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THE PROJECT OF A RESEARCH STATION FOR BIOLOGICAL INACTIVATION SYSTEM OF DOMESTIC SEWAGE WITH EXHAUST GASES FROM THE DIESEL ENGINE

Summary

Domestic sewage from unsewered scattered areas presents high environmental risk. Due to the high cost of transporting sewage to the municipal sewage treatment plants, the households try to solve the problem in another way, which is very often dangerous to the nature. Polish legislation authorizes the use of domestic sewage as an organic fertilizer in agriculture, once the proper parameters, mainly sanitary ones, have been reached. The main hazards in sewage include Salmonella bacteria and the eggs of intestinal parasites. That is why in the Institute of Biosystems Engineering at the University of Life Science in Poznań research works are carried out on biological inactivation of domestic sewage by means of exhaust gases from the diesel engine. Liquid or semi-liquid substances of animal origin may also be treated in a similar way. In order to carry out laboratory-scale studies, the project was developed along with the test model for domestic sewage inactivation, and then a full research station was created.
***Key words**: domestic sewage, inactivation of domestic sewage, sewage management, unsewered areas, exhaust gases*

PROJEKT STANOWISKA BADAWCZEGO SYSTEMU INAKTYWACJI BIOLOGICZNEJ ŚCIEKÓW BYTOWYCH GAZAMI SPALINOWYMI Z SILNIKA WYSOKOPRĘŻNEGO

Streszczenie

Ścieki bytowe z nieskanalizowanych terenów rozproszonych stanowią duże zagrożenie dla środowiska. Gospodarstwa domowe z uwagi na koszty związane z ich transportem do miejskiej oczyszczalni ścieków próbują rozwiązać problem w inny, często zagrażający przyrodzie sposób. Ustawodawstwo polskie dopuszcza stosowanie ścieków bytowych jako nawóz organiczny w rolnictwie, po osiągnięciu odpowiednich parametrów, przede wszystkim sanitarnych. Do głównych zagrożeń występujących w ściekach bytowych zalicza się bakterie z rodzaju Salmonella oraz jaja pasożytów jelitowych. Dlatego w Instytucie Inżynierii Biosystemów Uniwersytetu Przyrodniczego w Poznaniu trwają prace nad metodą inaktywacji biologicznej ścieków bytowych przy pomocy gazów spalinowych z silnika wysokoprężnego. Podobnym zabiegom mogą być poddawane również substancje płynne lub półpłynne pochodzenia zwierzęcego. W celu przeprowadzania badań w skali laboratoryjnej powstał projekt wraz z modelem stanowiska badawczego do inaktywacji ścieków bytowych, a następnie całe stanowisko badawcze.
***Słowa kluczowe**: ścieki bytowe, inaktywacja ścieków bytowych, zagospodarowanie ścieków, tereny nieskanalizowane, gazy spalinowe*

1. Introduction

Domestic sewage produced in unsewered scattered areas is a very high environmental risk. The problem became more apparent in the seventies of the 20th century. On the one hand the amount of domestic sewage discharged from individual households and habitats has increased considerably, on the other hand the chemical composition of the sewage changed at that time. The increase in domestic sewage discharges is directly related to the launch of sewage systems in rural areas and the development of tourism Whereas, the change in chemical composition of domestic sewage results from widespread introduction of new washing powders at that time. In order to soften the water another component was used namely sodium phosphate instead of soap. Later widespread use of dishwashing liquids and shampoos was another reason for the change in chemical composition of domestic sewage [16]. The sewage produced in agricultural rural areas often goes directly into the environment. The studies on non-domestic sewage management was presented by Osuch et al. [12] in the paper on occupational health and safety in the use of mineral fertilizers. In the literature you can also find information on leaking septic tanks [16]. In the Institute of Biosystems Engineering at the University of Life Science in Poznań, the research was started on the biological inactivation of domestic sewage by means of exhaust gases from the diesel engine. The research carried out by the research team was conducted on a specially modernized agricultural sanitation trailer and thanks to the support from the Voivodeship Fund for Environmental Protection and Water Management in Poznan, it confirmed the hypothesis that diesel exhaust gases can contribute to the hygenisation of domestic sewage. The hygenisation of domestic sewage and giving it a fertilizer value will contribute to its introduction on the fertilizer market, which will lead to the improvement of the environment, and in particular, the protection of local water bodies, thanks to stopping the discharge of raw sewage directly into the environment [16]. The studies on the protection of water resources and lake reclamation are described in detail in the literature [8, 9, 10, 11, 13, 14, 15]. While sewage from the urbanized areas caused mainly the degradation of rivers and the Baltic sea, sewage from rural areas caused the degradation of local watercourses and especially lakes [4]. When phosphates appeared in rural domestic sewage, they were scoured off from fertilized fields together with phosphorus compounds and they flowed into the surface water and accelerated the eutrophication of our lakes [3, 14].

It is worth mentioning that only about 3,8% of Polish lakes can be classified as first class water purity [17], and the deterioration of the purity is due to the fact that there are more phosphorus and sulfur compounds supplied to the hypolimnion [5, 6, 7]. It should be added that according to the data of communal infrastructure published by GUS in 2015 only 68,7% of the population used the sewage network, and about 906 hm^3 of sewage were discharged from households, and most of it , because 88% was the sewage from urban areas. Based on the population of 2014 living in cities (about 23,2 million) and in villages (over 15,2 million), it can be estimated that population living in the rural areas can produce about 524 hm^3 of domestic sewage, and only 106 hm^3 of it were discharged through the sewage network [1, 2]. Any actions influencing the global improvement of environmental conditions are strongly advised.

2. The purpose, the scope and the methodology of research

The aim of the study was to develop a project of a research station for the inactivation of domestic sewage. Undoubtedly, it was important to preserve the parameters of the constructed model which corresponded and reflected the actual modernized agricultural sanitation trailer, which is used to conduct macroscale research. The built model had to meet all the assumptions of the developed inactivation sewage system.

3. The results and the research analysis

The analysis conducted in the introduction proves the need to introduce appropriate methods of safe handling of domestic sewage in unsewered scattered areas. Due to the fact that a complete cut off of raw sewage flow into the land and surface water is organizationally very difficult (leaking septic tanks, high cost of sewage discharge to the local sewage treatment plant), in 2013 a research on safe use of domestic sewage to fertilize the fields started. It was considered that the easiest and the safest way to eliminate the biogens is to disperse them in the environment, which also has measurable fertilizer benefits. Figure 1 shows the adapter kit for the inactivation of domestic sewage used in field tests. Based on this a project model was created for conducting research and analysis in laboratory conditions.

Conducting the research on the agricultural sanitation trailer requires obtaining a large amount of domestic sewage for testing, because the capacity of the inactivation chamber is $6m^3$, and for the purpose of tests the tank should be filled up to at least 75%, so that the analysis of the domestic sewage samples and fertilized soil can be carried out after different periods of gasification. Due to the fact that there was a need for more analysis, there was a problem of accessing domestic sewage of specified parameters (contamination with salmonella and eggs of intestinal parasites). At that time it was decided that some of the analyses would be conducted on a smaller scale with the help of a station designed for such tests. The model in the constructional aspect had to match the technical parameters of the modernized sanitation trailer. It has been assumed that the capacity of the inactivation chamber of the research station cannot be less than 0,8 m^3 and more than 1 m^3. As a result a cylindrical structure was developed with the length of 0,8 m and the diameter of 0,36 m. Therefore the total capacity is about 0,8 m^3. Figures 2, 3 and 4 present the designed model of the research station while conducting the research on the inactivation of domestic sewage.

Source: own work / Źródło: opracowanie własne

Fig. 1. Adapted kit used for biological inactivation of domestic sewage used in field tests
Rys. 1. Zastosowany w badaniach polowych przystosowany zestaw do biologicznej inaktywacji ścieków bytowych

Source: own work / Źródło: opracowanie własne

Fig. 2. Research station for the inactivation of domestic sewage
Rys. 2. Stanowisko badawcze do inaktywacji ścieków bytowych

Source: own work / Źródło: opracowanie własne

Fig. 3. Research station for the inactivation of domestic sewage
Rys. 3. Stanowisko badawcze do inaktywacji ścieków bytowych

Source: own work / Źródło: opracowanie własne

Fig. 4. Research station for the inactivation of domestic sewage
Rys. 4. Stanowisko badawcze do inaktywacji ścieków bytowych

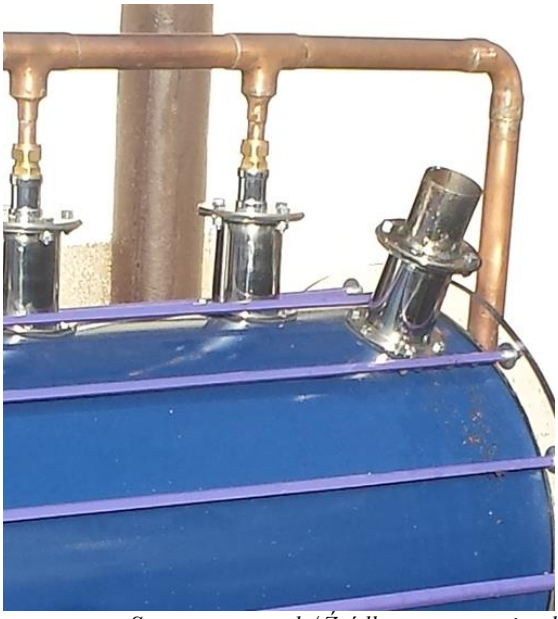
Both bases of the cylinder of the inactivation chamber are made of transparent material - it is essential for the observation of the processes taking place inside the chamber. Apart from the chamber the model is also equipped with drain ball valve. This valve is used to sample the test material and to discharge the contents of the chamber after the work is finished. The set also consists of the diesel engine with the maximum power of 4,27 KW. The capacity of the combustion chamber is 296 cm^3, and the engine revolutions at maximum power are 3600 rpm. In order to limit the transfer of the vibration from the engine to the inactivation chamber, a flexible connection between the engine exhaust pipe and the coil pipe distributing the exhaust gases inside the chamber is used. Pulverizers placed inside the inactivation chamber are the most important elements of the research station.

Source: own work / Źródło: opracowanie własne

Fig. 5. Placement of the pulverizers in the inactivation chamber
Rys. 5. Rozmieszczenie pulweryzatorów w komorze inaktywacyjnej

Near the bottom of the chamber three pulverizers with the length of 0,5 m are placed symmetrically. 12 holes with the diameter of 0,004 m were drilled in each pulverizer, the holes are used to pulverize the exhaust gases inside the inactivation chamber. Figure 5 shows the placement of the pulverizers.

The exhaust gases after being flushed with domestic sewage are disposed of in the altered chemical form through the gas outlet pipe in the upper part of the inactivation chamber (fig. 6). Further studies will also examine the chemical composition of the exhaust gases from the diesel engine used in the research station and exhaust gases pumped out of the inactivation chamber.



Source: own work / Źródło: opracowanie własne

Fig. 6. Gas outlet pipe from inactivation chamber
Rys. 6. Króciec ujścia gazów z komory inaktywacyjnej

4. Conclusions

The presented model of the research station allows us to formulate the following conclusions.

1. The developed research station enables to perform laboratory-scale tests which will allow us to specify the method of domestic sewage inactivation.

2. The exhaust gases after being flushed in domestic sewage change colour and smell, which may indicate a change in their chemical composition, but more detailed analysis should be carried out when it comes to this.

3. This research station may also be used for biological inactivation of liquid and semi-liquid substances of animal origin, however detailed research in the field is required.

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