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Sustainable Wastewater Treatment Solutions for Rural Communities': Public (Centralized) or Individual (On-Site) – Case Study

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Abstract: The implementation of Water Framework Directive, speaking about the need to achieve good water status, and thus the corresponding sewage treatment caused the problem of waste water management has become a very important starting from the municipal level, through the national and the European ending. Sustainability, although not explicitly mentioned in the relevant EU or national legislation, it is key to implement wastewater systems. Their main objectives are to protect and promote human health by providing a clean environment, and breaking the cycle of disease. In this paper sustainability of wastewater collection and treatment options in the rural communities' in Poland, are discussed in the context of recent infrastructure investments. The paper presents an attempt to evaluate the implemented solutions for wastewater management in rural areas considering sustainable development criteria. Advantages and disadvantages of proposed system has been analysed with the focus to the question of selecting the right strategy that would fulfil both population and environmental needs.

Keywords: wastewater treatment plant, sustainability criteria, local sanitation system

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1. Introduction

According to the World Bank, the greatest challenge in the water and sanitation sector over the

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next two decades will be the implementation of low cost sewage treatment that will at the same time do not deteriorate environment (Green Arth, 2012). It is crucial that sanitation systems have high levels of hygienic standards to prevent the spread of disease. The increasing amount of wastewater resulting from intensive economic development has caused the problem of wastewater management to become extremely important, starting from the municipality level and ending with the voivodship level. Growing ecological awareness, and therefore the requirements of the high life quality of the inhabitants and the legal requirements concerning the quality of wastewater disposed set up to the municipalities difficult task. As the municipalities are the bodies responsible (in accordance with the Polish Water Law Act; Regulation, 2001) for water and sewage management in their areas.

While the number of municipal WasteWater Treatment Plant's (WWTP's) in Poland is somewhat higher than 3000, the proportion of households in areas with no available sewerage system is close to 25% (Central Statistical Office, 2014). About 38.5% of population (14.7 million people) live in the rural areas and over 35% of them are not served by sewage systems, including wastewater treatment plants. The situation is very similar to that of other former CEE (Central and Eastern European) countries, where settlements with less than 2,000 inhabitants, represent almost 30% (42 million people) of the overall population (Istenic et al., 2015: 12880). These numbers show that former CEE countries have a still mainly rural character, although this is slowly decreasing. This share of population had been overseen by legislators when preparing the Water Framework Directive (European Comission, 2000), and the Urban Wastewater Treatment Directive (Regulation EU, 91), which focused on wastewater problems for larger agglomerations, and required significant discharges of urban wastewater to receive the appropriate level of treatment (according to current regulations, significant discharges are those serving population equivalents (P.E.) of more than 10000, reduced to 2000 when discharging directly to freshwaters and estuaries). In Poland, the Council of Ministers approved the National Programme for Municipal Waste Water Treatment (NPMWWT), which has been incorporated into the Water Law Act (Regulation, 2001) introduced into the national legal framework. The Programme includes a list of urban agglomerations including specification of the projects required concerning construction and modification of combined sewerage networks and municipal WWTPs. Since the adoption of such Programme, dynamic growth in facilities construction could be observed, especially for large municipalities. However in recent years, attention was focused on small-size facilities due to the large percentage of wastewater not yet treated. Still much delay exists in wastewater management in rural areas, where construction of centralized WWTP is considered too expensive. Polish regulations, in fact, allow the use of small/individual WWTPs only if the construction of municipal systems is not economically feasible, and there is no existing sewerage system in the area, as still the case for most of rural (and many suburban) areas in Poland. Small plants with capacity below 5 m^3/d can legally discharge effluent to soil or water within the limits of the owner's ground. This notable disproportion of required intervention between urban and rural areas poses a number of challenges for small/on site treatment plants, since discharge of untreated wastewater from unseweraged small settlements significantly contributes to the overall pollution of surface and groundwater, threatening human health and use of resources in those countries. It is estimated that in Poland approximately 1/4 of rural population does not have access to public drinking water supply at all, and uses individual wells or small local systems with often unsatisfactory chemical and microbiological quality of the drinking water supply (Mikosz, 2013: 2463-2465). In order to solve the problem of wastewater collection and treatment in the rural areas of Poland, where about 97% of around 40000 settlements have a population of less than 2000, it is expected that a large number of small, local WWTPs will be planned and constructed in the next 10 – 20 years.

The aim of this paper is to draw a current status and perspectives of on-site wastewater treatment systems in Poland, focus on rural areas and on small treatment plants for settlements of below 2000 people. Information for novel equipment for the treatment of domestic wastewaters is provided, with some decision methodology about choosing proper solutions of wastewater treatment in rural areas. Since this problem concerns many residents of suburban areas where there is no sewage system, therefore it is important to prepare appropriate steps for its progressive solution. The objective of this study was expanded for analysis of wastewater treatment solutions applied in the region of Poland selected for this case study.

2. Mainstream Technologies for domestic and local wastewater treatment

In heavily populated areas both domestic and commercial wastewater is treated using a central collection and treatment system. Individual residences, subdivisions and even entire cities and towns use this type of wastewater collection and treatment system. The wastewater is transported, via a collection system, from its origin to a central location where it is treated and disposed of in compliance with state and federal regulations. As many authors underline (Wiśniewska-Kadżajan, 2013: 427-257; Balkema, 2002: 153-161; Istenic, 2015: 12879-12884) central collection and treatment can be cost prohibitive in rural and/or less populated areas. In these areas, individual on-site sewage disposal systems are commonly used to treat and dispose of household wastewater.

In many Countries, small communities and domestic users are required to treat wastewater discharges to increasing standards of lower environmental impact, but must achieve that goal with local treatment systems, at locally sustainable costs. Decentralized treatment can be used to treat and dispose relatively small volumes of wastewater, originating from single households or a group of dwellings located in relatively close proximity (usually, a few hundred meters), that are not served by a central sewer system connecting them to a large wastewater treatment plant. This can be a sensible solution for communities of different sizes and demographics since it may lower capital and operational costs per unit of pollutant load removed.

There are many factors to consider in selecting a system. In order to determine the appropriate treatment system, the developer must consider the area's climate, topography, and socioeconomic factors (Balkema, 2001: 265-270; Istenic, 2015: 12879-12884). Each on-site sewage disposal system is designed for a specific site and a specific cost (initial and operation/maintenance). Capodaglio (2016) underline that the main influencing factors in the selection of a technology are: treatment efficiency in that specific condition, low operation and maintains (O&M) requirements, operational reliability and future, gradual expansion possibilities, favourable economics.

The simplest form of domestic treatment consisted historically of a simple underground septic tank (cesspool), which both settled suspended solids, and achieved some degree of anaerobic digestion. In hot climates, septic tanks can remove up to 50% of the organic load of "normal strength" sewage, but usually they achieve little in the way of pathogen reduction, requiring post-treatment (adding cost and complexity to the system) to achieve environmental standards.

Constructed wetlands (CWs) are being used throughout the world as local treatment systems, with diversity of design and operational features adaptable to domestic, agricultural and industrial (mostly agro-food) wastewaters. Use of CWs for small to medium size settlements is increasing sharply in Mediterranean countries due to favourable climatic conditions, although even in northern EU countries, such as Poland, Estonia and Lithuania, positive experiences with CWs have been reported (Mander et al., 2001: 201-224). Constructed wetlands have several inherent advantages compared to traditional systems, including: very low capital costs, less infrastructure, lower operating costs, simplicity of design and ease of operation. Multi-stage CWs have shown to provide excellent secondary and tertiary treatment for municipal and domestic wastewater with variable operative conditions in small size installations (up to 500 P.E.), in different climates. They offer reliable and steady removal of total suspended solid (TSS) and organic matter (in the long-term, over 97%), allowing to obtain very low concentrations in the effluent both in low and high inlet concentrations situations. Removal of nutrients has been observed at about 70-86% for ammonia, and 60-70% for Total N, with unit area (U.A.) requirements as low as 1.5 to 2 m^2/P.E. in warm climates (like Italy and Spain). In cold climate countries (e.g., Poland, Estonia, Lithuania) the required U.A. ranges usually from 5-12 m^2/P.E. Reported operating costs are quite low, about 0.1€ /m^3 treated wastewater, with construction costs related for the most part to the land surface needed (Masi et al., 2013: 1590-1598).

One of the most promising technologies capable of fulfilling current wastewater treatment requirements in traditional facilities are biologic membrane filtration processes, usually called Membrane Bio-Reactors (MBRs), integrating biological degradation of wastewater pollutants with membrane filtration. This ensures effective removal of contaminants and biological matter from domestic and/or industrial wastewaters, and has become a proven alternative to traditional activated sludge systems. The filtration component (in MBRs, pore size is typically < 1 μm) dispenses the need for gravity clarification of the effluent, eliminating a critical treatment bottleneck in small systems under highly varying hydraulic loads (Capodaglio, 2002). Use of membrane systems in decentralized treatment of household (domestic) wastewater was described by several researchers (Meuler et al., 2008: 285-294; Blstakova et al., 2009: 160-169; Pikorova et al., 2009; Chong et al. 2013: 338-347). MBRs, when properly operated, have also shown the capability to effectively remove nutrients and, to some degree, micropollutants, from a waste stream (Abegglen et al., 2008: 338-346). Treatment of residential wastewater by MBR systems would produce effluent with non-detectable TSS, BOD concentration (less than 2 mg/L), ammonia-N concentration of less than 0.5 mg/L, fecal coliform count of less than 20 per 100 mL and, with proper design, total N concentration of less than 5 mg/L. MBR application to domestic wastewater can remove more than 96% COD, 90% TSS and 90% TN. Comparative advantages with respect to traditional treatment techniques include smaller footprint, high loading rate capabilities, modularity and disinfected/highly clarified effluent immediately suitable for reuse. Consequently, MBR technology could play a prominent role in domestic wastewater treatment (DWT)systems.

Limitations inherent to these processes are the cost of membranes themselves, high maintenance and energy requirements, and the progressive loss of filtration capacity due to medium fouling.

A technology quite similar to MBRs, consisting of a reactor with suitable filters for biomass separation, was proposed by Capodaglio and Callegari (2016: 507-510), after successfully testing it with poorly-treatable organic contaminants (Capodaglio et al., 2010: 807-812, Capodaglio and Callegari, 2015: 681-687). The technology consists of an aerobic reactor vessel, in which treated effluent is filtered by a membrane-like medium, with pore size of about 20 µm for solids separation purposes, just like a MBR. In this case, however, due to the coarser characteristics of the filter, effluent filtration occurs by gravity only with a maximum head loss in the order of 2-3 cm. Such system, similarly to MBRs, can be modified to achieve nitrogen removal, and has shown to achieve 95-97% COD and 75-79% N removal, figures absolutely comparable to those of MBRs (Scott et al, 2013: 1412-1418).

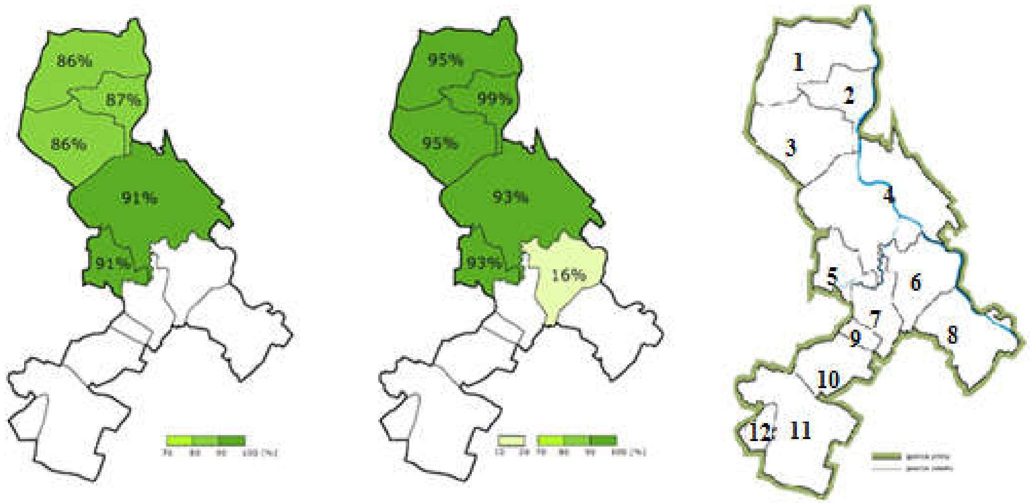
Today, UASB (Upflow Anaerobic Sludge Blanket) systems are among the most used, high-rate anaerobic digesters for treatment of wastewaters. Originally developed for industrial wastewater treatment (Lettinga et al., 1983: 1701-1723), UASB design required several adaptations for practical application to domestic wastewater, that has typically lower COD concentrations. This resulted in lower methane production, insufficient to heat the process reactors to the favourable mesophilic temperature range (35-45^{o}C). Full scale UASB applications initially showed excellent results under tropical conditions (T > 20-25°C), with COD removal efficiencies around 75% at 6 h HRT(hydraulic retention time), (van Haandel and Lettinga, 1994). UASB are widely used in Brasil and other countries in South America, India, Indonesia and Egypt, due to low construction and operational costs (Kalogo and Verstraete, 2000: 55-65), even though their nutrient removal capability is quite low. UASB application at lower temperatures is still feasible, however, with appropriate design. In these conditions, biogas generation diminishes considerably with decreasing temperature, and about 50% of it may escape the system with the effluent (Uemura and Harada, 2000: 275-282), making its recovery unprofitable, save for local use of small isolated communities. This, however, is of secondary importance compared to the general economic benefits of the process under these terms, somehow undermining the intrinsic merits of anaerobic processes as energy recovery technologies, consisting of low initial investment, low energy for operation, lower sludge production and easier maintenance than conventional aerobic processes.

3. Case study in Poland

Data obtained from the Regional Authority in Poland (Municipal Office Krapkowice), which collects annual and quarterly data on wastewater services in the area of Krapkowice were analyzed (BIP, 2013). Based on such data from 12 communities (Figure 1, c), referring to the period from 2011to2015, an assessment of wastewater infrastructure was carried out. It is believed that this province is fairly representative of the general rural situation in Poland, reflecting a generally insufficient development of wastewater infrastructure construction over the past years, during the communist, and also the pre-accession eras in Poland and all CEE countries, as well. Even in the years immediately prior to EU accession, Community's infrastructure investment funds in CEEs were focused mainly on large WWTPs (serving more than 10000 P.E.), resulting in approximately 70–80% of the urban population in these countries being connected to WWTPs, but more than 80% of the rural population remaining unconnected (Bodik et al., 2015).

The Polish data show, for the period indicated, an increase of people in the Krapkowice province connected to water collection system from 77% to 84%. In 2015, out of 22810 residents, 19163 were connected to sewer systems, and only 5 communities had sewerage system. The town of Krapkowice (capital of the province) in 2015 was served by a sewerage system with centralized WWTP covering 93% of the population. Four other cities/villages in the area had a service area covering from 87 to 91% of the population (Figure 1, a and b). Ten of them, however, do not have any sewage system, yet. In the absence of sewer connection, wastewater is often treated on-site by household treatment plants, or stored in a septic tank and transported later to larger treatment plants.

Figure 1. Area served by a sewerage system with centralized WWTP in communities of Krapkowice (c), year 2013 (a) and 2015 (b).



a) (b) (c)

where: 1 – Dąbrówka Górna,2- Rogów Opolski,3 –Gwożdzice,4- Krapkowice,5-Stebiów,6-Zywocice,7-Pietna,8-Zużela,9-Borek,10-Ściborowice11-Kórnica,12-Nowy Dwór Prudnicki

Source: Author's own elaboration based on data collected from Krapkowice Municipality.

Unfortunately, even when treatment is present, information available does not allow for a certain identification and assessment of the applied sewage treatment technologies. As no permits are required for the installation of household WWTPs of capacity smaller than 5m^3/d discharging within the owner's land, there is no reliable data on the number of such plants existing in Poland. Often, proper documentation and specific information is missing altogether, or sometimes misinformation is given concerning the technology used for example, in a verified case, a septic tank operated with addition of a bio-preparate was considered, and listed as, a biological treatment plant.

Facilities with discharge capacities from 5 to 20 m^3/d (serving groups of houses and/or local communities, roughly 20 to 100 P.E.) are classified as small plants. Often, small compact biological plants are installed by communes or groups of homeowners as solution to their wastewater management problems. These plants, however, are treated similarly to medium and large WWTPs, and can discharge effluents only into surface water, with a permit. According to the Polish discharge standards (based on Regulation EU, 91) only BOD_5, COD, and TSS in small plants' effluents are restricted. Removal of nitrogen and phosphorus is required only when the effluent is discharged to a lake or coastal waters. Since a construction permit must be obtained for these facilities' installation, their numbers and characteristics are better known, compared to individual household ones. Since these plants cannot discharge effluents to soil, they are often designed as compact versions of typical large facilities, with primary treatment by septic tanks, Imhoff, or even small settlers, followed by biological treatment. Often, these plants consist of pre-fabricated packaged version of large WWTPs, and they may use advanced biological methods based on suspended/attached biomass, even MBR technology, sometimes with nutrient removal. Compact, larger capacity plants may apply a nitrification–denitrification process, and chemical phosphorus removal technology.

Natural methods, such as constructed wetlands are sometimes used as treatment option or as a final treatment stage for biological plants. Poland reports high proportions of connectivity to nature-based systems (an estimated 6000-7000 with capacity below 5 m^3/d) and around 500 constructed wetland systems in the upper capacity range (Bodik et al., 2015), implemented with good long-term results (Paruch et al., 2011: 776-781). It has been shown that geographical, demographical and economic conditions for the local application of these systems are highly suitable (Kadlec and Wallace, 2009).

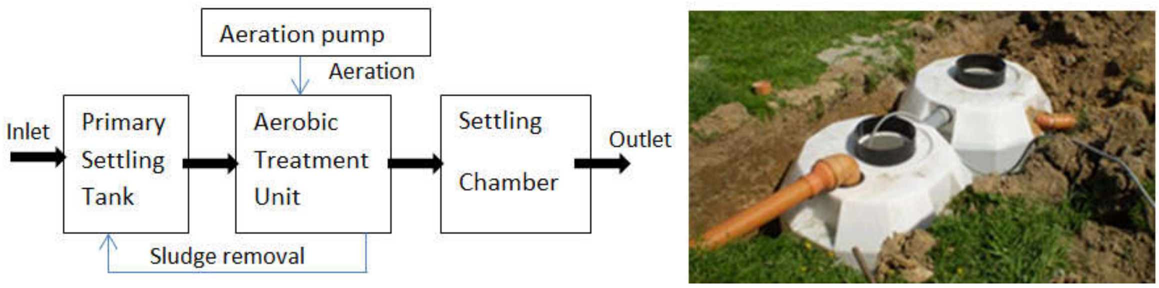
Since 2003, the number of officially installed individual WWTPs has almost doubled, reaching about 47,000 in year 2009. Still, this number is likely to be underestimated. The number of designed, built, and registered on-site treatment units (up to 5 m^3/d capacity) in the considered province is 95. Due to existing regulations, plant volumetric capacity decides the treatment technology. Household facilities below 5 m^3/d usually adopt septic tanks for preliminary and (some) biological treatment, and a drainage system to discharge the effluent into the soil. This is very common in Poland due to its simplicity and low costs. It is estimated that about a half of all household WWTPs in Poland use soil for discharge of treated wastewater. In the studied area, 60% of domestic wastewater is stored in septic tanks, and the owners have contracts with a licensed service provider for subsequent wastewater disposal to collective treatment plants. The remaining 40% is treated on-site, with 70% discharged to drainage ditches and about 30% into the soil.

A representative example of decentralized treatment was taken from a small (31 houses) countryside community in the south of the region (Borek), where dwellings have either a septic tank, or individual wastewater treatment.

3.1. Example of current decentralized treatment technology

An analysis of the decentralized wastewater treatment facilities installed at one of the houses at the Borek community was carried out to assess the current technological situation. The COMPACT FA wastewater treatment facility, designed to accommodate discharges from 3 to 40 people, consists basically of an activated sludge process, composed by a pre-settler dual-chamber, bioreactor system with aeration and sludge recycling, and secondary settling tank. (Figure 2). Wastewater flowing into the plant is directed to the pre-settler, where removal of suspended solids occurs. A baffle divides the settling tank into two chambers, by providing an increase in preliminary purification treatment. Wastewater, free of suspended solids, is transferred into the aeration chamber, where is subjected to periodic intensive aeration with compressed air. The aeration system is a membrane blower with a capacity of several tens of watts, with a driver switched on periodically to supply compressed air to membrane diffusers mounted in the tank. Secondary treated wastewater enters through a low gap into the secondary settling tank, where it is separated from the sludge suspension.

Figure 2. COMPACT FA process scheme (left), and facility during construction (right).



Source: Author's own elaboration based on data provided by owner in Borek village.

Because of considerable variability of inflow from single households, and high sewage composition oscillations, these mini-treatment plants, particularly those based on activated sludge, often face operational problems, such as SVI (sludge variability index) rapid variations, leading to poor sludge settleability, anoxic periods and sudden flow surges, that may flush biomass out of the system, all factors that considerably diminish treatment efficiency.

These small-scale units have high relevance in low population-density areas, where discharge of sewage to a central WWTP through a central drainage system is not economically feasible. Discharge of treated wastewater hence occurs to the communal drainage ditch near the house, based on a permit issued to each home owner (or group thereof), with possible public hygiene consequences. Most dwellings use the aforementioned COMPACT FA system for a people equivalent P.E. equal 5. Table 1 summarizes design hypotheses and legal requirements of a typical water and wastewater permit, which is associated to a fee for pollutants discharge. However, since the frequency of governmental controls of treatment efficiency depends on the plant capacity (in the case of small WWTPs, legal control requirements range from just one verification per year to a few), there might be incentives to owners to overstate treatment efficiency during the permit request phase, to decrease the payment fee for pollutants discharge. It should be noted that the parameters for treatment (outflow value in Table 1) are based on legal requirements imposed by the Polish Ministry of Environment (Regulation, 2014). Table 2 shows average values of parameters from monitoring visits made to the selected individual treatment facility.

Table 1.Wastewater parameters in the water permit documentation issued by the Municipality.

Parameter	**Inflow** (from design documentation)	**Outflow** (based on legal requirements)
COD [g/m3]	800	150
BOD_5 [g/m3]	400	40
Suspended solids [g/m3]	433,3	50

Source: Author's own elaboration based on design documentation and legal requirements, 2016.

Table 2. Results of analyses of wastewater quality in on-site treatment plants.

Sample no.	**COD in**	**COD out**	**BOD_5 in**	**BOD_5 Out**	**Susp. Solids In**	**Susp. Solids out**	**TN in**	**TN Out**
1 – October	944	85	405	46	(not measured)	48	108	101
2 – December	750	59	392	39		44	112	100
3 - March	763	61	386	35		44	98	82

Source: Author's own elaboration based on measured values, 2016.

It can be seen that, during the observation period, the samples taken indicate a substantial compliance (BOD_5 exceeded the allowed value on one instance, by about 15%) with the permit, however, due to the extremely low frequency of the programmed controls, these values may not be fully representative of the actual situation.

Innovative solutions for small volume wastewater treatment are more frequently proposed, and adopted, in order to make such small treatment plants more stable and reliable. Attention should be also paid to solutions combining classical activated sludge method with filtration post-treatment (MBRs, etc.). Beside their advantages involving considerable resistance to fluctuations in the volume and composition of inflowing sewage, they are characterized by low costs of construction and operation.

4. Discussion

Local or domestic wastewater management can be a sensible solution for communities of largely different sizes and demographics in any country, but, like any other WWTP system, it must be properly designed, maintained, and operated to provide optimal benefits. In general, almost all current wastewater treatment technologies could theoretically be applied into a decentralized setting; not all of these technologies constitute, however, sensible choices. The advantages of local wastewater management are several: they can effectively and efficiently treat domestic sewage to protect health, water quality, and support local water supplies, since wastewater treated by decentralized systems is more likely to remain in the local watershed. Using decentralized systems may thus make it easier for a community to implement local water reuse schemes for maintaining the quality of local water resources, and hence reduce inappropriate demand for additionally treated drinking water. A big advantage consists of the initial savings when setting up the system: about 80-90% of capital costs in centralized systems are related to the collection system itself, with some economy of scale in densely populated areas. A local treatment system requires a much smaller collection network for much lower flows.

Sustainability, although not explicitly mentioned in the relevant EU or national legislation, it is key to implement wastewater systems. Their main objectives are to protect and promote human health by providing a clean environment, and breaking the cycle of disease. The "most appropriate technology" in any situation is the one that turns out to be economically affordable, environmentally protective, technically and institutionally consistent and socially acceptable for the specific application. In other words, sustainable. When improving an existing and/or designing a local sanitation system, sustainability criteria related to the following aspects should be considered:

(1) Health and hygiene: minimizing risk of exposure to pathogens and hazardous substances that could affect public health from the toilet to the point of disposal (or reuse);

(2) Environment and natural resources: considering energy, water and other resources required for construction and operation, as well as potential emissions resulting from use. This should include the degree of recycling and re-use practiced and their effects (e.g. returning water, nutrients and organic material to agriculture), and the protection of other non-renewable resources (e.g. production of renewable energy, like biogas);

(3) Technology: maximizing functionality, and ease with which the entire system can be constructed, operated and monitored by local utilities. Its robustness and vulnerability towards power cuts, water shortages, floods, etc., and flexibility/adaptability to existing infrastructure and demographic or socio-economic developments are also important aspects;

(4) Financial and economic issues: relating to the capacity of households/communities to pay for the system, including construction, operation, maintenance and necessary reinvestments;

(5) Socio-cultural and institutional aspects: socio-cultural acceptance, convenience, perception, impact on human dignity, compliance with the legal framework and institutional settings must be considered. Table 3 summarizes these issue for the most commonly applied technologies in local wastewater treatment.

Table 3. Sustainability-related issues with most common local treatment technologies

	Health & Hygiene	**Environment & Resources**	**Technology**	**Financial**	**Socio-cultural & Institutional**
Constructed Wetlands	Poor coverage. May be set up for solar disinfection (post treatment)	Natural engineered systems Low energy demand. Good compatibility with sparsely populated locations. No resources	Easy to operate. High robustness and low vulnerability to crises. High adaptability if extra land available. High land requirements in cold climates.	Investment cost mostly for land plot. Operation close to free if gravity flow possible.	Acceptance good if "out of the way" and not causing nuisance. Possible poor institutional understanding (since not

	Health & Hygiene	Environment & Resources	Technology	Financial	Socio-cultural & Institutional
		recovery (possible vegetation harvesting)			standard practice)
Aerobic Conventional	Poor coverage. Require post-treatment	Energy and cost intensive. Possibility of tertiary recovery of nutrients (struvite) and energy from sludge.	Relatively easy to operate with remote monitoring. Medium robustness and vulnerability (power cuts, discharge toxicity). Suitable for "package" construction for small facilities.	High investment and O&M costs (energy and sludge management).	Acceptance depending on location and past experience. Possible nuisance from odours. Well accepted institutionally.
MBR (filtration) Aerobic	May be suitable for reuse without post-treatment, depending on degree of filtration	Very energy intensive. Smaller footprint than aerobic conventional. Higher efficiency. Possibility of tertiary recovery of nutrients.	More complex operation, with fouling problems in time. Robust towards flow and load variations, vulnerable to power cuts (medium), less to toxicity. Expansion requires high investments. Suitable for cheaper "package" construction for smaller facilities.	Highest investments and O&M (increased for energy, but less sludge to manage)	Acceptance depending on location and past experience. Possible nuisance from odours. Accepted with cost-concerns institutionally
UASB	Poor coverage. Require post-treatment	Anaerobic technology can be energy neutral or positive (biogas generation in the presence of strong wastes). Possibility of post-recovery of nutrients. Sludge is suitable to spread in agriculture	Relatively easy to operate at optimal conditions. Robust towards flow/load variations, vulnerability low. Expansion at medium cost. Suitable for cheaper "package" construction for smaller facilities.	Medium investment, Low O&M, sludge and effluent management. Possible revenue from biogas recovery.	Acceptance depending on location and past experience, considering likely nuisance from odours. Cost-efficiency and recovery (biogas energy) enhances institutional support.

Source: Author's own elaboration based on Capodaglio et al., 2016

5. Conclusion

The current Polish situation, and several possibilities for the realization of localized, domestic sewage treatment plants have been presented in this paper. They can ensure, if properly designed, highly efficient reduction of pollutants, by themselves or in combination with pre- or post-treatment steps. In practice, the selection of technology for wastewater treatment often depends on costs and on the possibility of its adaptation to local conditions. A simple method of multicriteria analysis, illustrated above, in agreement with the concept of sustainable development, takes into account the basic applicable criteria.

The illustrated data underpin the need for on-site local WWTPs in Poland. Construction of collective sewerage system with central wastewater treatment plants is mostly unfeasible (from the economic point of view) because of disperse settlements, and of long distances to be covered by collection networks. Construction of household or small communities sewage treatment plant becomes a challenge for municipalities and potential investors.

In summary, currently, knowing that this system operates in the municipality only about 3 years, it can be stated that the problem of sewage management was solved. It is not an ideal system, and if less expensive than a system based on sewerage and collective sewage treatment plant will be able to tell after several years of exploitation. An important role here will be the monitoring of both the proper operation of the treatment unit and the preventive monitoring of water quality in the water bodies.

Decentralized wastewater treatment systems designed to operate at small scale, not only can reduce the effects of wastewater disposal on the environment and public health, but may also increase the ultimate reuse of wastewater, depending on community type, technical options and local settings.

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Zrównoważony rozwój przy rozwiązaniach oczyszczania ścieków na terenach wiejskich: publiczne (centralne) czy indywidualne (lokalne) - case study

Streszczenie

Wdrożenie Ramowej Dyrektywy Wodnej, mówiącej o potrzebie osiągnięcia dobrego stanu wód, i w związku z tym odpowiedniego oczyszczenie ścieków spowodowało, iż problem gospodarki ściekowej stał się bardzo ważny poczynając od szczebla gminnego, poprzez narodowy na europejskim kończąc. Zrównoważony rozwój choć nie został wyraźnie wymieniony w odnośnym prawodawstwie krajowym i europejskim jest kluczowy dla wdrażania programów oczyszczania ścieków. Głównym celem jest ochrona i promowanie zdrowia ludzi poprzez zapewnienie czystego środowiska. Zrównoważony rozwój przy wyborze systemów oczyszczania ścieków na terenach wiejskich w Polsce omówiono w kontekście niedawnych inwestycji infrastrukturalnych.
W artykule przedstawiono próbę oceny wdrożonych rozwiązań dla gospodarki ściekowej na terenie wiejskim biorąc pod uwagę kryteria zrównoważonego rozwoju. Wady i zalety proponowanych systemów oczyszczania ścieków analizowano z naciskiem na kwestie wyboru właściwego systemu, który zaspokoi potrzeby ludności i nie wpłynie negatywnie na środowisko.

Słowa kluczowe*:* oczyszczalnie ścieków, kryteria zrównoważonego rozwoju, lokalny system unieszkodliwiania ścieków

Kody JEL: Q56, Q53

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