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Wastewater management in small communities in Poland

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ABSTRACT

Pollution of freshwater resources in Poland is a result of negligence in wastewater management in the past. Major sources of pollution are effluents from municipal wastewater treatment plants and surface runoffs. While in the cities, large wastewater treatment plants are gradually modernized and new ones are constructed, in small communities the situation is changing very slowly. The development of wastewater infrastructure in rural areas is a difficult and costly process that does not produce immediate reduction of large pollution loads discharged to the environment. Hence, people living in rural areas have worse access to sanitation services than the residents of large agglomerations do. Local communities undertake efforts to improve this situation but they often encounter financial and organizational barriers. The national program of improvement in wastewater management focuses its efforts on massive reduction of pollution loads from large agglomerations. The other program that refers to small communities has significantly smaller budget and a number of limitations. In effect, despite the fact that the progress in development of wastewater infrastructure in rural areas is apparent only about 26% of rural population in Poland is served by wastewater treatment plants. Nevertheless, many of them apply very modern treatment technologies with nutrient removal. The article reports the situation in this area, analyzes the causes of it, and presents perspectives for the future.

Keywords: Water management; Wastewater management; Sanitation; Small wastewater treatment plants; Nutrient removal

1. Introduction

Effective wastewater management requires integrated approach that must consider environmental, technical, economic, and social issues. Small communities are in specific situation, as usually they do not have enough expertise, and organizational and financial resources to undertake such task on their own. Thus, they need real assistance from the regional or national level institutions. However, such assistance programs by their nature are uniformed and usually do not consider local conditions, that often determine the type of a wastewater system and restrict the range of feasible technical solutions that can be applied in a specific location. Under such conditions, the final form of the systems is a compromise between the needs and the expectations of a local community on one hand, and the technical, economic, and environmental restrictions on the other.

Various historical, social, and cultural legacies that usually are more noticeable in a local scale can make

this process even more difficult. The situation that exists in rural areas and in small communities in Poland may serve as an example. Over 40 years of communist rule in Poland contributed to not only economic and environmental damage but it has also ruined people's sense of responsibility for their local communities. This affects the current situation in all aspects of life including the people's attitude toward protection of the environment in general, and specifically concerning protection of water resources. Discharge of untreated household wastewater to soil or to a nearby stream in order to save on costs of emptying a septic tank still is a common practice in many places in rural areas and in small communities. In such situation, the perspective of construction of a sewer system and a wastewater treatment plant in a community not always is warmly welcomed by all inhabitants, as it would probably cause the increase in the costs of sanitation. Therefore, except the financial and technical issues also such factors must be considered when planning new programs aimed at improvement in wastewater management in small communities.

Table 1
Comparison of total freshwater resources per capita in selected EU countries [3] (long-term annual average in m^3 per capita)

Country	Precipitation	Total freshwater resources*
Norway	98,072	80,016
Sweden	36,466	20,112
Slovakia	6,901	14,842
Portugal	7,731	6,925
Greece	10,213	6,394
Netherlands	1,806	5,440
Italy	4,930	2,914
France	7,546	2,894
United Kingdom	4,465	2,667
Spain	7,561	2,425
Germany	3,744	2,293
Belgium	2,686	1,854
Poland	5,063	1,655
Czech Republic	5,221	1,526
Cyprus	3,822	405
Malta	362	188

*Calculated as a sum of precipitation and actual external inflow less actual evapotranspiration.

2. Freshwater resources in Poland

Poland is a country with relatively small freshwater resources. With the average annual precipitation of only about 617 mm as a 30-year average, the freshwater inflow of 63,100 million m^3 and with relatively low natural retention it is placed about the end of list of all European countries ranked according to freshwater resources per capita [1,2]. The available freshwater resources per capita of 1,655 m^3 as a long-term annual average is less than in any other European country, except Czech Republic, Cyprus, and Malta (Table 1). Under so, unfavorable hydrological conditions still about 80% of total water demand is covered from surface water sources. Regional variations in precipitation and irregular distribution of freshwater resources throughout the regions that do not coincide with the places of high water demand make the situation even worse.

Even this relatively small quantity of freshwater cannot be fully utilized because of its poor quality. This is mostly due to a historic heritage of the communist system that ended in 1989 and promoted unlimited industrialization at the cost of natural environment. The natural resources were valued exclusively on the base of the potential revenues they could generate being a material for industrial production with almost total negligence to their environmental values [4]. For the past 20 years, the condition of surface water resources in Poland's rivers and lakes has significantly improved but still it is far from good. According to the chemical and microbiological criteria used in Poland for surface water classification, the quality of water in over a quarter of the length of river sections is bad or poor, in about 66% it is satisfactory, and only in 6% it is good. It is very good in merely few places in the mountain regions of the country [5]. One of the major problems with water quality is eutrophication caused by large input of nitrogen and phosphorus discharged with municipal effluents and with polluted surface runoff resulting from improper agricultural practices. Industrial effluents being kept under strict regulatory control and continuously monitored contribute significantly less to surface water pollution [2]. However, in recent years (data for 1998–2008) nitrogen and phosphorus loads transported through Polish rivers have been reduced by about 50% (from 260 to 133 thousand tons of N and from 15.5 to 7.4 thousand tons of P) still they remain the major pollutants that affect freshwater's quality [5]. In effect, practically all surface water in Poland is sensitive to eutrophication and the same problem exists in the Baltic Sea where all Polish rivers drain.

3. Access to sanitation services in rural areas

Provision of sanitation services in rural areas encounters a number of difficulties that are nonexistent in urban areas. The specific conditions include among the others low settlement concentration, intensive agricultural activities, low ratio of covered surface, and high seasonal variation of water use [6]. In Poland, there is also an important social factor that affects the development of water and wastewater management systems. It is relatively low level of urbanization with almost 40% of the population living in rural areas, usually in scattered settlements and with limited access to sanitation services. Due to insufficient investments in water and wastewater systems, approximately 1/4 of this population do not have access to public drinking water supply at all and they use individual wells or small local systems for water supply (Fig. 1). Chemical and microbiological quality of drinking water derived from such sources is often unsatisfactory. The situation with wastewater management is even worse as 3/4 of the rural population in Poland is not served by public sewage systems and wastewater treatment plants (WWTPs) [1]. In such situation, the domestic wastewater is often treated in small household wastewater treatment plants or it is retained in septic tanks that are irregularly emptied and often the content is illegally drained directly to soil or to a nearby river or stream. Such practices contribute to the increasing pollution of groundwater and surface water in rural areas.

However, the level of sanitation in rural communities is still significantly lower than in the urbanized areas, the improvement in this area in recent years in Poland is evident. Especially if considering the starting point of early 1990s when only about 3% of rural population was served by WWTPs (Fig. 2). One of the

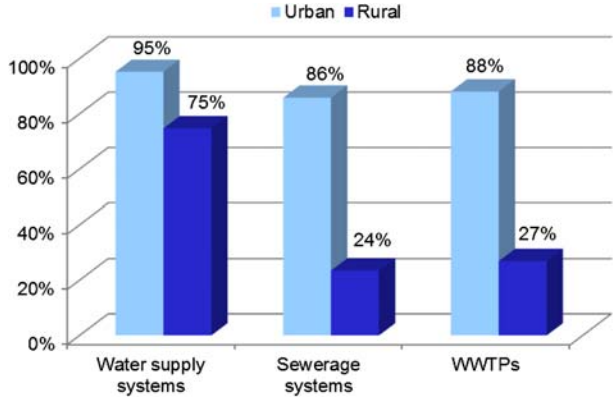

Fig. 1. Access of urban and rural population to sanitation services in Poland in 2009 [1].

important reasons for this improvement was Poland's accession to European Union in 2004 and the pre-accession assistance programs. The EU regulations that Poland had to implement in the area of environmental protection on one hand, and the financial assistance programs in form of structural funds on the other were essential in changing wastewater management system in the country.

4. Legislative and financial framework

4.1. Environmental regulations

Essential EU legislation regarding water and wastewater management was implemented into the Polish law already in 2001—few years before Poland's accession in 2004. Major legal acts that created the basis for its practical implementation include Water Law (2001), Environmental Protection Law (2001), Municipal water supply and sewage discharge law (2001), the orders of Ministry of Environment on quality of effluents discharged to the environment (last revised 2009), and many other more detail regulations [7,8]. In Poland each of almost 2,500 communes, that are the smallest administrative units, is exclusively responsible for water supply and wastewater management in its area. The Minister of Environment is responsible only for coordination of water and wastewater management plans. In this task, it is assisted by the National Board of Water Management with its seven regional branches organized in the watershed structure.

In the accession treaty, Poland among the others has negotiated the transition period for the implementation of the urban wastewater treatment Directive 91/271/EEC. According to this exemption, Poland would gradually improve its wastewater management system reaching the ultimate goal in 2015 when all agglomerations of capacity above 2000 PE and many smaller ones are to be equipped with WWTPs. There are two national programs aimed at implementation of the Directive 91/271/EEC. The first one is the National Urban Wastewater Treatment Program signed in 2003 and several times amended since then, usually due to delays in its implementation [9]. This program is aimed at agglomerations larger than 2000 "population equivalent" (PE). It is expected that in 2015 approximately all urban and about 60% of rural population will be served by sewerage systems and by WWTPs [4]. However, now achieving of this goal is endangered as the program is delayed. The second program is aimed at agglomerations smaller than 2000 PE that already are equipped with sewerage systems. It is referring to article 7 of the Directive [10]. Started

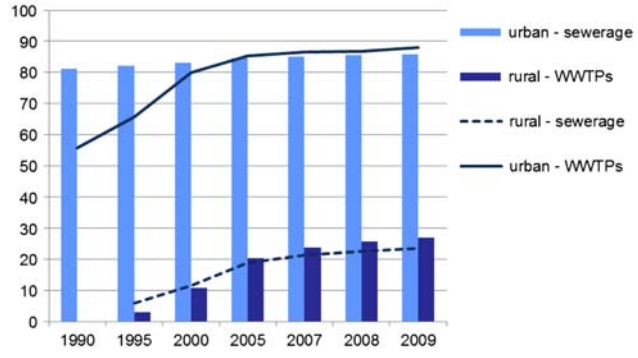

Fig. 2. Percentage of urban and rural population using sewerage systems and WWTPs [1].

in 2007, it is far smaller with the budget being only about 2% and the concerned pollution load being only 1% of that for the large plants. However, it directly addresses the needs of many small communities in Poland. It includes 379 agglomerations of 444,273 PE with 221 WWTPs to be extended or modernized and another 29 new to be constructed. Planned is construction of 1,241 km of sewage lines to ensure that 85% of population served by sewage networks [11]. It is important to note that none of the above programs applies directly to diffuse settlement in rural areas and to small household WWTPs.

4.2. Financing of investments

There are few major sources of financing the improvements in wastewater infrastructure in Poland and their participation in total investment costs depend mostly on the scale of the investment (Fig. 3). Large communal and municipal investments on average in about 30% are financed with water companies' own resources coming from user fees. About 25% is financed with foreign funds, especially with the EU structural funds, and another 25% with various Polish ecological funds. Primarily, it is the National Fund for Environmental Protection and Water Management that collects the money from environmental fees in Poland. The remaining 20% is financed with commercial loans and credits. For small and household WWTPs, the situation is somewhat different as no foreign funds are used for such investments. They are financed mostly with investor's private resources with some support from communal budgets, and with significant participation of various ecological funds. In total, this is about 80% of the investment costs. The remaining part comes from bank credits, loans or as subsidies from regional budgets [1].

4.3. Financing of operation

According to the Polish regulations, sanitation is defined as an exclusive responsibility of each individual commune. The water and wastewater systems can be public or privately owned. Public water companies usually have a legal form of joint-stock company and operate according to the commercial law. Thus, operation of water and wastewater systems is based on financing through a system of user fees. A consumer connected to a water supply and sewerage systems pays for each m^3 of used water and discharged wastewater. If there is no sewerage system, only a fee for water supply is charged. The table of tariffs is usually proposed by a water company to the local authorities and then it has to be approved by appropriate communal council. The unit rates for water and wastewater depend on operational costs of a specific company (including repayment of investment costs) and may significantly vary among the communes. The costs of operation of a small household WWTP is the responsibility of a homeowner.

5. Wastewater treatment standards and technologies

In 2009, almost 2/3 of total volume of municipal wastewater generated in Poland was treated with biological methods and almost a half with high-effective methods for nitrogen and phosphorus removal [1]. Only a minor portion of wastewater was discharged untreated, and about 20% was treated only mechanically. Almost all newly constructed large and majority of medium WWTPs in Poland use high-effective biological nutrient removal methods—nitrification, denitrification, and biological phosphorus removal, supported with chemical precipitation. Small compact WWTPs plants usually apply simple biological methods with nitrification and sometimes with denitrification. However, there are many small plants with advanced biological phosphorus removal technologies despite that usually it is not formally required.

5.1. Individual household WWTPs

Polish regulations allow the use of small individual WWTPs only if the construction of municipal wastewater systems is not economically feasible and there is no existing sewerage system in the area. This is still the case for most of rural and for many suburban areas in Poland. Small plants of capacity below $5\,m^3/d$ can discharge effluent to soil or to water within the limits of the owner's ground. No water or construction permits are required for such installa-

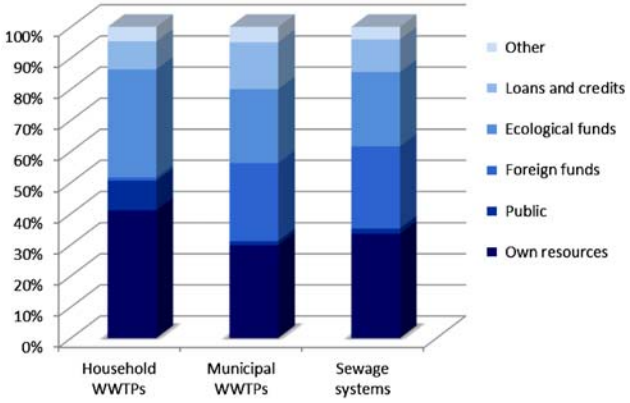

Fig. 3. Sources of financing of wastewater investments in Poland [1].

tions but local environmental authorities must be informed about the fact. As no permits are required for installation of household WWTPs there is no reliable data on the number of such plants existing in Poland. Many, or maybe even the majority of them, are not reported to local administrations. On the other hand, due to the lack of sewerage systems in many rural and suburban areas, often this is the only feasible solution to the problem of household wastewater disposal. Thus, it is not surprising that small household WWTPs have been gaining increasing interest in many small communities in Poland. 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 much underestimated. The market for such small systems is very competitive and the prices are dropping.

Due to the existing regulations, the plant capacity decides about the treatment technology. Household plants of capacities below $5\,m^3/d$ usually use septic tanks for preliminary and rough biological treatment, and then the drainage system to discharge the effluent to soil (Fig. 4). Drainage systems are 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.

5.2. Small WWTPs

The WWTPs of capacities from 5 to $500\,m^3/d$ that serve as a group of houses and/or a local community are classified as small plants. Small compact biological plants are installed by communes or by groups of homeowners as a solution to their wastewater management problems. Concerning formal and administrative procedures, such plants are treated similarly as medium and large WWTPs, and they can discharge effluent to surface water only and a water permit and an appropriate construction permit must be obtained for their installation. Only the effluent standards are less strict and sometime do not include the requirement of nitrogen and phosphorus removal. According to the Polish discharge standards that are based on Directive 91/271/EEC, as a general rule only the values of BOD_5, COD, and TSS in effluent from small WWTPs are restricted. Removal of nitrogen and phosphorus at small WWTPs is required when the effluent is discharged to a lake or to coastal waters. Even then, the limit values are so high that this condition can be easily met with relatively uncomplicated treatment technologies. Still the effluent from such plants must be precisely monitored about its quantity and quality.

As the plants of capacities above $5\,m^3/d$ cannot discharge effluent to soil they often are designed as miniaturized and compact versions of typical large mechanical–biological WWTPs. Primary treatment in septic tanks, Imhoff's tanks, or even small primary settlers is followed by the biological treatment (Fig. 4). They use more advanced biological methods based on suspended or attached biomass, or the combination of the above, sometimes with advanced nutrient removal. Compact plants of larger capacities almost always apply nitrification–denitrification process and sometimes use biological phosphorus removal technology supported with chemical precipitation. The experience shows that the compact plants with biofilters of different design and the systems based on cyclic activated sludge technologies (sequencing batch reactors [SBR]) that are often used in such plants produce very little operational problems. The range of such plants, offered in Polish, marked large with variety of technologies and capacities. Sometimes they use natural methods such as constructed wetlands or ponds as a final treatment stage. Constructed wetland technology is not very common in Poland—however, in 2007 there were about 70 constructed wetlands of capacity above $5\,m^3/d$ and approximately 6,000–7,000 of smaller systems [12].

6. Conclusions

Poland being a country with relatively small freshwater resources and the burden of environmental damage from the communist period struggles to improve the quality of its natural water resources. Since late 1990s with the new environmental regulations and the EU structural funds, it continues to redefine its water management system with major

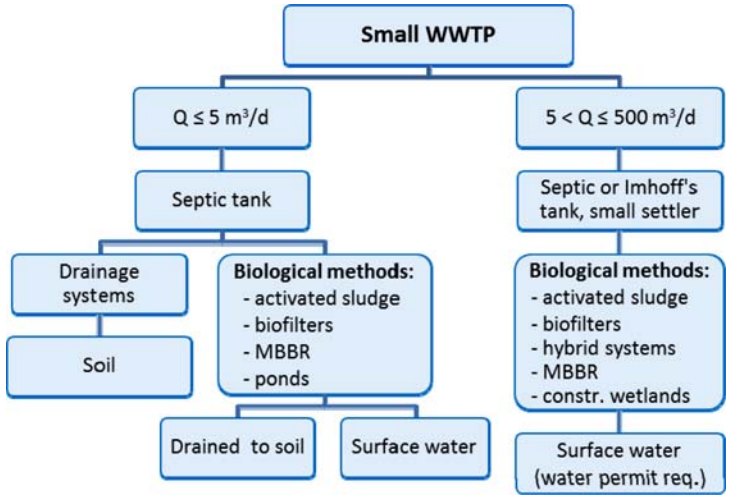

Fig. 4. Treatment technologies applied at small WWTPs in Poland.

stress put on effective protection of freshwater quality. This is done mainly through substantial investments in the wastewater infrastructure. Poland's accessions to the EU in 2004 put formal obligation on the country in regard to reduction of pollution loads discharged with wastewater from large agglomerations of above 2000 PE, but smaller communities have been left somewhat aside of this process. Despite the fact that about 40% of Poland's population lives in rural or suburban areas, the amount of money invested in improvements in water and wastewater management in small communities is considerably less what directly translates into noticeably worse access to sanitation services.

Small communities in Poland try to solve their wastewater management problems through construction of local sewage systems and small WWTPs. Among the major barriers for such investments is insufficient financing and complicated changeable legal regulations in Poland that prolong the formal procedures. Important obstacle in this process is also the lack of technological expertise at the level of local decision-makers. The capacities of such plants sometimes reach even several hundreds of cubic meters per day and they often apply advanced treatment technologies. If the technology is not well suited to the local conditions, a newly constructed WWTP will not operate effectively and the ecological effect will not be satisfactory. In spite of these obstacles, the increasing number of small wastewater systems constructed in rural areas in Poland has contributed to gradual reduction of discharged pollution loads throughout the last decade. The program of construction of wastewater treatment plants in small communities in Poland should be further strengthened in future in order to achieve improvement in freshwater resources' quality.

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