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WATER MANAGEMENT IN POLAND IN VIEW OF WATER SUPPLY AND SEWAGE DISPOSAL INFRASTRUCTURE DEVELOPMENT

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Summary

The quantitative and qualitative state of water resources in Poland were presented in the paper. Discussed were selected factors shaping changes of water quality, including: improvement in sewage treatment balance, increase in the sewage system length, increase in the population number using sewage treatment plants, diminished outflow of organic substances and biogens in treated sewage. Presented state of water purity in Poland indicates, that despite improving quality, their state is still bad and the date when the desired state may be reached is still distant. The needs of municipal economy were presented against the state of water management, including the characteristics of selected systems of waterworks and sewage disposal systems development during the period of the last two decades, indicating the specific character of these systems in rural areas.

Key words: water resources, water management, waterworks, sewage system

INTRODUCTION

Water supply for cities and villages together with sewage disposal are the priority tasks of local self-governments. The accompanying problems are due to the state of Poland's water resources, but on the other hand they also affect this state. Quantitative and qualitative state of water resources, both surface and groundwaters is the basic factor of potential water supply and treated sewage disposal, including the costs involved in these operations. A diversity of con-

sumers using water resources and affecting their state may pose a question about the share of water supply and sewage disposal systems of settlement units in the balance of water management in the whole country.

The paper aims to address selected issues of water resources development in Poland as connected with the state of water supply and sewage system infrastructure development.

QUANTITATIVE STATE OF WATER RESOURCES

The quantitative state of surface water resources in Poland is characterised by several indices, including:

- Annual resources of surface water flowing away from the territory of Poland in 1980-2010 were on average 63.1 km^3, including own resources and inflows from abroad.
- The minimum resources were 37.9 km^3 (1990) and the maximum exceeded 90 km^3(1981).
- The average annual precipitations in Poland over the 1951-2000 multi annual period were 617.4 mm, which gives almost 193.1 $km^3$of water.
- Poland's own water resources are 54.3 km^3.
- The surface water collection in relation to own resources is 18.2% (Hungary 333.2%, Sweden – 1.2%).
- Water collection per 1 inhabitant is 302 $m^3 \cdot M^{-1} \cdot year^{-1}$ (Estonia – 1036 $m^3 \cdot M^{-1} \cdot year^{-1}$, Denmark – 120 $m^3 \cdot M^{-1} \cdot year^{-1}$).

Summing up it may be stated that the numbers describing the above mentioned flowing water resources indicate the following:

- Against the other European countries Poland is poor in water resources – 4.5 $dm^3 \cdot s^{-1} \cdot km^{-1}$ (European average – 9.5).
- A diversity of climatic conditions occurring in Poland causes a diversity in annual flows.
- The capacity of retention reservoirs is too small and does not provide an efficient protection against floods or droughts, moreover limiting the possibility of using water for municipal economy needs.
- The qualitative-quantitative state of water resources in Poland causes that local self-governments face problems with fulfilling their statutory obligations and bear higher costs of adjusting to the quality requirements for potable water (Rozporzadzenie … 2010).

Groundwater resources have not been precisely defined for the whole territory of Poland. Hydrogeological works in result of produced additional evidence, caused an increase in the exploitable groundwater resources. The exploitable resources are a part of the resources which may be collected without disturbing the

hydrogeological balance. In 2010 the documented groundwater resources were 449.7 $m^3 \cdot M^{-1} \cdot year^{-1}$, but the degree of their utilisation does not exceed 8%. The quantitative characteristics of the documented groundwater resources was presented in Table 1. These resources should be under special protection, whereas their utilisation should involve collection for waterworks purposes

Table 1. Characteristics of exploitable resources of groundwater in Poland (Ochrona środowiska, 2012)

	Unit	1990	1995	2000	2005	2010
Total	$km^3 \cdot year^{-1}$	14.04	15.39	16.05	16.58	17.18
Quaternary		9.13	9.99	10.57	10.93	11.38
Tertiary		1.54	1.64	1.63	1.68	1.78
Cretaceous		1.82	2.11	2.18	2.26	2.34
Older		1.54	1.65	1.67	1.70	1.67
Per 1 inhabitant	$m^3 \cdot year^{-1}$	368.7	401.9	431.3	434.4	449.7

SELECTED FACTORS SHAPING CHANGES OF WATER QUALITY

Improvement in treated sewage balance

From the perspective of water and sewage management, the possibility to use water resources determined by spatial and time variability of not only water quantity but also its quality should be regarded as the most important. Water quality depends on many factors. Water pollution affects the state of water ecosystems and water depended systems, sometimes leading to a change of plant species, including the disappearance of some populations. Water quality directly determines the costs of water extraction for waterworks.

A noticeable improvement of water resources quality in Poland results from various activities undertaken for many years, among others by water and sewerage companies. A systematically diminishing volume of sewage from municipal sources has been observed since 1980. In 1980-2005 the volume decreased by 46%, whereas in the following years its slight increase (1%) was observed, Table 2. The volume of untreated sewage has been diminishing systematically and over the last thirty years it decreased from 55 to 4.3%.The volume to sewage supplied to treatment plants, therefore treated sewage could be higher if the sewerage systems were more extensive, particularly in rural areas. It should be emphasized that in 2010 as much as 81.5% of sewage was treated including increased biogen removal.

Table 2. Balance of treated and untreated municipal sewage in Poland (km^3) (Rocznik 2011)

	1980	1990	1995	2000	2005	2010
Total	2.34	2.31	1.85	1.49	1.27	1.30
Sewage demanding treatment	2.34	2.31	1.85	1.49	1.27	1.30
Sewage treated:	1.04	1.39	1.26	1.24	1.14	1.24
– mechanically	0.52	0.55	0.26	0.08	0.05	0.01
– chemically	0.00	0.00	0.04	0.00	0.00	0.00
– biologically	0.52	0.85	0.88	0.71	0.37	0.23
– with increased biogen removal	-	-	0.07	0.44	0.72	1.01
Untreated	1.30	0.92	0.59	0.25	0.13	0.06

Increase in the sewerage system length

The activities undertaken to improve the state of the environment caused that in recent years a considerable increase in the length of sewerage system has been observed in Poland, particularly since 1990. A considerable increase has been characteristic especially for rural areas. Table 3 shows the development of sewerage system in Poland and the accompanying increase in the number of sewer connections.

Table 3. Increase in the length of sewerage system in Poland (Rocznik, 2011)

Year	Length of sewerage system (thous. km)			Number of sewer connections (thous.)		
	rural areas	city	total	rural areas	city	total
1995	5.4	28.1	33.5	73.4	657.5	730.9
2000	16.2	35.0	51.2	259.6	867.8	1 127.4
2005	38.7	41.4	80.1	598.0	1 156.5	1 754.5
2010	55.6	51.9	107.5	906.3	1 412.7	2 319.0

The compilation shows that during 15 years the length of the sewerage system in rural areas increased by 929.6% and in the city by 84.7%, whereas the number of sewer connections increased by 1134.7% in rural areas and by 109.1% in urban areas.

Increase in the population number using sewage treatment plants

The increase in sewerage system length observed in Poland since 1990 causes a proportional increase in the population number using sewage systems.

The increase is particularly great in rural areas, as has been evidenced by the data in Table 4.

Table 4. Population using sewage treatment plants in Poland (Ochrona środowiska 2002)

Specification	1990	1995	2000	2005	2010
Population using treatment plants in population total	-	41.5	53.1	60.2	65.2
People in the cities using treatment plants in % of urban population	55.6	65.7	80.0	85.2	88.6
Rural population using treatment plants in % of rural population	-	3.1	10.8	20.4	28.8

Despite an apparent increase in the population number using sewerage systems, Poland is still located very far on the list of European countries. It concerns particularly rural inhabitants, where great delays in water supply and sewerage network, particularly water supply and sewage disposal infrastructure development still require enormous financial outlays and must be the main focus of local self-governments.

Decrease in the outflow of organic substances and biogens

Improvement of surface water quality is visible in the amount of organic substances and biogens outflow with the rivers to the Baltic Sea (Knapik, Pawełek, 2013). The increase in the treated sewage volume and improvement of its treatment technologies causes a decrease in the pollutant load supplied to waters or to the earth with treated sewage, Table 5.

The improvement is also influenced by a diminishing sewage volume.

Table 5. Pollutant loads in municipal sewage supplied to waters of earth in Poland after treatment (Ochrona środowiska 2012)

Index	Annual load (thous. tonnes·year^{-1})			
	2000	2005	2009	2010
BOD_5	57.7	27.2	11.7	12.6
COD	149.9	101.5	73.3	80.2
Suspended solids	61.0	36.1	18.2	19.0
Total nitrogen	36.8	28.2	21.1	22.4
Total phosphorus	5.1	2.7	1.2	1.1

THE STATE OF SURFACE WATER QUALITY

The five grade water quality classification became obligatory following Poland's accession to the EU. The criteria of the classification were stated in the Regulation of the Minister of Environment, dated 11 February 2004 establishing the classification for presentation of surface waters and groundwater state, their monitoring and interpretation of results, and presentation of the state of these waters (Rozporządzenie 2004).

The classification replaces the term: water purity grades with i, ii, iv and v. water quality grades. The system was further clarified in the subsequent regulations (Rozporządzenie 2008, Rozporządzenie 2009 and Rozporządzenie 2011). Five grades of ecological state refer to natural surface waters. In case of watercourses and artificial or strongly changed reservoirs, the ecological potential is mentioned. The changes of classification methods make impossible conducting many-year comparative analyses of changes in water comprising the period before and after the issuing of a new regulation (Rozporządzenie 2004).

The activities so far focused on the water resources protection have causing their gradual improvement. Nevertheless, the results of diagnostic monitoring in 2007-2009 indicate that for 154 uniform water parts only 7 (4.5%) were in a good state, whereas 147 (95.5%) in a bad state. In case of operational monitoring, in the total number of 186 uniform water parts only 22 (11.8%) were in a good state and 164 (88.2%) in a bad state (Główny… 2011).

Presented data confirm a common opinion about a poor quality of Polish rivers. It is the result of inefficient "interventionism" of water authorities in the investment outlays allocated to water protection by water users. Therefore, the volume of untreated sewage is diminishing very slowly and still too high quantity of sewage has been insufficiently treated. As a result, the date of reaching the desired river purity state seems very distant.

An important criterion of surface water quality assessment is surface water assessment regarding its potential use for potable water supply to people. It is water categorisation regarding their potential use and its possible health hazard as a drinking water (Rozporządzenie 2002). The regulation states three categories of water: A1 – water requiring a simple physical treatment (filtering, disinfection), A2 – water requiring a typical physical and chemical treatment (initial oxygenation, coagulation, flocculation, decanting, filtration and disinfection with final chlorination) and A3 – water requiring a high performance physical and chemical treatment (oxygenation, coagulation, flocculation, decanting, filtration, activated carbon adsorption, disinfection by ozonation or final chlorination). According to this criterion, water quality is still unsatisfactory, because in 2009 in 132 water quality testing points only 10.6% were A1 category, whereas

respectively: 33.3% and 27.3% were in A2 and A3 category, and in 28.8% of testing points water did not meet the requirements of either category.

SATISFYING WATER SUPPLY NEEDS

The needs of population and economy regarding water are satisfied using surface water and groundwater resources. Over the last twenty years surface water resources provided the main source of water collection, Table 6. In 2010 surface waters constituted 84.4% of the total water collection, whereas only 15.0% was collected from the groundwater resources, and the remaining 0.6% was taken from waters originating from mining and construction facilities drainage. About 85% of collected water returns to surface waters as more or less polluted sewage. The other 15% evaporate or undergo transpiration process.

Table 6. Water collection for the needs of national economy and population in Poland against water resources

Specification	Water volume ($km^3 \cdot year^{-1}$)				
	1990	1995	2000	2005	2010
Resources: – surface waters	43.3	61.6	71.0	56.7	86.9
– groundwaters	14.04	15.39	16.05	16.58	17.18
Collection total:	14.25	12.07	11.05	10.94	10.87
– surface waters	-	-	9.15	9.21	9.17
– groundwaters	-	-	1.75	1.64	1.63
– drainage waters	-	-	0.15	0.09	0.07
Production purposes:	9.55	8.43	7.64	7.73	7.65
– surface waters	-	-	7.22	7.42	7.38
– groundwaters	-	-	0.27	0.22	0.20
– drainage waters	-	-	0.15	0.09	0.07
Agriculture, forestry, fish ponds	1.69	1.18	1.06	1.10	1.15
Waterworks:	3.00	2.46	2.35	2.10	2.06
– surface waters	1.52	1.24	0.87	0.68	0.64
– groundwaters	1.48	1.42	1.48	1.42	1.43

A considerable decrease in water consumption for municipal purposes has been observed in recent years. Also a change in water collection structure occurred, since in 1990 out of 3 $km^3 \cdot year^{-1}$of collected water, surface waters constituted 1.52 $km^3 \cdot year^{-1}$, i.e. 50.7%, whereas in 2010 water collection fell to

68.7% in comparison with 1990. It concerned mainly surface water, its collection diminished to 42.1% at a slight decrease in groundwater extraction (3.4%).

A decrease in tap water consumption causes various effects, among others leading to problems with maintaining the proper water quality in waterworks, particularly in distribution sub-systems, which makes necessary flushing waterworks pipes. This hazard is best illustrated by selected indices of water supply systems referring to a decreasing average water consumption per one house connection and water consumption per one km of waterworks length, Table 7. Also worthy of note is a reversed trend towards increase in the waterworks length per one sewer connection in the cities, which is undoubtedly caused by connecting the houses situated on the city peripheries and connecting suburban areas to water supply systems.

Table 7. Indices characterising water supply systems in cities and rural areas in Poland

year	Water consumption ($m^3 \cdot km^{-1} \cdot year^{-1}$)			Water consumption per sewer connection ($m^3 \cdot rok^{-1}$)			Length of waterworks per one sewer connection (m)		
	rural areas	city	total	rural areas	city	total	rural areas	city	total
1995	2 787.3	30 339.3	10 659.3	189.9	1 000.0	556.5	68.1	33.0	52.2
2000	1 977.7	20 758.4	6 418.1	139.3	664.9	352.2	70.4	32.0	54.9
2005	1 822.8	15 879.8	4 965.0	126.3	496.2	270.4	69.3	31.2	54.5
2010	1 785.7	13 434.4	4.389.5	124.6	428.9	242.9	69.8	31.9	55.2

Economic conditions increasingly more stimulate construction of more complex water supply systems, particularly in the vicinity of larger city agglomerations. A necessity of ensuring of proper quality water at increasing costs of its treatment and meeting legal requirements, made local self-governments seek possible cost reduction, which could be achieved through the aggregation of water supply and sewage disposal systems.

Irrespectively of seeking possible reduction of water supply costs at the tendency to decrease the collected amount, maintenance of fixed assets per $1m^3$ had to grow in a natural way. Therefore, independently of other factors shaping economic bases of water and sewerage companies operation, it had to cause an obvious increase in water supply costs for the consumers. The factors affecting the price of water supply comprise also water losses which in some waterworks are still high (Bergel et al. 2013, Bergel and Pawełek 2008).

CONCLUSION

1. Water management is an integrated set of activities comprising the use of water resources and their protection. A necessity to ensure the pop-

ulation safety and the bases of civilisation development, taking into consideration environmental requirements, gives much to do to people managing water resources and units using them, requiring specific measures and professional staff, as well as appropriate legal and economic instruments.

2. Local self-governments are responsible for collective water supply to people and they are using water resources in compliance with obtained water permits. At the same time, by a wastewater discharge according to the permits concerning the contaminant load, they significantly affect the quality of water resources.
3. Water supply and sewage disposal systems are important consumers of water resources. The amount and way of water utilization are important indicators of the population living standards and civilisation development.
4. The obligation to ensure water meeting the quality standards, irrespective of the current state of raw material, sometimes generates high costs, which in fact must be borne by the consumers, whereas the state activities targeting the improvement of water resources quality are insufficient, sometimes the state proves ineffectual in the law enforcement.
5. The out of control wastewater discharges from the sparsely built-up areas, from fish ponds or due to chaotic sewage management in rural areas, still cause a high level of pollution of river waters.

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