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Water and Sewage Management Issues in Rural Poland

Adam Piasecki

Faculty of Earth Sciences, Nicolaus Copernicus University, 87-100 Torun, Poland; adm.piasecki@gmail.com

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Abstract: Water and sewage management in Poland has systematically been transformed in terms of quality and quantity since the 1990s. Currently, the most important problem in this matter is posed by areas where buildings are spread out across rural areas. The present work aims to analyse the process of changes and the current state of water and sewage management in rural areas of Poland. The author intended to present the issues in their broader context, paying attention to local specificity as well as natural and economic conditions. The analysis led to the conclusion that there have been significant positive changes in water and sewage infrastructure in rural Poland. A several-fold increase in the length of sewage and water supply networks and number of sewage treatment plants was identified. There has been an increase in the use of water and treated sewage, while raw sewage has been minimised. Tap-water quality and wastewater treatment standards have improved. At the same time, areas requiring further improvement—primarily wastewater management—were indicated. It was identified that having only 42% of the rural population connected to a collective sewerage system is unsatisfactory. All the more so, in light of the fact that more than twice as many consumers are connected to the water supply network (85%). The major ecological threat that closed-system septic sewage tanks pose is highlighted. It is pointed out that they are mainly being replaced by household wastewater treatment systems with ineffective filtering drainage. Furthermore, recommendations were also made for the future development of selected aspects of water and sewage management, including the legal and the political.

Keywords: water supply network; wastewater treatment; holding tanks

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1. Introduction

Water and sewage management is one of the most important elements of any country's ecological, social and economic policy. Proper water and sewage management relies on the sustainable development of both components. In Poland, for many years, environmental aspects have only marginally been included in investment processes. As a result, there is still a significant imbalance in the development of infrastructure between that for the supply of water (water intakes, treatment stations, water supply network) and that for its later collection (sewage network, pumping stations) and treatment. The lack of a sense of social responsibility for the poor condition of the natural environment, especially on a local level, was also significant. It was therefore common for domestic sewage to be drained into the soil or to a nearby stream in order to save on the cost of emptying a holding tank [1]. The period of political and economic transformation in Poland that began at the turn of the 1990s initiated a slow evolution in environmental protection. Poland's desire to join the European Community (later the European Union (EU)) played a significant role in this respect. The country had to meet a number of criteria regarding, among other things, the economy, finance, politics and law. There were also criteria relating to environmental protection, including the improvement of water quality and water and sewage management. Poland obtained significant financial resources for these purposes under pre-accession funds (about 7 billion euros in the years 1990–2003) and post-accession funds (member funds after 2004).

The socialist economy that prevailed in Poland in the years 1945–1989 significantly polluted the aquatic environment. In the 1990s, more than 35% of the total length of rivers in Poland was considered excessively polluted (not meeting the norms) and more than 80% failed sanitary norms. In the years 1991–1995, over one third of the number and total volume of the lakes examined failed to meet the standards and lakes in the first (best) cleanliness class accounted for only approx. 1.5% [2]. Poland was the country that supplied the most pollution to the Baltic Sea, mainly as phosphorus and nitrogen compounds. Therefore, the EU countries were keen to improve the condition of Polish rivers as quickly as possible. The Accession Treaty contained detailed related requirements, which Poland pledged to complete. Important guidance is contained in the Directive Water Framework (DWF) number 2000/60/EC [3]. In general terms, the DWF set the goal (for all EU Member States) of achieving good ecological status for all water types by 2015 [4]. Poland implemented the EU law in this area back in 2001, amending the Water Law Act [5] and the Environmental Protection Act [6]. In 2017, for substantive and formal reasons (introducing internal consistency to the water law), a new Water Law Act [7] was passed. The requirements for sewerage systems and municipal sewage treatment plants came mainly from Directive 91/271/EEC [8]. The basic instrument for implementing the Directive is the National Programme for Municipal Waste Water Treatment (NPMWWT) [9]. The goal of the NPMWWT is to reduce discharges of insufficiently treated wastewater and to thereby protect the aquatic environment. Eliminating the largest point sources of pollution was the most urgent task but also, relatively, the easiest (and the most expensive). It was necessary to build new wastewater treatment plant (WWTP)) serving cities and industrial plants or to thoroughly modernise old ones. This goal was achieved and now all cities and plants are serviced by WWTPs. Over half of them provide an increased level of nutrient removal. Industrial plants have been modernised or closed, minimising possible emissions of untreated sewage into the environment. Currently, the biggest problem remains the elimination of pollution from dispersed sources in rural areas. Other Central and Eastern European countries have similar problems related to water and sewage management as Poland. According to estimates, over 80% of the Central and Eastern Europe's rural population in small, remote settlements are not connected to sewage treatment systems. Moreover, according to expert assessments, by 2030, more than 22 million inhabitants of Central and Eastern Europe will still not be connected to centralised sewage treatment plants [10]. This may be of great significance to the natural ecosystems of such areas, primarily as a result of the solutions that are used in small, decentralised sewage treatment systems [11–13].

The present work aims to analyse the process of changes and the current state of water and sewage management in rural Poland. The author's intention was to present the aforementioned issues in a broader context, taking into account local, natural and economic conditions. It was the author's intention to present these issues in the broader context, taking into account local, natural, economic and legal conditions. Furthermore, recommendations were also made for the future development of selected aspects of water and sewage management, including the legal and the political.

2. Materials and Methods

The main research material for the analyses was data from the Central Statistical Office in Warsaw and supplementary information from other Polish institutions for environmental protection (including Provincial Inspectorates for Environmental Protection) and agriculture (including the Agency for Restructuring and Modernisation of Agriculture). A database of the information most important to the issues being addressed was created. The time span of the data is inconsistent, which is mainly due to changes in reporting methodology over the last few decades. For each issue, the researchers tried to obtain the longest time series of data for the fullest possible depiction of the change process. The database contains information on the following topics:

- length of water supply and sewage network,
- percentage of people using the water supply and sewage treatment plants,
- amount of water consumed by households,
- amount of treated wastewater (including type of treatment) and untreated wastewater,
- pollutant load in treated wastewater,
- number of sewage treatment plants, including type,
- capital costs of investments for water and sewage management,
- consumption of mineral fertilisers,

The collected data allowed us to trace the water and sewage management modernisation process in rural Poland. Thus, it was possible to determine trends and directions of changes, as well as assessing the current status.

The paper also takes into account state institution studies and reports on water and sewage management in rural areas of Poland. These allowed the analysed changes to be analysed in depth, including from the perspective of legal and political conditions.

3. Results and Discussion

In 1989–2017, household water consumption in rural areas grew systematically (Figure 1). At the same time, the opposite trend was observed nationwide [14,15]. This was caused by the closure of many unprofitable industrial plants, which often had high water consumption. In the case of households, one important factor that reduced consumption was the widespread metering of tap water consumption and its increased price, as was the spread of water-saving sanitary installations and household appliances [16]. Rural areas' increased water consumption was due to two main factors. Firstly, in the period in question, the water supply network in rural areas was dramatically extended (Figure 1). Water intakes were also modernised in many places to enable increased water production and to ensure adequate quality. The length of the water supply network increased by almost 350% (from 52,600 km to 235,000 km). As a result, the percentage of people using the water supply network increased from around 30% in 1989 to over 85% in 2017. Earlier, the rural population used household intakes (wells), which were usually poor in quality [17–20]. The second factor was the systematic increase in rural populations. This was partly due to natural growth but also to increased migration from urban to rural areas [21]. As a result, the share of rural population in the total population of Poland increased from around 38% in 1989 to 39.9% (15.3 million people) in 2017.

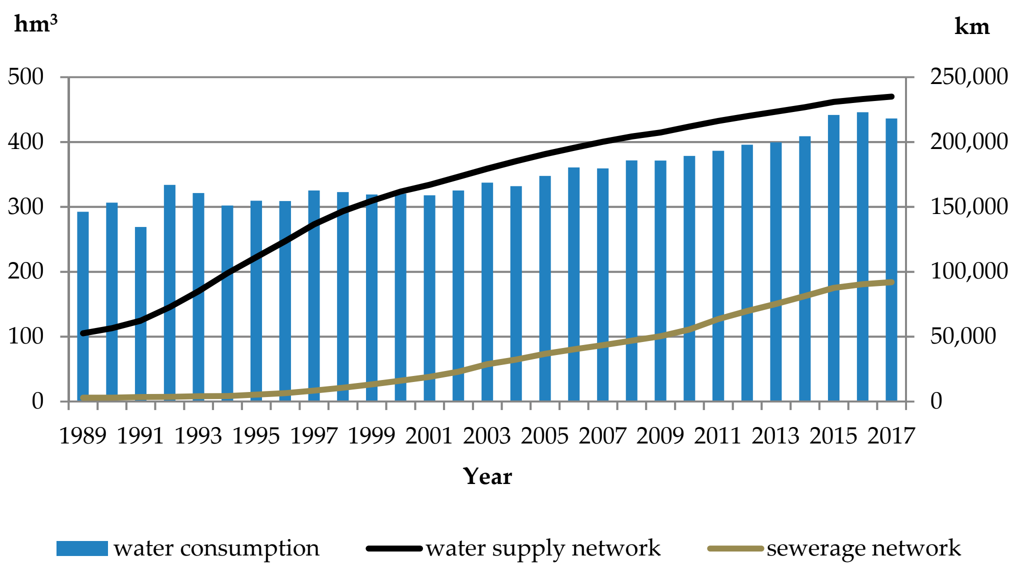

Figure 1. Water consumption and length of sewerage and water supply networks in rural Poland.

In the research period, a several-fold greater increase (of around 3000%) was recorded in the length of the sewerage network (from 2900 to 92,000 km). The annual average rate of change in length of the sewerage network was over 2.5 times that of the water supply network. In the years 1989–2017, the average annual increase in the length of the sewerage network was 13%, with the greatest growth (of over 20%) in the years 1995–2003. Increased investments in this period resulted from the need to adapt to the accession requirements imposed on Poland by the EU. In recent years, the rate of change in the length of both networks has weakened notably. However, this is mainly due to the base line being so high. In the last 10 years, the length of the sewerage network has increased annually by an average of 4800 km and waterworks by 3500 km. However, in the last two years, this increase was only 2800 and 1600 km for the sewerage network and 2.2 and 1.8 for the water supply system. There is still a clear disproportion between the lengths of the two networks, at 1:2.5 in favour of the water supply system (in 1989 this figure was 1:18). That such a large discrepancy between the two types of infrastructure has persisted for many years is due to the significantly lower costs of building the water supply network and to social considerations. In the rural population's hierarchy of needs, increasing infrastructure for supplying drinking water was much higher than for waste carrying away impurities [22]. To a large extent, this can be explained by the low ecological awareness of rural communities. For this reason, after joining the EU, alongside infrastructure investments, educational activities were also carried out. The latest results of research commissioned by the Ministry of the Environment confirm the effectiveness of these activities and a significant increase in public environmental awareness [23].

The slowing growth of the sewerage network in recent years suggests saturation with this type of infrastructure. However, the percentage of people using the sewerage network in rural areas only slightly exceeds 42% (in 1989 it was about 5.7%). In the coming years, one can expect a further increase in the length of the sewerage network but it will probably never approach the length of the water supply network. The reasons are both technical and economic. Rural buildings are much more spread out than urban buildings, which in many cases removes the economic justification for investment [24]. It should be remembered that WWTP is both the most important and the most expensive feature of wastewater management. There are also often technical limitations on constructing infrastructure in areas of diverse relief [25] and the risk of sewage standing in channels (in cases of low-volume discharge). The NPMWWT [9] update (2017) is also of importance to the further development of the sewage network in rural areas. The document assumes that plans to invest in extending the mains sewage network will be restricted to cases in which at least 90 residents per planned kilometre of network will be served. On this basis, it was only proposed to construct a sewage system in areas meeting the above criterion. According to [9] 14,661.2 km of sewerage network are planned for construction, of which over 6300 km will be within the smallest agglomerations ($\geq$ 2000 <10,000 population equivalent (PE)).

Due to these factors, in most cases the only solution is individual sewage management systems. Two solutions dominate in Poland and other countries. The first consists in the storing wastewater in holding tanks, which appropriate service providers or companies are commissioned to empty. In this case, sewage is only treated once it arrives at an WWTP. This solution is widely criticised because it does not dispose of wastewater but only retains it temporarily. In addition, these tanks often leak, which is a serious threat to surface and underground waters and land, lowering their quality [26–28]. Meanwhile, the high cost of emptying tanks encourages users to greatly reduce water consumption, which significantly increases the concentration of pollutants contained in them. In addition, excessively large intervals between emptying tanks mean that the waste is generally transported in a septic state. Biological treatment processes (which are used by most WWTPs in Poland) are sensitive to large changes both in quantity and in quality of sewage. Therefore, transported sewage can be a major threat to WWTPs [29]. Therefore, many authors emphasise the need to be very careful when dispensing this type of wastewater into the total amount of sewage being treated [30–33].

Despite the unfavourable consequences of using holding tanks, they are still the most widespread form of wastewater management in rural areas (Table 1). According to a Supreme Audit Office (SAO) report [34], holding tanks are one of the main causes of underground water pollution in rural areas [34]. This is due to property owners' failure to empty tanks with the appropriate frequency. SAO inspection results have shown that local authorities often do not even know how many tanks there are in their jurisdiction. Incorrect wastewater management in areas not covered by central sewerage causes measurable economic and ecological losses. According to [34] estimates, in the analysed communes, 80.5–99.9% of sewage was discharged untreated into the ground and waters. At the same time, existing treatment plants were not being used to their full capacity. Local authorities lacked basic information and so were unable to take well-substantiated decisions on developing the sewage infrastructure.

Table 1. Number of holding tanks and household sewage treatment facilities in rural Poland.

	2008	2012	2017	2008–2017 (%)
independent wastewater treatment facilities	45,225	114,214	214,225	373.7
holding tanks	1,978,673	1,903,055	1,806,228	−8.7

In recent years, the number of holding tanks has gradually been decreasing. They are being replaced by household sewage treatment facilities or connection to the sewage network. The speed of this process, however, seems unsatisfactory.

The aforementioned household sewage treatment facilities should be counted as the second solution for private sewage disposal. The number of household sewage treatment facilities has increased almost fourfold in the last 10 years (Table 1). This is despite this investment being significantly more expensive than holding tanks. However, according to many authors [35–37], running costs are significantly lower for household sewage treatment facilities than for holding tanks (taking into account the cost of periodic removal of waste to communal sewage treatment plants). Therefore, the high initial investment cost is quickly returned. At the same time, it should be noted that this solution is certainly environmentally better, because it removes a lot of pollution. Detailed requirements for wastewater treatment levels are contained in the Regulation of the Minister of Environment of 2014 [38]. It sets requirements for household treatment facilities that are decidedly lower than the requirements for WWTPs serving a larger number of residents. The most common technologies used in household wastewater treatment plants in Poland are filtering drainages, sand filters and hydrobotanic beds [39]. According to Błażejewski [40], 63% of household installations are household sewage treatment facilities with a septic tank and filtering drainage. Many authors [41,42] believe that sewage treatment facilities with infiltration drainage pose a serious threat to the quality of surface waters and groundwater. They should not be used in isolation to treat sewage but only for discharging biologically treated sewage. In addition, constructing such treatment facilities makes it impossible to monitor processes occurring in sewage introduced into the soil, so it is difficult to say whether they meet the applicable standards. These systems are now undesirable and are even banned in some EU Member States, due in part to problems related to the lack of control over their operation [43]. In France, following a detailed study showing a deterioration in groundwater quality in areas using this type of sewage treatment system, their construction was banned [44].

Undoubtedly, newly emerging household sewage treatment systems should be counted among the positive changes in water and sewage management in rural Poland. However, more attention should be paid to the type of technology they use. All the more so that domestic sewage treatment plants in Poland receive higher concentrations of pollutants than comparable treatment plants in Europe or the USA [45]. In addition, the proper operation of household treatment systems is essential, regardless of the technologies they employ. Incorrect use significantly reduces the effectiveness of pollutant removal from sewage [42,46]. It is estimated that the sustainable management of sewage and waste in rural Poland will require a further 700,000 systems to be constructed, to service approx. 3.8 million inhabitants [47].

As a result of the dynamic increase in the length of the sewerage network, it has been necessary to build new WWTPs in the last ten to twenty years. The total number of WWTPs increased from 451 in 1995 to 2068 in 2017 (Table 2). However, the quantitative increase aside, the change in quality should also be looked at. This is seen in the departure from the simplest and least effective wastewater treatment methods: in the years 1995–2017, the number of mechanical WWTPs decreased by more than half. However, until 2004, they were growing dramatically in number (in 2004 there were over 80). Only after Poland's accession to the EU did they begin to systematically decrease in number. At the same time, there was an increase in biological WWTPs (four-fold) and in WWTPs with increased nutrient removal (eighteen-fold). The increase in this last type of WWTP should be considered the most valuable in terms of environmental protection.

Table 2. Number of sewage treatment plants by type.

Wastewater Treatment Plants	Number of Plants				1995–2017 (%)
	1995	2004	2013	2017	
mechanical	23	82	39	11	−52
chemical	4	-	-	-	-
biological	402	1537	2014	2082	418
with increased nutrient removal	22	327	438	426	1836

The construction of new sewage treatment plants and the expansion of the sewer network was required in order to comply with the Directive 91/271/EEC. It should be noted that for a long time Poland misinterpreted one of the directive's main provisions concerning reducing biogenic pollutants. Poland assumed that it would reach the required level of reduction by implementing Art. 5 (4) of Directive 91/271/EEC (enhanced nutrient removal in all sewage treatment plants over 15,000 PE). The European Commission (EC) questioned this approach. According to the EC, Poland should have implemented a law based on Art. 5 (2) of Directive 91/271/EEC. Therefore, Poland is currently obliged to use enhanced nutrient removal for all sewage treatment plants in agglomerations of over 10,000 PE. Furthermore, it needs to be highlighted that in agglomerations of over 10,000 PE with several sewage plants of various sizes, each one must have enhanced nutrient removal technology. The change in interpretation of the provisions of Directive 91/271/EEC significantly increased its cost of implementation. This is also one of the main reasons why Poland has not yet fulfilled all of its conditions. It should be noted that a similar problem of legal implementation also occurred with Council Directive 91/676/EEC [48] (the nitrates directive). In this case Poland, too, was forced to change its current approach [49].

Constructing a new network of sewers and WWTPs increased the amount of treated wastewater nearly nine-fold. It also reduced the amount of untreated sewage. In 2017 this totalled 121,000 m^3, compared to more than 24,900,000 m^3 in 1998. Currently, more than half of treated sewage undergoes a treatment process with increased nutrient removal, while the remaining sewage is biologically purified (Figure 2). The change in the breakdown of the degree and method of sewage treatment is particularly important given the widespread threat of surface water eutrophication and the need to reduce it.

There is reason to doubt the statistics given on untreated sewage. As demonstrated by the SAO report [34], the amount of treated wastewater relative to amount of generated wastewater averaged 8.4% (from 0.1 to 29.5%) in the inspected municipalities. Bearing in mind that the local authorities in most of the municipalities in the report did not keep reliable records, the information they submitted to the statistical offices must also have been imprecise. It should be emphasised that the low values of this indicator relate only to areas not covered by the sewage system. However, this shows that there is a serious problem despite the official good statistics. Despite the increasing number of wastewater treatment plants, their capacity continues frequently to be a problem. This problem is currently hidden in many municipalities. This is due to the aforementioned low ratio of wastewater treated to wastewater generated. However, it becomes visible when municipal authorities begin enforcing regulations on waste removal among property owners. Then, analyses show, in many communes the sewage treatment plant will turn out to have insufficient capacity [34].

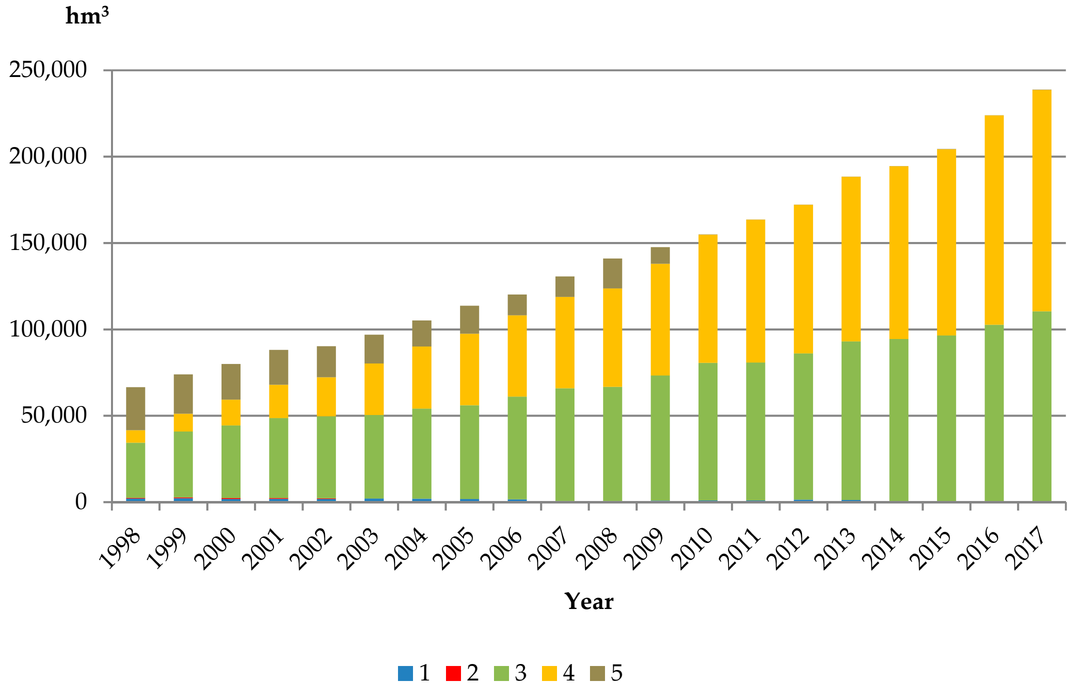

Figure 2. Wastewater requiring treatment fed into surface water or soil, 1998–2017 Explanations: 1 - mechanically treated wastewater; 2 - chemically treated wastewater; 3 - biologically treated wastewater; 4 - treated wastewater with increased nutrient removal; 5 - raw sewage.

In 1998–2017, the main organic and inorganic pollutant loads in treated sewage were reduced in Poland by between 53.5% and 84.2%, respectively (Table 3). In rural areas, the opposite trend was observed. Chemical oxygen demand almost quadrupled. The smallest increase was recorded in biochemical oxygen demand (an increase of 85%). The reason for such large increases is the aforementioned several-fold increase in the amount of sewage treated in rural areas. For this reason, the increase in pollutant loads should not raise any objections. There may be anxiety at the fact that this sewage is usually fed into small watercourses. Due to their size, they are the most exposed to the effects of climate fluctuations, which have become increasingly significant in recent years. Long drought periods that significantly reduce river discharges (deep and long-lasting low flows) are particularly dangerous. In the case of low river flow, discharges of treated wastewater still containing a certain amounts of pollution may disturb local aquatic ecosystems [50]. There is no similar threat in larger urban centres, as their sewage is usually discharged into large rivers.

Table 3. Change in pollution loads in treated sewage, 1998–2017.

Territorial Unit	Biochemical Oxygen Demand		Chemical Oxygen Demand		Total Suspension		Total Nitrogen	
	$kg \cdot year^{-1}$	%	$kg \cdot year^{-1}$	%	$kg \cdot year^{-1}$	%	$kg \cdot year^{-1}$	%
Poland	−62,088,255	−84.2	−93,388,192	−53.5	−44,563,460	−71.6	−21,283,030	−54.7
Poland - city	−63,503,374	−88.0	−110,136,935	−64.8	−47,477,235	−78.4	−23,701,159	−63.0
Poland - village	1,415,119	85.4	16,748,743	369.2	2,913,775	168.1	2,418,129	192.5

The development of the sewerage network resulted in more complex systems and certain negative phenomena, including increased susceptibility to failures. The network's sensitivity to short-term but intense precipitation also increased. Such extreme rainfall phenomena are increasingly common, which is most often associated with climate change. Rainwater and snowmelt get into sewers through openings and gaps in manhole hatches or through roof drains and gully traps being illegally connected to sewers [51–54]. They are detrimental not only to sewers and network facilities but also the operation of WWTPs. Sanitary sewage that is significantly influenced by rainfall sewage has a different composition and is more oxygenated and dilute. Excessive amounts of wastewater flowing in a short time causes hydraulic overloading of sewage treatment plant equipment or the leaching of activated sludge from a bioreactor [55,56]. This disrupts the proper process of nutrient compound removal [57]. Meltwater and rainfall significantly cool sewage [54]. This reduces the effectiveness of biological purification processes, which are at maximal efficiency at around 20°C [58,59]. Diluted wastewater has lower 5-d biochemical oxygen demand (BOD5) values—which inhibit denitrification processes—as well as reduced chemical oxygen demand (COD) and total suspended solids [60]. Total nitrogen and total phosphorus are also lower in raw sewage [61].

The opposite problem to that described above is hydraulic underloading of WWTPs in dry periods. In rural areas, this is a very common situation due to the amount of sewage flowing into WWTPs being highly variable over time. This may affect subsequent wastewater treatment stages, because the contaminant removal processes require a certain volume of wastewater [62–64].

There are also many problems with the water supply network. Water quality analyses conducted in 2015–2016 in rural communes of four provinces (Mazowieckie, Podkarpackie, Śląskie and Zachodniopomorskie) showed poor quality in approximately 4500 samples (14%). Of those, in about 1300 cases, decisions were issued that the water's use was conditional and in 277 cases the water was found to be entirely unfit for use. The poor water quality was mainly caused by the poor condition of the technical water supply infrastructure. In many cases, it continues to deteriorate, resulting in a growing number of failures. The blame for this should mainly be attributed to local authorities, which often fail to comply with their statutory obligation to develop a long-term plan for the development and modernisation of water-supply and sewage facilities [65]. Frequent failures and the poor technical condition of some part of the water supply system result in major water losses. The percentage water loss for 11 companies audited by the SAO [66] ranged from 4.4% to 48.5% of produced water volume. In addition, the [66] uncovered inefficient use of water for its own needs among water and sewage companies (flushing the water supply system, rinsing filters, etc.). Another significant irregularity lies in the lack of water quality assessment when events occur that may damage it (e.g., water supply system failures). This is in spite of water supply companies being obliged by law to do so [67].

As recipients of sewage, surface waters in rural areas can take in pollutants coming not only from WWTPs but also from pollution flowing off arable land. This is particularly significant in Poland, because, since the beginning of the 1990s there has been a systematic increase in the use of mineral fertilisers (Figure 3). This applies first of all to nitrogen, potassium and phosphorus fertilisers, that is, those that have the greatest impact on the eutrophication of surface waters. As a result, surface waters in agricultural areas are threatened by increasing pollution loads [68]. In the event of the aforementioned harmful climate fluctuations (long-term droughts), this threat increases. In Poland, the eastern part of the Wielkopolska-Kujawy Lake District is particularly predisposed to such a state of affairs. The region is one of intensive agriculture, with quite a high population density and a very unfavourable vertical exchange index. In some years evaporation is more than double total atmospheric precipitation [69,70]. An additional problem is drainage associated with the operation of open-pit mines lowering the water table and forming cones of depression [71–73]. For these reasons, the region is widely recognised as Poland's most problematic in terms of water resources. This example perfectly highlights the special role of water and sewage management, which must take into account local conditions. Otherwise, it may exacerbate the pressure on a region's aquatic ecosystem.

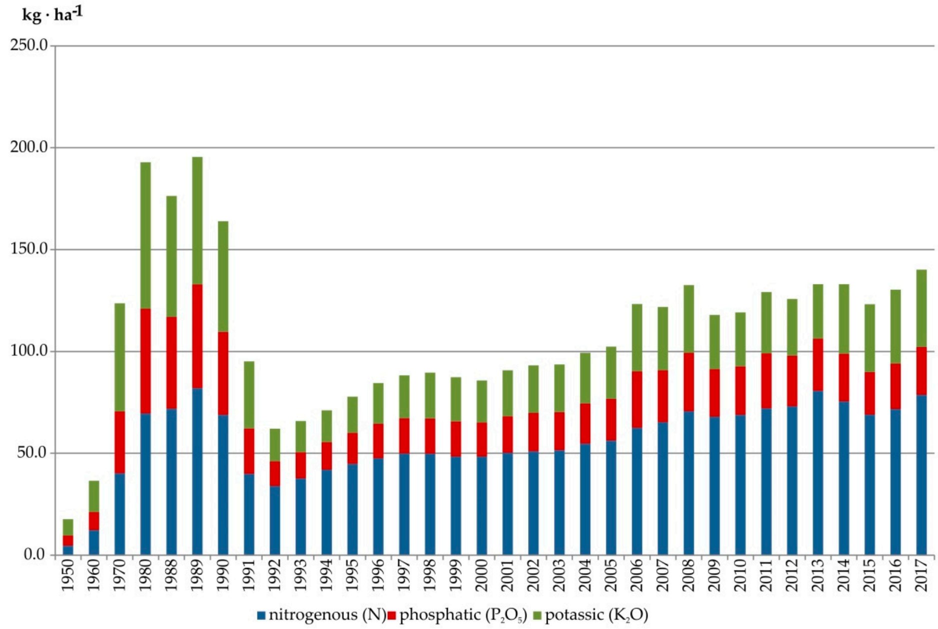

Figure 3. Amount of fertiliser (kg) per hectare in Poland.

Water and sewage infrastructure is one of the most expensive and, at the same time, most fundamental parts of economic infrastructure. The amount of funding needed to implement investments in this type of infrastructure is often beyond the means of local authorities. Therefore, the development of water and sewage infrastructure in rural areas has mainly been possible through additional funding from the state budget or other external sources. For Poland, the significant external funding sources include EU funds [74–76]. In 2003–2017 Poland allocated 10 billion euros to developing rural water and sewage infrastructure. That is approximately 30% of the revenue for the 2003 national budget. More than half of the funds were allocated to expanding the sewerage network and the least to individual sewage treatment systems (Figure 4). In recent years, the funds allocated to investment have clearly decreased. One of the main reasons is that most of the most socially, ecologically and economically important investments have been completed. The other investments are technically difficult to implement due to the terrain being varied and buildings being spread out. As a result, the outlays required for these investment are significantly higher. They often outweigh municipalities' current financial means, which means that in the coming years no further rapid development of water and sewage infrastructure should be expected [77].

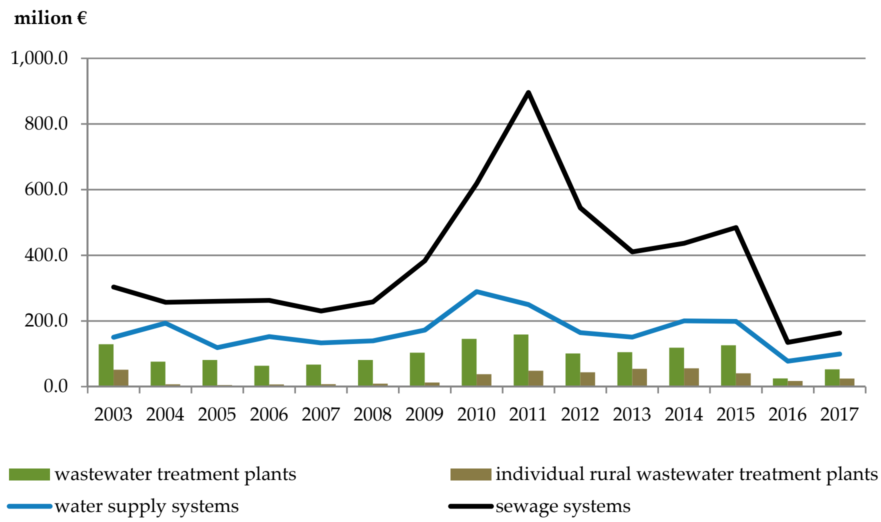

Figure 4. Expenditure on selected elements of water and sewage management in rural Poland.

The estimated cost of investment in sewage infrastructure by 2021 according to the [9] is approximately EUR 6.4 billion. This amount includes investments for towns and cities. Forecasts indicate that, despite these large expenditures, the requirements [8] will be fully met in only about 65% of agglomerations, which corresponds to 80% of the rural equivalent.

4. Conclusions

Adapting to EU requirements has been the main driver of positive change in Poland's water and sewage management in recent years. EU financial support in this regard has also been important. In most cases, EU law has been properly implemented. Attention has been drawn to problems in the implementation of provisions from two directives (91/676/EEC and 91/271/EEC). Poland's different interpretation of the regulations was motivated by a desire to reduce costs. Ultimately, Poland was obliged by the EC to implement solutions that would ensure fuller environmental protection. Nevertheless, the implementation of EU regulations into Polish legislation should be evaluated very positively. Without the requirement to quickly adapt to EU regulations, water and sewage management would probably have made far less progress.

Water and sewage management in rural Poland has greatly developed, both quantitatively and qualitatively, since the early 1990s. The length of the water supply and sewage system has increased many-fold, which has increased its accessibility for rural society. The amount of water consumed and wastewater treated has increased. This required investment in water intakes and WWTPs. There has been very great progress, particularly in WWTPs. Over 2000 new WWTPs were built, including more than 400 providing increased nutrient removal. This significantly reduced the discharge of untreated or partially treated wastewater into surface waters.

Despite the undoubted progress that has been made in water and sewage infrastructure, there are still some areas needing improvement. Furthermore, the conducted analysis demonstrated irregularities in the management, inspection and enforcement of the law. The introduction of improvements must be deemed necessary. The following recommendations were formulated in this regard:

- Consolidation of small water and sewage companies. As research results indicate, large enterprises in the sector are better managed and have modern tools. This allows them to provide higher quality services. They also have more opportunity to raise external funds for investments and to attract highly qualified employees.
- Implementation of solutions to reduce water losses in the water supply network. This could include installing flow recorders and introducing pressure regulation. Enterprises that have applied this solution have recorded a significant reduction in water losses [59]. Because the costs of implementing this solution are relatively low, legal requirements on the use of these devices should be considered.
- Introduction of the requirement to provide up-to-date tap-water-quality information using media, in particular the Internet (websites, social media). At the same time, an increase in number of tap-water-quality inspections by external state institutions.
- A detailed inventory of water and sewage management facilities in rural communes. Development of a long-term plan for the development and modernisation of water supply and sewage facilities—implementation of the statutory obligation [66]. Introduction of restrictions on applications for funds to invest in water and sewage management for the fulfilment of the aforementioned conditions. At the same time, free (or subsidised) help for municipalities to be provided by external water and sewage management specialists. Analyses show that some municipalities are unable to meet statutory requirements due to human resources issues.
- Introduction of legal regulations requiring the removal of existing holding tanks within a particular timeframe (e.g., 15 years) and prohibiting the construction of new ones. Comparable regulations should be introduced for household sewage treatment plants that do not provide

an adequate level of wastewater treatment or those for which wastewater treatment cannot be inspected. At the same time, during the transitional period, it is necessary to introduce the obligation for municipalities to collect sewage and sludge (generated by the technological processes of household wastewater treatment plants). Property owners would be required to bear the cost of these services. This solution would be similar to that in operation since 2011 in the field of municipal waste collection [78]. In the case of municipal waste, it has had very good results.
- Development and dissemination of new solutions in the field of individual wastewater management. One of these might be to create a group system in which several farms are connected to a system supplying sewage to a shared treatment plant that is based on a simplified technology, for example, constructed wetland [79].
- Introduction of obligatory training in the field of domestic wastewater treatment and proper operation of implemented systems for owners of individual wastewater treatment plants. The training would include knowledge about the ecology of water and sewage management in the broader sense.
- Introduction of financial incentives (discounts and rebates) for customers connected to the sewerage network to collect and use rainwater (e.g., for watering lawns).
- Water-quality control of rivers that receive treated wastewater during periods of low water levels. In the case of permissible pollution values being significantly exceeded, the obligation of enterprises to develop appropriate solutions.

The presented recommendations are very wide in scope and concern various aspects of water and sewage management. However, their implementation depends mainly on two questions. The first is financial resources. Without additional external funds, it will be impossible to improve water and sewage management in rural areas. It should be remembered that many municipalities are already in significant debt. In large part, this is the result of investments made in recent years involving EU funds. Currently, despite the possibility of co-financing projects with external funds, many rural communes cannot implement them due to not being able to provide their own required share. This is a very serious problem that needs to be solved by authorities at the central level.

The second equally important question is of how self-government authorities operate. Even the most well-constructed law is irrelevant in the absence of proper enforcement. In Poland, there are currently a number of good solutions addressing the issues at hand. Unfortunately, as research has shown, many laws are simply not being put into effect. As a result, water and sewage management is unsatisfactory in many rural communes. In addition, the failure of self-governmental administrations to properly execute their statutory duties may increase inappropriate behaviour among citizens. This can manifest as a lack of respect for established law and pro-ecological policy. It is therefore necessary to significantly improve water and sewage management at the local government level.

It should be emphasised that, despite being focused on Poland, the issues raised in this study are of much broader import. The majority of Central and Eastern European countries have a similar situation in terms of the number of people living in rural areas. This is a consequence of the common political and economic system (communism) that dominated this part of Europe until the 1990s. Therefore, with some local modifications, some of the conclusions and recommendations contained here could also be applied in those countries.

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