Analysis of domestic sewage treatment system

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Introduction

Industrial growth, as well as development of rural and urban areas contribute to an increased amount of generated wastewater that must be treated in order to avoid negative environmental impact, especially on contamination of soil and water [1, 2]. Maintaining the proper sanitary state forms and foundations for the improvement of life quality and comfort of inhabitants – this can be supported by devices providing wastewater disposal and neutralization [3]. Transport and treatment of domestic wastewater from rural areas (dispersed, moderately dense buildings) requires application of different techniques than ones applied in towns and cities. In case of rural areas, one has to take into account various environmental, economic and social limitations that result from the existing infrastructure [4].

Every year new solutions emerge allowing more effective sewage treatment. One of the interesting solutions for households, where it is impossible to connect to collective sewage system, is a household biological wastewater treatment system BioPura by Kingspan. This solution is intended for domestic wastewater treatment in accordance with the requirements of standard (PN-EN 12566–3+A2:2013). The innovation of this technology lies in the application of moving biofilters (polypropylene profiles) presented in Figure 1.

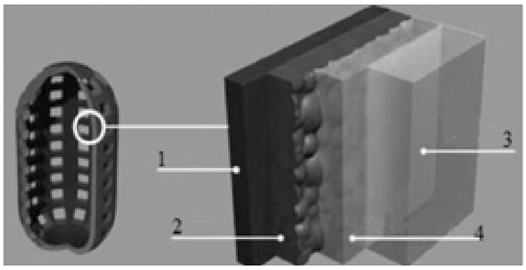

Fig. 1. Biological substrate cross-section [5]: 1– substrate, 2– biomass, 3– flowing water layer, 4– still liquid layer

Household biological wastewater treatment system BioPura has simple design and simple operating principle. Figures 2 and 3 present its design. The operation of the system involves raw wastewater flowing intoprimary settling tank, where particulates settle and aggregate forming a sludge that should be removed periodically. While the lighter particles float on the surface. Cleared wastewater passes to aerobic treatment section. In the 1st aerobic zone, oxygen flowing into through diffusers to biofilter – polypropylene profiles, helps to develop biological film (system of aerobic bacteria that remove organic compounds from the wastewater).

Then the wastewater passes to the 2nd part of the aerobic chamber, where secondary treatment occurs. The last stage is inflow of the wastewater to the secondary settling tank. Dead biological film is cyclically recirculated from the secondary settling tank to the primary one [5, 6].

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Biological wastewater treatment system BioPura is reliable, tight and cost-effective solution. Cost-effectiveness plays here an important role, as the system has low electricity consumption – 0.52 kWh/day. This type of wastewater treatment systems is usually used in 4–10 person households [6].

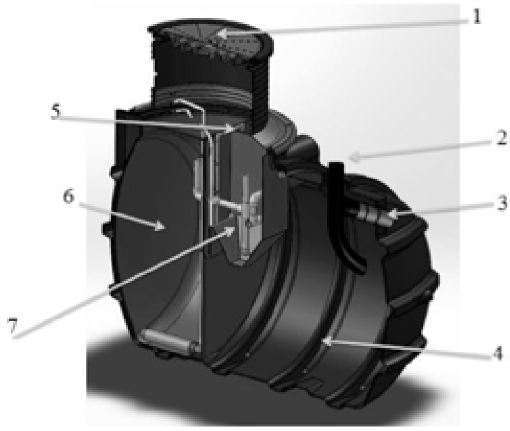

Fig. 2. Design of biological wastewater system (BioPura) [7]: 1– plastic cover, 2– venting, 3- wastewater inflow, 4– primary settling tanks, 5– sludge recirculation, 6– one of two aerobic treatment zones, 7– secondary settling tank

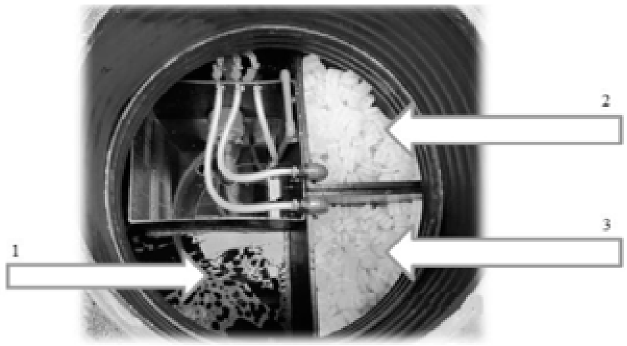

Fig. 3. Household biological wastewater system (BioPura) – view from above [6]: 1–access to the primary settling tank (from where once a year excessive sludge shall be removed), 2 –1st aerobic zone with biofilter, 3– 2nd aerobic zone with biofilter

Study methodology

In order to assess operation of the household biological wastewater treatment system, a system operating at single family house inhabited by 4 persons and located in the rural area was analyzed. This system has been in constant operation for 3 years.

The studies involved treated wastewater. Sludge samples were collected in accordance with the requirements of PN-ISO 5667–10:1997. The analyses involved the following contamination indicators determined in accordance with the applicable standards:

- pH – potentiometric method, acc. to PN-90/C-04540/01,
- BOD_5 – titration method, acc. to PN-EN 1899–1:1998,
- total suspended matter – gravimetric method, acc. to PN-EN 872:2005,
- chlorides – titration method, acc. to PN-EN 9297:1994,
- nitrate nitrogen – photometric method using multi-parameter

photometer Hanna Hi 83200 (converting nitrates to nitrate nitrogen according to the Regulation of the Ministry of Environment of 23rd December 2002 on the criteria for designation of waters sensitive to pollution by nitrogen compounds from agricultural sources).

- sulphates – titration method, acc. to [2],
- heavy metal content (Cd, Pb, Cu, Zn, Cr, Ni) by means of flame atomic absorption spectrometry (ASA) using atomic absorption spectrometer – Solaar 6M by Thermo.

Result discussion

In order to assess the effectiveness of wastewater treatment using the selected technology it was compared to other commercially available system, as presented in Table 1.

Table 1

Comparison of various technologies of household biological wastewater treatment systems in terms of wastewater treatment effectiveness and electricity consumption

Domestic biological sewage treatment plant						
Firm		**Kingspan**	**Ekopol**		**Bioires**	**Eko-Sum**
Model		**BioPura**	**Bio-Hybryda 2500**	**Bio-Hybryda 4000**	**Traidenis NV-1**	**Bio Hero 2,000**
		[5]	**[8]**	**[8]**	**[9]**	**[10]**
Wastewater treatment effectiveness, %	COD	90.6	86	86	84	94
	BOD_5	94.4	97	97	92.4	98
	Suspended matter	92.7	92	92	91	95
Electricity consumption, kWh/day		0.52	0.6	0.9	1.44	0.96

According to the manufacturer data, the discussed technology has high wastewater treatment parameters. For all determined properties the manufacturer declares treatment effectiveness over 90%. Only solution offered by Eco-Sum – Bio Hero 2000 provides higher wastewater effectiveness by 2.3% for suspended matter, 3.4% for COD and 3.6% for BOD_5 in comparison to BioPura. Household biological wastewater treatment system BioPura has the lowest electricity consumption in comparison with other presented system and based on the manufacturer data it may be concluded that is one the most effective technologies available on the market.

The analysis of own test results of treated wastewater in comparison to values given by the manufacturer and acceptable parameters according to [11] are presented in Table 2.

Table 2

Physical and chemical parameters of treated wastewater in comparison to values provided by the manufacturer and allowable values

Contamination indicator	Unit	Values given by the manufacturer [5]	Mean values	Limit values [11]
pH	-	-	7.56	6.5–9.0
Nitrate nitrogen	mg NNO_3/dm^3	-	3.01	30
Chlorides	mg Cl/dm^3	-	611.39	1,000
Suspended matter	mg/dm^3	27	< 2.00	50
Sulphates	$mgSO_4/dm^3$	-	262.25	500
BOD_5	mgO_2/dm^3	20	2.15	40
Ammonium nitrogen	mgN_{NH4}/dm^3	0.4	-	10
COD	mgO_2/dm^3	67	-	150

The results of conducted determinations of physico-chemical parameters are within the limits of acceptable values specified in the Regulation of the Ministry of Environment of 18th November 2014 on the conditions to be met for the introduction of sewage into the water or soil and on substances particularly harmful to the aquatic environment. The lowest values were found for total suspended matter, nitrate nitrogen and BOD_5. Nitrate nitrogen content was almost ten times lower than allowable value. Content of chlorides and sulphates in treated wastewater were above half of the acceptable limit acc. to [11]. The results obtained by BioPura system indicated by the manufacturer acc. to [5] are in the limits of acceptable values specified in the Regulation of the Ministry of Environment of 18th November 2014 and are higher than parameters obtained from physicochemical analysis.

The determinations of heavy metals in the treated wastewater are presented in Table 3 and in the sludge in Table 4.

Table 3

Heavy metals content in the treated wastewater

Heavy metals, mg/dm^3	Mean values	Limit values [11]
Cd	<0.005	0.4
Pb	0.093	0.5
Cu	0.046	0.5
Zn	0.220	2.0
Ni	0.036	0.5
Cr	0.012	0.1

The content of all the tested heavy metals in the treated wastewater are not only within the limits of acceptable values specified in the Regulation of the Ministry of Environment of 18th November 2014 on the conditions to be met for the introduction of sewage into the water or soil and on substances particularly harmful to the aquatic environment, but are in the lower range. In the treated wastewater the highest values were obtained for zinc and lead. Whereas, trace quantities of cadmium and chromium were found.

The comparison of heavy metals content in sludge (Tab. 4) shows that it does not exceed limit values specified in the Regulation of the Ministry of Environment of 6th February 2015 on municipal sewage sludge.

Table 4

Heavy metals content in sludge

Heavy metals, $mg/kg_{dry\ mass}$	Mean values	Limit values [12]		
Cd	5.3	20[1]	25[2]	50[3]
Pb	14.0	750[1]	1,000[2]	1,500[3]
Cu	209.4	1,000[1]	1,200[2]	2,000[3]
Zn	586.0	2,500[1]	3,500[2]	5,000[3]
Ni	9.0	300[1]	400[2]	500[3]
Cr	11.0	500[1]	1,000[2]	2,500[3]

Heavy metals content in mg/kg of sludge dry mass not higher than for use of municipal sewage sludge:
[1] – in agriculture and land reclamation for agricultural purposes,
[2] – for land reclamation for non-agricultural purposes,
[3] – for adaptation of land for specific purposes resulting from waste management plans, spatial development plans or zoning and land development decisions, for cultivation of plants for compost production, for cultivation of plants not intended for consumption or production of animal feed

The low content of heavy metals in the sludge allows its application even in agriculture and for land reclamation for both agricultural and other than agricultural purposes.

In conclusion, it may be stated that household sewage treatment system – BioPura allows effective treatment of sewage from the households in the rural areas, where it is impossible to use collective sewage systems. The conducted physical and chemical analysis and comparison of parameters confirm that the treated wastewater is environmentally safe and the obtained sludge can be widely used.

Summary

Domestic biological sewage treatment plants more and more often replace the classical solutions in form of septic tanks. They are usually used if it is not possible to use collective sewage system in the area with dispersed buildings. Among commercially available technologies, solution by Kingspan stands out. Many advantages such as robust design, simple operation mechanism and first of all high treatment efficiency and low electricity consumption make such wastewater treatment systems are of great interest. The conducted tests of physicochemical parameters show that tested parameters of treated wastewater are within the allowable limits specified in relevant Regulations of the Ministry of Environment. The conducted analysis has confirmed that this solution is environmentally safe.

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12. Rozporządzenie Ministra Środowiska z dnia 6 lutego 2015 roku w sprawie komunalnych osadów ściekowych (Dz.U. 2015 poz. 257).

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35. nowych Liderów

35. naukowców otrzyma łącznie ponad 39 mln PLN w konkursie Lider, którego siódmą edycję rozstrzygnęło Narodowe Centrum Badań i Rozwoju. Za otrzymane finansowanie laureaci będą mogli realizować swoje innowacyjne projekty i zarządzać własnym zespołem badawczym. Celem programu Lider jest aktywizacja środowiska młodych naukowców i wspieranie ich rozwoju. Udział w programie daje im wyjątkową szansę, by prowadzić własny projekt badawczy i zarządzać zespołem naukowców. Jednocześnie program stymuluje współpracę młodych naukowców z przedsiębiorstwami, a także mobilność uczonych wewnątrz sektora nauki oraz pomiędzy nauką i przemysłem.

W tegorocznej edycji przyznano środki m.in. na pracę nad szczepionką przeciwko wirusowi Zika; przygotowanie przetworów z karpia o charakterze prozdrowotnym; platformę wspomagającą wytwarzanie oraz utrzymanie systemów Internetu Rzeczy; przenośne mikrourządzenie do szybkiego i specyficznego wykrywania białek oraz fragmentów kwasów nukleinowych. Najwyższe dofinansowanie sięgające 1,2 mln PLN otrzymało pięciu laureatów: Łukasz Pieczonka oraz Piotr Boryło z Akademii Górniczo-Hutniczej im. S. Staszica w Krakowie; Marcin Gołębiewski ze Szkoły Głównej Gospodarstwa Wiejskiego; Michał Silarski z Uniwersytetu Jagiellońskiego; Łukasz Rąbalski z Uniwersytetu Gdańskiego. *(kk)*

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Znamy laureatów II edycji ADAMED SmartUP

Blisko 3 500 zarejestrowanych uczestników, 14 wyjątkowych naukowych zagadek i 50. uczestników innowacyjnego obozu naukowego – te liczby najlepiej obrazują sukces drugiej edycji programu naukowego ADAMED SmartUP. 12 września br., podczas uroczystej gali w warszawskim Centrum Nauki Kopernik zaprezentowano dziesięcioro tegorocznych laureatów programu, a są to: Agata Janczak, Jaromir Hunia, Milena Malcharek, Mateusz Wawrzeńczyk, Maria Michna, Maciej Draguła, Wiktor Czepczyński, Jakub Wornbard, Jakub Dranczewski i Małgorzata Róg. Zwycięzcy ADAMED SmartUP objęci zostaną programem indywidualnych konsultacji edukacyjnych, w ramach których znakomici polscy i zagraniczni eksperci oraz naukowcy opracują, a także poprowadzą dla każdego z uczniów indywidualny program zajęć dostosowany do możliwości, potrzeb i aspiracji laureatów. Nagrody wręczyli przedstawiciele Rady Naukowej Programu, a wśród gości znaleźli się reprezentanci najlepszych polskich uczelni wyższych, przedstawiciele rządu, biznesu oraz edukacji. *(kk)*

(*http://adamed.com.pl/, 13.09.2016*)

Dokończenie na stronie 629