Specifics of the sewerage in Poland in the context of green infrastructure application

Specyfika kanalizacji w Polsce w kontekście zastosowania zielonej infrastruktury

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The basic features differentiating the sewage disposal systems in Poland from the systems existing in Western countries have been described. The much greater content of separate systems in the country and the assignment of the entire territory of Poland to the sensitive area in respect of the requirements for parameters of treated wastewater, make the use of green infrastructure a promising solution in terms of reducing pollution loads discharged into rivers. The use of green infrastructure may contribute to the improvement of the unsatisfactory condition of surface waters in Poland. Moreover, it brings numerous other benefits for the inhabitants of urban areas. A comparison of the law requirements to combined sewerage overflows in selected countries showed that those imposed in our country are very liberal, and the scale of the impact of emergency discharges from the sanitary sewerage systems on the poor condition of surface waters is not known. None statistics of such cases are elaborated, due to the current legal rules. All these circumstances and delays in the construction of retention reservoirs prove the need to improve the quality of surface water, which may be helped by green infrastructure, the types and distribution of which should result from the solution of optimization tasks.
Keywords: rainwater, combine sewer overflow, sewerage, retention

Opisano podstawowe cechy różniące systemy odprowadzania ścieków w Polsce od systemów istniejących w krajach zachodnich. Znacznie większy udział w kraju systemów rozdzielczych i przypisanie praktycznie całego terytorium Polski do obszaru wrażliwego jeśli chodzi o wymagania stawiane oczyszczanym ściekom powoduje, iż zastosowanie zielonej infrastruktury jest obiecującym rozwiązaniem w zakresie zmniejszenia ładunków zanieczyszczeń zrzucanych do rzek. Zastosowanie zielonej infrastruktury może przyczynić się do poprawy niezadowalającego stanu wód powierzchniowych w Polsce. Ponadto przynosi ona liczne inne korzyści dla mieszkańców terenów zurbanizowanych. Porównanie przepisów dotyczących przelewów w wybranych krajach pokazało, że w Polsce są bardzo liberalne, a skala wpływu zrzutów awaryjnych z kanalizacji bytowo – gospodarczej na zły stan wód powierzchniowych nie jest znana, gdyż nie są prowadzone statystyki takich przypadków, a to z uwagi na obowiązujący stan prawny. Wszystkie te uwarunkowania i zapóźnienia w budowie zbiorników retencyjnych świadczą o potrzebie poprawy stanu wód w czym pomóc może infrastruktura zielona, której rodzaje i rozmieszczenie powinno wynikać z rozwiązania zadań optymalizacyjnych.
Słowa kluczowe: wody opadowe, przelewy burzowe, kanalizacja, retencja

Introduction

Revolutionary legal changes in the field of water protection took place in Poland with the entry into force of the Ordinance of the Minister of Environmental Protection, Natural Resources and Forestry of November 5, 1991 "On the classification of waters and the conditions to be met by sewage discharged into water or into the ground" (Issue 116, item 503). There have been fundamental changes in the issue of water-legal permits for extraordinary use of water in the scope of sewage disposal. At that time, the issuance of water-legal permits based on the balance of pollutants in the receiving body was abandoned and the requirements were adopted according to the so-called best available and economically justified wastewater treatment technologies. In practice, it was only this Regulation that indirectly introduced the requirement to apply, in all conditions, second-stage wastewater treatment and removal of nutrients by specifying in Annex 2 such values of "maximum permissible values of pollutants in sewage discharged into water and soil", which could not be obtained only by mechanical cleaning. The introduction of these new legal conditions significantly improved the quality of surface waters, but was associated with irrational management of financial resources, which will be described later in the article. There is a common misconception that, until the Round Table Agreements were reached, no efforts were made to improve the quality of Poland's waters. Meanwhile, the statistical data show that in the mid-1980s, i.e. before 1989, more biological treatment plants began to be launched. It was probably concluded that the poor quality of water began to constitute a barrier to the economic development of the country and

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that the low life expectancy of Poles should be extended, and it would not be possible to do so without improving the quality of the environment.

The order in which funds were spent

The aforementioned Regulation of November 5, 1991 "On the classification of waters and the conditions to be met by wastewater discharged into waters or into the ground" (Journal of Laws No. 116, item 503) was introduced for all objects for which no final construction decision was made. Thus, all newly designed treatment plants had to meet these requirements. On the other hand, the existing ones could still be operated, and industrial plants could apply for a favorable change in the permissible parameters of wastewater discharged into the environment. After the expiry of the water-legal permits, the explorers of the existing treatment plants applied for new permits, which were not able to meet without the modernization of the treatment plant. The discussed regulation [10] meant that as early as 1999 in Poland, 48% of wastewater was treated at least in conventional biological treatment plants, and at that time only 18% in Greece, 25% in Ireland and 40% in Italy [1,2]. The worst European examples were selected here and most developed European countries still had a much higher percentage of biologically treated wastewater than Poland, eg Finland in 96%. Of course, it was essential to enable a smooth transformation of the approach to environmental protection. The problem, however, was that updated environmental charges and fines did not provide sufficient incentives for the swift modernization of large wastewater treatment plants. As a result of such a policy, financial resources were first allocated to new (usually small), and only then to old (and therefore large and largest) sewage treatment plants. As the total cost of treating wastewater quickly decreases with throughput, it wasted some money. In this situation, it is true that in 1991 a sewage treatment plant, designed from 1976, collecting sewage from the right-bank districts of Warsaw (capital of Poland) and the surrounding municipalities, started operations, but the treatment technology used did not meet the statutory requirements and the sewage treatment plant required thorough modernization, which was one of the arguments for building one central sewage treatment plant that also served central and northern part of left-bank Warsaw. This, in turn, required the construction of two siphon lines under the Vistula River, the causes of whose failure in 1919 and 1920 have not yet been announced. Regardless of this matter, it should be stated that it was only in 2012 that the expansion / modernization of the modern Czajka sewage treatment plant was completed, which more than meets the current legal requirements. The treatment plants in large provincial cities were modernized similarly late, and the costs in almost all cases were partially covered by the European Union.

Summing up, it can be stated that during the transformation of the wastewater treatment system, legal conditions meant that financial resources were transferred more quickly to smaller than to the largest wastewater treatment plants, where a cheaper reduction of pollutant loads discharged into rivers was achieved. When assessing this unfavorable shift in time in years, it should be remembered that the process of obtaining approval to design such large investments takes years.

Rainwater drainage and green areas

Combined sewerage is considered to be the worst type of sewage system due to the pollution loads discharged by storm overflows to the receivers. In addition, rainwater can be stored in separate and semi-separate sewage systems, treated and used for various purposes. In areas served by combined sewerage systems, SBMS (Stormwater Best Management Strategies) methods can also be used to reduce and delay runoffs, but only directly at the point of rainfall, and not after collecting runoff in combined channels. In this respect, Poland has a special situation in Europe, predisposing it to use green rainwater retention, because in the country we have just over 20% of the length of combined sewers, while in Austria 75-80%, in Belgium 70%, in Denmark 45-50%, 67% in Germany, 75-80% in France, 20% in Greece, 60-80% in Ireland, 60-70% in Italy, 80-90% in Luxembourg, 74% in the Netherlands, 40-50% in Portugal, in Spain 90-95%, in Finland 10-15%, in Sweden 40% and in the United Kingdom (UK) 70% [1,2,7] of the total sewage area. This is, paradoxically, some progress due to the delay. In the countries of the western part of Europe, sewerage systems were built at a time when separate systems were not used. Nevertheless, regardless of the reasons Poland now has a unique opportunity to increase bioretention and use of rainwater runoff outside the rainfall area itself, thanks to a much larger share of separate sewage systems compared to Western countries.

Uncontrolled discharges from storm overflows

Both in the case of leaky sewage systems and in emergency conditions, there are inevitable and uncontrolled discharges through emergency overflows of sewage treatment plants and outflows from household and combined sewerage systems [6,13]. In a 1996 report [12], the Environmental Protection Agency of the United States of America estimated that 43% of these spills were caused by excessive sewage sludge, 27% incidental and infiltration water, 12% cracks and leaks, and 11% electrical power failures. pumps and 7% too low capacity of the channels. It has been estimated that approximately 40,000 such discharges occur annually in this country. U.S.A. procedures operators of wastewater drainage systems in the case of discharges via emergency overflows or overflows from the sanitary sewage system are described in the national literature [6]. Any company operating a wastewater disposal system is required to report to the U.S. Environmental Protection Agency a plan of reducing and finally hopefully eliminating emergency discharges in future. The plan is to include a list of actions to be undertaken, along with a time schedule and planned costs, and is subject to verification and approval by the Environmental Protection Agency (US EPA). When there is an uncontrolled discharge of sewage, the operator is obliged to report this fact in any way within 24 hours, even by phone. Further proceedings depend on the state in which the incident occurred, as the legal system is not the same everywhere. In most cases, a detailed incident report is to be submitted within five to seven days, which should include topographic data, estimated volumes of discharged pollutants and a description of the action taken to reduce the nuisance to the environment. The Environmental Protection Agency checks whether: there is a corrective action plan approved by it, whether the actions provided for in this plan were carried out and appropriate financial sources spent for this purpose, and whether the submitted discharge report is reliable. If so, neither the institution operating the sewerage system, nor any of the people who manage it, bear any consequences. No such mechanism has been established in Poland and each emergency discharge is an offense or a crime, depending on the scale. Such a law leads to a situation in which no one reports these discharges and we do not have figures for such incidents. We only know that emergency discharges occur, and most likely on a large scale, especially in cases where the sanitary sewage system is leaky and large amounts of infiltration and accidental waters get into it. One of the possibilities of relieving the sewage system and reducing the environmental nuisance of these discharges is the construction of green infrastructure. It can be cheaper than constructing reinforced concrete retention tanks, and additionally brings other benefits for residents, such as: local climate change, increasing the value of real estate and a dozen others [8].

Influence of storm overflows on rivers

In the Regulation of the Minister of Environmental Protection, Natural Resources and Forestry of November 5, 1991 "On the classification of waters and the conditions to be met by wastewater discharged into waters or into the ground" (Journal of Laws No. 116, item 503), not only revolutionary changes in the requirements for the degree of wastewater treatment, but also completely different requirements were introduced regarding the limitation of discharges from storm overflows. Until the implementation of this regulation, these requirements concerned the coefficient of initial dilution of domestic sewage with rainwater (Initial Dilution Factor), which was assumed in the range of 1:6 to 1:2 depending on the size of the receiver, the sewerage network and also the location of the overflow. From the end of 1991, restrictions were imposed on the number of times the discharges happen in an average year. First, the allowable discharges frequencies depended on the average low annual flow rate in the watercourse, then, for some time, the obligation to exceed the flushing rainfall intensity before the start of discharges through the overflows was introduced, and then both these conditions were abandoned. In previous regulations, as at present, discharges from combined sewerage systems into surface water reservoirs were not allowed, and moreover, discharges from rainwater sewers into non-flowing reservoirs were prohibited and the average annual number of rainwater discharges into flow-through reservoirs was limited to five times a year. Currently [11] the regulations allow for discharging from storm overflows of combined sewerage systems to watercourses while maintaining an average number of overflows operation of no more than 10 per year, and for sewerage catchments with an Population Equivalent (BOD PE) over 100,000, this number should be determined on the basis of numerical calculations based on o measurements of rainfall intensity over a period of at least ten years. For sewerage catchments with a lower value of BOD PE, it is allowed to determine the average annual frequency of discharges based on observations covering two years. This method of determining the average annual number of discharges is at least questionable as it is not known whether it will come across dry or wet years. Sometimes the hydrological cycles repeat even in periods of more than ten years. For drainage basins up to 99,999 BOD PE,

Table 1. Overview of the combined sewer overflows designing criteria in Europe [14],[3].

Country	Qmax		f; V	Standards	Contaminant load	Mathematical modelling
Belgium	6 Q_p	10 Q_m	f=2	UES+	No	No
Denmark	5 Q_p	8-10 Q_m	f=2-10	UES+ and EQO/EQS	Yes	Yes
France	3 Q_p	4-6 Q_m	-	UES+ and EQO/EQS-	Yes	Yes
Germany	-	7 Q_m*	V=10-40	UES	Yes	No
Greece	-	3-6 Q_m	-	UES+	No	No
Irland	-	6 Q_m	-	UES+	No	No
Italy	-	3-5 Q_m	-	UES	No	No
Luxembourg	3 Q_p*	4-6 Q_m	V=10-40	UES	No	No
Netherlands	-	7 Q_m	-	UES+ and EQO/EQS	No	No
Portugal	-	6 Q_m	-	UES	No	No
Spain	-	3-5 Q_m	-	UES	No	No
Great Britan	-	6.5-9 Q_m**	-	EQO/EQS	Yes	Yes

Q_{max} - the maximum allowable volume flow of wastewater directed to the treatment plant, m^3/h,
Q_p - maximum hourly wastewater volume flow during dry weather, m^3/h,
Q_m - average hourly volume flow of wastewater during dry weather, m^3/h,
* - the German ATV-128 standard requires 90% of the pollutant load to be directed to sewage treatment plants,
** - as a collective result (also taken into account in Ireland),
UES - Uniform Emission Standards,
UES+ - unified emission standards taking into account certain elements of the receiver,
EQO / EQS - environmental quality objectives / Environmental Quality Objectives / Environmental Quality Standards),
EQO / EQS- - method applied but it is not known to what extent used,
f - frequency of the discharge during a year,
V - unit retention volume (volume /area), m^3/ha.

the use of the Initial Dilution Factor is permitted. The regulation [11] specifies its value as 3, so the overflow edge should be located at least at the filling height in the sewer corresponding to four times the average daily flow of sewage in dry weather.

When considering national regulations on storm water in relation to the need to invest in green infrastructure in urban areas, several important facts should be taken into account. Storm overflows did not have a significant impact on the quality of surface waters before 1991, when we did not have efficient biological treatment plants and when it was not required to remove nutrients beyond the effects accompanying the improvement of other physical and chemical parameters of the treated wastewater. On the other hand, in highly-efficient sewage treatment plants in the area served by combined sewerage system, the annual loads of COD from the treatment plants and from storm overflows are very similar on a yearly basis [7]. So now the impact of stormwater overflows on receiving waters is extremely important. The book [7] reviews the legal status in several European countries and in the U.S.A. in respect to the requirements relating to storm overflows. The comparisons were made with reference to the literature research covering mostly the period of 2000 – 2004 and showed a much weaker requirements in Poland than in other countries. In those countries where the conditions for combined sewer overflows were determined on the basis of the Initial Dilution Factor in relation to the average daily flow during dry weather, the required dilution ratios were much higher than in Poland. For example in the Netherlands there were at least 3-10, in Belgium in relation to the existing overflows 2-5, and for the new 5-10, in Denmark 5, in Portugal 6, in Greece 3-6, in Spain and Italy 3-5, in Great Britain traditionally 6 in England and Wales. However, in the seventies of the last century, rules in GB for assessing storm overflows were established based on the so-called A formula for small overflows, and for medium and large overflows on modeling of the impact of overflows on the water quality in the watercourse. In particular, the concentrations of ammonia nitrogen and oxygen in watercourses are normalized in the periods of 1h, 6h and 24h [7]. In France and Luxembourg, the Initial Dilution Factor was set at 3, but in relation to the maximum hourly flow rate in dry weather, so this condition is much more restrictive than in Poland, especially for streams and small rivers.

Retention reservoirs

In some countries, such as in the Netherlands, a specified value of precipitation is required. The Germans did the most when it comes to retaining rainwater in retention reservoirs. Already in the book from 2004 [7] it was stated that in this country over 34,700 retention reservoirs with a volume exceeding 12.8 km3 were built in sewerage networks. The total volume of retention reservoirs in Poland is not known to us, but it is incomparably smaller. While large tanks should be dimensioned based on real-time flow simulation, in Germany, the ATV 128 standard can be used for the dimensioning of small tanks, according to which one hectare of impermeable surface should have from 20 m3 to 40 m3 of retention. It is true that in Germany the average annual amount of precipitation is clearly higher than in Poland. However, in both countries the total highest rainfall occurs in July and in this month it is almost identical, or even slightly higher in Poland. So, on this basis, we can estimate our delays in creating retention and it is probably cheaper to create it in the form of green infrastructure than in a form of grey infrastructure.

European Standard for Outdoor Sewerage

The European standard PN-EN 752: 2017-06 [9] (previous version of PN-EN 752:2008) introduced significant changes in the design of gravity sewerage systems. Traditionally, in Poland, the rainwater and combined sewers were designed to be fully filled during design storm events. It was even allowed to accept the storm water table 0.5 m below the ground surface in drainage inlets. The design frequencies of rainfall adopted in these calculations do not differ significantly from those given in the PN-EN 752:2017-06 standard. However, it introduced a new design requirement to specify the design rainfall frequency at which it is still possible to collect rainwater from the ground surface. In accordance with the Water Framework Directive, not collecting storm water or discharging it to the ground surface is considered as a flood and therefore the standard [9] allows it rarely, for high rainfall design frequencies much higher than those considered in traditional design computations done according to former Polish standards. Thus, the rainwater and combined sewage systems are usually undersized in respect to new requirements [5]. Green infrastructure can be one of solutions to be applied for relatively low cost.

Rainfall intensity

Traditionally, since the 1950s, the design intensity of rainfall has been determined based on Błaszczyk's formula [4], which was developed on the basis of measurements carried out only in Warsaw and later generalized to the whole territory of Poland on the basis of analogy with the Gorbaczew equation. Not only the data on rainfall were collected in one place, but also the entire period of their collection was 67 years, but due to the lack of data, only the 37-year period was taken into account for interpretation. The intensity of torrential rains determined in this way, was assigned to the 67-year period, which obviously resulted in assigning them to higher storm return periods than in reality. Moreover changes of climate result in more frequent heavy storms.

Conclusions

According to the official statistics in Poland the percentage of combined sewer systems is much lower than in Western European countries, which results from the fact that in those countries sewerage systems were constructed much earlier, when separate and semiseparate systems were not applied. This creates the opportunity of using green infrastructures for collecting and treated stormwater in some other places, not only in the place of precipitation. Green infrastructure is a promising technology for dealing with too small sewers dimensions resulting from new design requirements established by European standards and too small storm water intensities determined according to the Błaszczyk formula.

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