculations were carried out for a 5 - persons mousehold family living in one farm and utilizing the same type of installations. Optimum soil - water conditions were accepted for founding a system of wastewater treatment.

Investment expenditure included the costs of: the technical project, installations, transportation and assembly. The costs of removal of sludge from chapter tanks, as well as consumption of electrical energy were subjected to the analysis within the frame of operational costs.

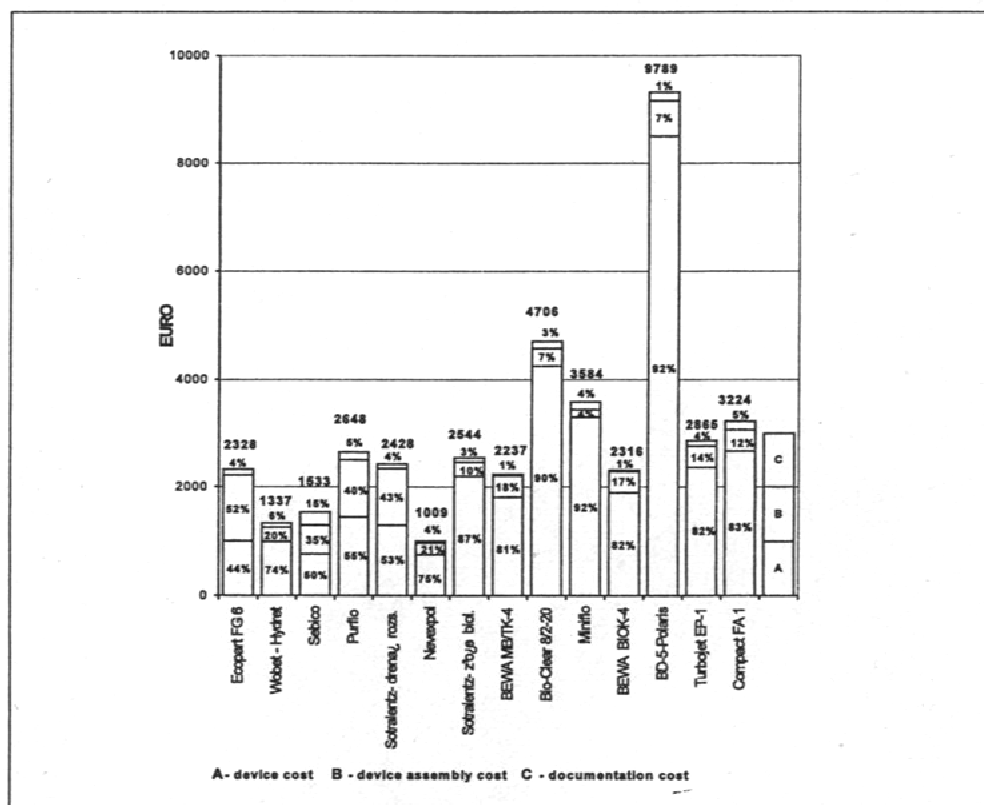
## Results and Discussion

### Investment expenses

The analysis proved that the costs of developing a project documentation are significantly varied. The cheapest set of documents (26 EURO) is offered by Bewa firm for plants with biofilters: sprinkled or immersed. Whereas the most expensive documentation (237 EURO) is the set offered by the Delfin firm accompanying Sebico treatment plant construction project. The plant operates on the basis of chapter tank and leachline. The

Figure 1 Financial expenditure (transportation excluded) necessary to construct a house wastewater treatment plant in the alternative for a five – persons household

Obrázok 1 Investičné náklady (bez transportu) na výstavbu malej domovej čistiarne odpadových vôd pre 5-člennú domácnosť



average cost of the project documentation for the construction of a small house wastewater treatment plants equals to 108 EURO.

The costs of the analysed alternative installations, suitable for a 5 – persons household are also significantly varied. The cheapest systems consist of a chapter tank and leachline produced by Nevexpol (760 EURO). On the other hand, the more expensive solutions are the plants in which activated sludge or biofilters constitute the biological part. They are advanced technology solutions which provide a high level of pollutants reduction. The most expensive is the plant of BD-5 Polaris type produced by Halson operating on circular filter and its price amounts to 8973 EURO. The averaged cost of the analysed alternatives reaches 2412 EURO. The transportation cost is the higher, the longer the distance is. Mean rate per 1 km is 0.50 EURO. This component has been left out in the carried out analysis since the transportation cost is not a meaningful position.

Calculating the expense of installing the respective alternatives of the plants was possible owing to the assumption the construction takes place in optimum soil – water conditions. The costs of the installation of the purifying equipment are significantly varied and oscillate from 131 to 1210 EURO. The highest assembly costs correspond to the plants produced by: Ecopartner (1210 EURO), Dalon (1052 EURO) and JPR System (1052 EURO). They are the systems which combine the chapter tank with leachline. High costs of installations are

understandable, especially due to high labour demand connected with the filter assembling. It comprises digging ditches, spreading aggregate, placing pipelines with a proper downgrade, covering drains with aggregate and a layer of geocloth. The price of the aggregate should also be included in the cost of assembling. The installation of the Ecopart FG 6 plant was calculated at 895 EURO and the cost of aggregate reached 316 EURO. On the other hand, the cheapest offer (131 EURO) was presented by JPR – System firm, which produced Miniflo type plant with an immersed biofilter.

The total investment expenses spent on the construction of the analyzed alternatives of small house wastewater treatment plants, including the discussed cost components are shown in Fig. 1. The costs of the undertaking, excluding the transportation expenses, are significantly varied and oscillate from 1009 to 9789 EURO. The presented data show that the cost of the installations themselves is the highest. Their share in the total cost amounts from 44 to 92%. The other most meaningful component of the undertaking is the cost of assembling which ranges from 42 to 52%. The remaining part of the cost within 1–6% and in only one case 15%, is the cost of the project documentation for the alternative solutions.

#### Operational costs of the installations

The costs of both removal of the sludge concentrated in chapter tanks and energy consumption in the model solutions in which

biological sewage treatment takes place utilizing biological filters or activated sludge installations (Bykowski et al., 2001).

Disposal expenses are dependent upon the number of users of the plant, the volume of the sanitation vehicle tank and the distance between the plant and the disposal site.

To evaluate the operational costs of the house wastewater plants, the basic problem that appears is a supposed frequency of sludge removal from the primary tanks. The relevant literature (Heidrich, 1998; Wierzbicki et al., 2000) presents an opinion that the sludge should be removed in the period between 12 and 24 months. The estimations accept the opinion that a single 24-hour production of sludge equals to 0.65 dm<sup>3</sup> per capita and assumption that the sludge will be removed after the activated tank sludge has been filled up to 50%. Usually 90% of the sludge is removed; to enable proper operation of the plant 10% of the tank sludge content should be left. On the basis of the amount of the sludge produced per year in a five-persons household home (0.65 dm<sup>3</sup>/Md × 5 m × 365 d = 1 186.25 dm<sup>3</sup> = 1.186 m<sup>3</sup>), as well as volume of primary tanks applied in respective systems of wastewater treatment, it was accepted that sludge is taken away in a vehicle tank of 4.5 m<sup>3</sup> volume. It was also assumed that the distance of the disposal site measures respectively 5, 10 or 15 kilometers. The highest level of the discussed costs (63 EURO) was calculated for BD-5-Polaris in which the smallest container of 0.95 m<sup>3</sup> was utilized for removing the sludge 15 kilometers away. The lowest value of annual removal costs (6 EURO) was obtained for the MB/TK - 4 system applying the tank of 6 m<sup>3</sup> volume and removal distance of 5 kilometers.

A significant factor of exploitation costs is the electrical energy consumption. The highest consumption is observed in Miniflo plant with biofilter produced by JPR System. The calculated annual cost for the plant reaches 121 EURO. The lowest energy consuming solution is BLOK - 4 plant produced by Bewa; the annual energy consumption is 124 kWh (0.34 kWh/d × 365 d), and the cost per annum = 9 EURO. The cost of electrical energy is a meaningful share in the total exploitation cost. It was calculated it oscillates between 24%, for the BD-5 Polaris, to 91%, for the above mentioned Miniflo system.

Table 1 presents operational costs of individual sanitation systems, incurred annually, constituting the sum of sludge removal and transportation, as well as energy expenditure. The table shows that the highest annual exploitation costs (133-141 EURO) are connected with the Miniflo plant, produced by JPR System. They result mainly from a very high consumption of energy, which represents 90% of the total costs. The lowest costs, reaching 12 EURO (5 kilometers distance of sludge disposal site), are incurred while operating the systems such as Ecopart FG6, Wobet - Hydret, Purflo, Sotralentz. Their common feature is lack of necessity of electrical energy consumption, and the amount results exclusively from the costs of sludge removal, gathered in the sludge tank of 3 m<sup>3</sup> volume.

### Conclusions

On the basis of the analysis carried out for 14 systems of small house wastewater treatment plants, meant for a 5 - persons household in optimum soil - water conditions, the following conclusions were built:

1. The highest participation in investments spent on the house wastewater treatment plants oscillating from 44 to 92% of the analysed costs use the devices. Their significant diversification results from various technological advancement of the applied solutions. The cheapest

installations characterize the Nevexpol plant with leachline. The most expensive plant is BD-5-Polaris produced by Halson, working on filter

2. Annual sludge transportation costs depend to a high degree on the volume of the chapter or primary tank and the distance of the disposal place. They are the higher, the more frequent the necessity of emptying the tank is (the lower the volume and the further the disposal site). The highest value of the costs (63 EURO) was for the BD-5-Polaris with the smallest tank (0.95 m<sup>3</sup>) and the 15 kilometers distant disposal site. The lowest annual costs value of the sludge disposal (6 EURO) corresponded to MB/TK- 4 system utilizing the tank of 6 m<sup>3</sup> and 5 kilometers distant disposal site.
3. The cost of electrical energy is a significant element in the annual costs of exploitation of house wastewater treatment plants. The lowest energy consumption was performed by BLOK-4 biological plant with sprinkling filter produced by Bewa (124 kWh/year) and the highest - Miniflo plant with the immersed biofilter produced by JPR System (1642 kWh/year).

The highest annual operational costs (from 507 PLN to 536 PLN) were calculated for Miniflo produced by JPR System. They result mainly from the high-energy consumption; its cost reaches 90% of the total operational cost.

### Súhrn

V príspevku je znázornená analýza štruktúry nákladov na výstavbu a prevádzku malých domových čistiarň odpadových vôd, ktoré sa v súčasnosti využívajú v Poľsku. Výskum zahŕňal 14 typických variantov zariadení ponúkaných poľskými a zahraničnými firmami. Na základe analýzy dostupných dát možno konštatovať, že v investičných nákladoch na malé domové čistiarne odpadových vôd majú najväčší podiel náklady na technologické zariadenia, ktoré tvoria od 44 do 92% celkových nákladov. V nákladoch na prevádzku za 1 rok sú najpodstatnejšou zložkou náklady na energiu.

**Kľúčové slová:** malé čistiarne odpadových vôd, investičné náklady, prevádzkové náklady

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