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Analysis of domestic sewage treatment system in the aspect of sustainable development

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Abstract: Year by year domestic sewage treatment plants are becoming more popular. A pilot solution used on a grand scale in Pietrowice Wielkie commune allowed for the construction of a sewage system for villages located far from each other and made the commune more attractive. This paper presents the analysis of investment and operating costs, the assessment of environmental benefits and social aspects. The solution used had a significant effect on the improvement of living conditions of the residents. The conducted analyses of the domestic sewage treatment system in the aspect of sustainable development allowed for the recognition of domestic biological sewage treatment plants as an economical, modern and safe solution and also as a cheap alternative to traditional sewerage systems.

Keywords: domestic biological sewage treatment plants, cost analysis, sustainable development

JEL codes: O30, Q01, R10, R11

1. Introduction

Sustainable development combines goals concerning environmental protection, society development and also the economy. The idea dates back to the late 1960s and early 1970s (Baum, 2003: 3-10; Prandecki and others, 2013:49-61). The idea of sustainable development was formulated in the Report of the United Nations World Commission on Environment and Development in 1987, which was chaired by Gro Hardlem Brundtland. The report contained trend analyses concerning economic development and the reduction of natural resources. The growth of the global economy called for the beginning of a new era, i.e. sustainable development

(Gawor, 2006:59-66; Polish National Commission for UNESCO). Sustainable development means having a right to achieve development aspirations without limiting the rights of next generations. Economic and civilisation progress should not be made at the expense of exploiting non-renewable resources and damaging the environment (Toruński, 2010: 21-32; Wall, 2013:27-41). There is no doubt that the Polish society attempts to adopt the average standard of living in the European Union to the standard of living in Poland (Jaśkiewicz, 2008: 33-38). Ecological, economical, modern, and environmentally - safe solutions open up possibilities to meet the desires of future generations and current social needs.

Nowadays the matter of sewage management is one of the most important environmental protection problems. In spite of a significant progress in terms of water supply and sewerage systems, residents of rural areas still have a limited access to these systems (Jóźwiakowski and others, 2014: 74-84). More and more domestic sewage treatment plants have been built in recent years (Jóźwiakowski, 2008: 159-167).

Pietrowice Wielkie commune (located in Śląskie province, Racibórz county) is an example of an area where the domestic sewage treatment plant solution was implemented in the whole area of the commune. The area itself is hilly and buildings are located far from each other. The pilot solution used caused an increase in the competitiveness and attractiveness of the commune. Domestic septic tanks were replaced by a more environmentally - safe solution. 1,362 biological domestic sewage treatment plants were built in a two-step process in the area of Pietrowice Wielkie commune. A quick construction and assembly, which only took one or two days, brought the residents closer to the European standards (Pietrowice Wielkie Commune Office).

The aim of the paper is to analyse the domestic sewage treatment system in the aspect of sustainable development including economic and social factors and environmental benefits provided by the solution used.

2. Economic analysis

Economic and technical analyses, which were carried out by Pietrowice Wielkie commune and included the character of the dispersed households in 11 villages and also the length of the sewerage network needed, contributed to choosing domestic biological sewage treatments plants

over the traditional sewerage system. The alternative solution became cheaper than the construction of the traditional sanitary network with a wastewater treatment plant (Pietrowice Wielkie Commune Office).

Performing a financial calculation of the domestic sewage treatment system allows for the comparison of capital costs incurred by the resident and commune. The list of operating expenses regarding the current service and operation of appliances was included in the analysis.

The project of building 1,362 domestic sewage treatment plants was carried out with the use of the funds obtained from a loan, grant, and the own contribution of the commune and residents. The operation of the investment was possible with the use of the funds obtained from the National Fund for Environmental Protection and Water Management, Provincial National Fund for Environmental Protection and Water Management and Rural Development Programme.

The total investment costs were as following:

- the total investment costs of the commune are estimated at 23 612 782 PLN (the expenditure cost from the commune funds is circa 2 312 133 PLN)
- the own contribution of the residents of Pietrowice Wielkie Commune – 1,845 PLN/household (Pietrowice Wielkie Commune Office), which amounts to the total own contribution sum of 2 512 890 PLN.

The following assumptions for calculating the operating costs of a household (resident) were made:

- 25.92 PLN/month - the maintenance and service costs of a domestic biological sewage treatment plant (Pietrowice Wielkie Commune Office),
- 100 PLN/year - the cost of electricity (Kessel Sp. z o. o.).

The following costs were considered operating costs: the maintenance and service costs (the cost of transporting the sludge once a year, the monthly charge for the SIM card used to monitor the operation of the plant 24 hours a day, the costs of servicing, the depreciation costs connected with the wear and tear of plant parts) and the cost of electricity.

Apart from the one-off investment cost, the residents were also charged a monthly fee after the implementation of HBSTPs (Domestic Biological Sewage Treatment Plants).

In order to assess the operating costs of various sewage treatment systems, i.e. the domestic sewage treatment plants, traditional sewage systems, and septic tanks, a comparative

analysis of them was carried out. To that end, the following assumptions resulting from their use were made:

- 3 members of a family,
- 8.04 PLN/m³ of sewage, 3.13 PLN/period - service charge (ZWiK Sp. z o. o. in Racibórz),
- 2.4 m³/resident/month - the average quota of water consumption per resident whose house is connected to a septic tank in an unsewered area, with a water supply system, toilet, bathroom, and a local hot water source (Ministry of Infrastructure, 2002),
- 91.80 PLN/4 m³, sewage disposal from the septic tank with a septic tanker by ZWIK Sp. z o. o. in Racibórz according to the price list for liquid waste removal (concerning the Jelcz SCK vehicle) (ZWiK Sp. z o. o. in Racibórz),
- 34.26 PLN/month - the operating cost of a household (resident),

The costs of maintenance, service, and electricity were included in the operating costs of a domestic biological sewage treatment plant). In case of the septic tank, the charge includes sewage disposal with a septic tanker from a household of three, in which the average quota of water consumption per resident is 2.4 m³/resident/month. The cost incurred by the traditional sewage system includes the service charge and the rate corresponding to the amount of m³ of sewage generated.

A consolidated summary of monthly and yearly operating costs of domestic sewage treatment plants, septic tanks and traditional sewage systems is shown in Table 1.

Table 1. Comparison of operating costs of different technological solutions

Technological solutions	A consolidated summary of monthly operating costs	A consolidated summary of yearly operating costs
Domestic sewage treatment plant	34.26 PLN	411.04 PLN/year
Septic tank	183.60 PLN	2,203.20 PLN/year
Traditional sewerage system	61.02 PLN	732.24 PLN/year

Source: author's own elaboration on the basis of the Regulation of the Polish Minister for Infrastructure of 14 January 2002 on the determination of average quotas of water consumption, the data published by Pietrowice Wielkie Commune Office and ZWiK Sp. z o. o. in Racibórz

Given the above analysis, it is clear that the most beneficial and economical solution is to implement domestic biological sewage treatment plants. This technology allows building up sizeable savings in the household budget. The choice of the HBSTP over the septic tank

guarantees the reduction of monthly costs by 81.34%, and in comparison to the traditional sewerage system by 43.85%. In case of the septic tank, in comparison to the domestic biological sewage treatment plant the yearly cost of use would be higher by 1,792.16 PLN, and in case of the traditional sewage system by 32.20 PLN.

Based on the analysis carried out, it may be concluded that domestic biological sewage treatment plants improved the standard of living of the residents. A cheaper and effective alternative was used in an area of scattered buildings, because the construction of the traditional sewerage system would not be simply economic there.

3. Assessment of environmental benefits

No municipal sewage system in Polish rural areas is a big challenge for local authorities. Sewage was often channelled to nearby ditches or bodies of water in unsewered areas, which posed a risk to the environment. Untreated sewage is a threat to animals, people, surface water and ground water. It has to be environmentally - safe before channelling.

Increasingly, the popularity of modern solutions is a result of an increasing awareness of citizens. A long lifetime of appliances or their failure-free use most of the time are also decisive. High-quality and durability treatment plants turn out to be the least harmful. In good solutions producers give a long warranty period to ensure their proper operation (in case of domestic biological sewage treatment plants a warranty period of 20 years is given for parts made of PE). If the appliances are chosen appropriately, made carefully and used properly, they guarantee reliable operation. Domestic biological sewage treatment plants are very airtight and use little electricity. In case of domestic biological sewage treatment plants, there is no risk that waste will escape in the building as opposed to septic tanks. The construction of 1,362 domestic biological sewage treatment plants is a unique project on a national level. Safety and environmental protection are ensured by, among others, a high efficiency of sewage treatment and also high quality of execution.

In Poland domestic sewage treatments plants that meet the PN EN 12566 INNO-CLEAN standard are available, which achieve the following parameters in treatment class D: BOD₅ up to 25 mg O₂/L, COD up to 125 mg O₂/L, total suspended solids up to 50 mg/L.

In order to achieve the above-mentioned parameters, the proper amount of sewage from households flowing to the given volume of the plant has to be maintained (Kessel Sp. z o. o.).

Domestic biological sewage treatment plants are considered a safe, ecological, and environmentally - friendly solution.

4. Assessment of social benefits

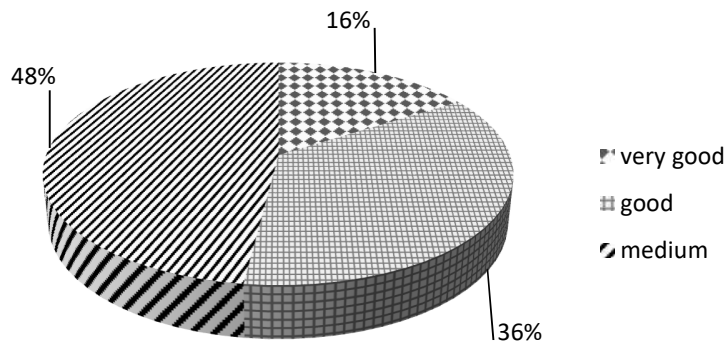
The goal of sustainable development may be to ensure appropriate living conditions to residents today and in the future. Development should be measured by access to water, electricity, and a sewerage system. The proper standard of living, safety, and participation in and influence on making decisions concerning the surrounding areas relate to sustainable development.

A survey was carried out in February 2016 in order to determine the public opinion of the commune. 25 respondents of a different age from Pietrowice Wielkie commune took part in the survey and answered 3 questions. They all have domestic biological sewage treatment plants.

The survey revealed that 92% of the respondents are satisfied with the current domestic sewerage system (domestic biological sewage treatment plant). The percentage of negative opinions was only 8% among the respondents. It should also be emphasised that the project was carried out with the approval of the residents. All Pietrowice Commune residents had an impact on the decisions made concerning the project, i.e. the construction of domestic biological sewage treatment plants on a grand scale. Many meetings were held allowing the residents to learn about the technology and its operation. The plants were built only where the owner gave his/her consent. The construction of the domestic biological sewage treatment plant was voluntary; therefore, people who were not interested in this solution still use the septic tank and remove waste on their own. However, a great majority of the residents opted for domestic biological sewage treatment plants.

The analyses show that all the residents have a positive opinion on, among things, the quality of domestic biological sewage treatment plants (48% of the respondents said their quality is average, 36% of the respondents said it is good, and 16% of the respondents said it is very good) (Figure 1).

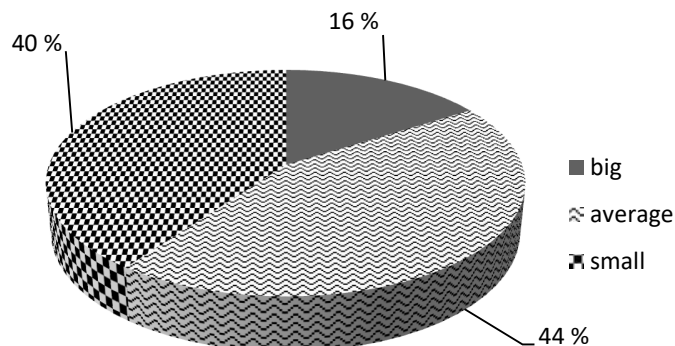
Figure 1. Quality assessment of domestic biological sewage treatment plants



Source: author's own elaboration.

The majority of the respondents said the investment costs were average (44%), 40% of them said they were low, and 16% of them said they were high (Figure 2).

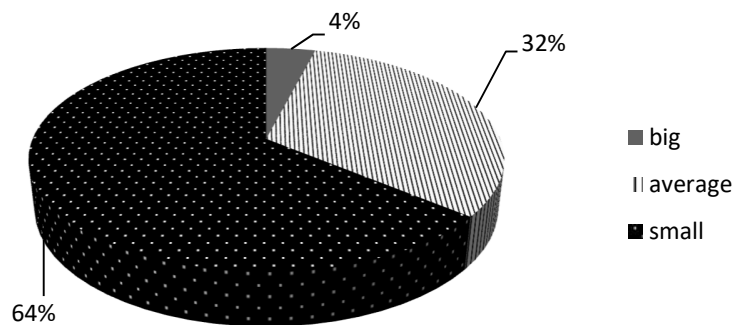
Figure 2. Assessment of investment costs



Source: author's own elaboration.

The monthly cost regarding the operation/maintenance of domestic biological sewage treatment plants was considered low (64%), average (32%), and high (4%) (Figure 3). In this case, the funds obtained from the National Fund for Environmental Protection and Water Management, Provincial National Fund for Environmental Protection and Water Management and Rural Development Programme are probably decisive.

Figure 3. Assessment of monthly costs resulting from the operation of the appliance



Source: author's own elaboration.

Every solution provided has its proponents and opponents. The majority of the residents is satisfied with the current solution and if they had to choose their domestic sewage treatment system, they would choose domestic biological sewage treatment plants again.

5. Conclusion

Domestic sewage treatment plants are becoming more popular year by year. Technology development contributes to the upward trend in innovative solutions that allow for sewage treatment in low-urbanised areas. The unique solution provided on a grand scale in Pietrowice Wielkie Commune had an effect on the commune development in accordance with sustainable development principles and its attractiveness.

The domestic biological sewage treatment plant is a solution that is accepted by the local society and attractive from economic and ecologic standpoints. On the basis of the performed analysis of the domestic sewage treatment system in the aspect of sustainable development, it should be stated that domestic sewage treatment plants, if used properly, may work for many years and meet the demands of future generations as well.

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Analiza przydomowego systemu oczyszczania ścieków w aspekcie zrównoważonego rozwoju

Streszczenie

Na terenach wiejskich, z roku na rok przydomowe oczyszczalnie ścieków mają coraz większe znaczenie. Zastosowanie tego systemu oczyszczania pozwala na rozwiązanie problemu ze ściekami zgodnie z zasadami zrównoważonego rozwoju. Przykładem terenu, na którym zamiast tradycyjnej kanalizacji zamontowano przydomowe biologiczne oczyszczalnie ścieków na dużą skalę, może być gmina Pietrowice Wielkie, która zlokalizowana jest w południowo – zachodniej części Polski. W gminie tej zastosowanie przydomowych biologicznych oczyszczalni ścieków pozwoliło na skanalizowanie oddalonych od siebie sołectw oraz zwiększenie atrakcyjności gminy. Nowoczesne bezpieczne dla środowiska rozwiązanie miało znaczący wpływ na polepszenie warunków życia mieszkańców przybliżając ich do europejskich standardów. Przedsięwzięcie zrealizowano dzięki pozyskanym środkom z pożyczki, dotacji, wkładzie własnym gminy i mieszkańców. W artykule dokonano analizy przydomowego systemu oczyszczania ścieków- funkcjonowania biologicznych przydomowych oczyszczalni ścieków w dużej skali w aspekcie zrównoważonego rozwoju. Dokonana analiza kosztów inwestycji i eksploatacji obiektów, aspektów środowiskowych oraz zadowolenia mieszkańców pozwoliła na stwierdzenie, że przydomowe biologiczne oczyszczalnie ścieków są ekonomicznym, nowoczesnym i bezpiecznym rozwiązaniem oraz tanią alternatywą w porównaniu z tradycyjnymi oczyszczalniami ścieków.

Słowa kluczowe: przydomowe biologiczne oczyszczalnie ścieków, zrównoważony rozwój, analiza kosztów.