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The transformation of water and sewage management in Poland and Ukraine in the light of socio-economic and political conditions

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Abstract. The study aims to evaluate and compare the transformations in water and sewage management that have taken place in Poland and Ukraine since the early 1990s. This required the collection of an appropriate dataset. Due to differences in reporting methods between countries, it was decided to select only those variables and indicators that allowed for a comparative analysis. The analysis indicated significant and positive changes in the scope of water and sewage management in both countries. Much greater progress was seen in Poland, where, mainly thanks to EU funding, the costly water and sewage infrastructure was more quickly modernised and expanded. However, it is also emphasised that areas related to water and sewage management in Poland still require improvement. In the case of Ukraine, it is indicated that measures should be aimed most urgently at reducing the quantity of untreated sewage discharged into waters and soils and to increasing wastewater treatment standards (including nutrient reduction, in particular). It is also extremely important to introduce in law – and ensure the effective enforcement of – appropriate environmental protection regulations.

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1. Introduction

Water management and related environmental issues are now a major thematic area on the international stage. This is because, in many countries, water resources are still being excessively exploited to meet production sector needs, while the treatment of discharged wastewaters is either lacking or insufficient. Additionally, in many regions, works that artificially change natural river regimes are being conducted, in turn leading to degradation processes and reducing the ability of water systems to replenish and self-purify (Döll et al., 2009; Lane et al., 2017).

Changes in water and wastewater management are exemplified in a particularly interesting way in the European continent. Here, the approaches to this issue have been very diverse for a long time. Western European countries in the EU were among the pioneers of positive changes. As early as 1975, they adopted the first legislative solutions regarding standards for rivers and lakes used for the abstraction of drinking water. In 1991, these countries adopted two important directives on protecting water resources. The first, the Urban Waste Water Treatment Directive, provided for secondary (biological) wastewater treatment, and even more stringent treatment where necessary (Kemp, 2001). The second, the Nitrates Directive, addressed the pollution of water by nitrates from agriculture (Ptak et al., 2020). However, the most comprehensive changes in the approach to water management in the EU came early in the 21st century with the introduction of the *Water Framework Directive* (WFD). The WFD required the implementation of numerous projects in each Member State, including management plans, technical solutions, and socio-economic and legal instruments (Koundouri & Papandreou 2014; Scaduto, 2016; Marszelewski & Piasecki 2020).

Much later, there were positive changes in the approach to water and wastewater management in other European countries. This was especially true of the countries of Central and Eastern Europe, which, for various reasons, have chosen a very different direction in political and economic changes in the last few decades. This has also directly determined how environmental protection issues have been addressed in these countries. Poland and Ukraine are perhaps the best examples in this respect. These countries, being neighbours, are linked by a shared and complex history. After the Second World War, both found themselves in the Soviet sphere of influence. Like most countries of Central and Eastern Europe, they were included in the group of communist countries known as the Eastern Bloc. In Poland, in the mid-1980s, social and political life began slowly to democratise and liberalise. In 1989, a free-market economy was introduced. In Ukraine, a similar transformation took place with the 1991 collapse of the USSR. However, in the ensuing years, the two countries took very divergent paths of economic and political development. Poland, unlike Ukraine, undertook a raft of economic reforms geared towards EU accession. As a result, by 2021, Poland's GDP was four times that of Ukraine (in 1990, Ukraine's GDP had been 25% greater than Poland's). Nevertheless, both countries had experienced decades under the same political and economic system. One characteristic feature of those regimes had been a focus on industry (mainly heavy industry) with minimal consideration of environmental costs. In general, protection of the environment, including water resources, had not been a priority in any communist country. The communist ideology assumed the absolute subordination of nature to man, who had the right to change and shape the planet at will (Domke, 2018). This short-sighted approach to economic activity under this communist ideology degraded large swathes of the former USSR. One of the best examples of this is modern-day Ukraine. It is considered to be one of the most ecologically degraded parts of the former Soviet Union, with 70% of the population living in environmentally hazardous areas (Khmelko, 2012). Given the aforementioned differences in political and economic transformation processes between Poland and Ukraine, it is extremely interesting to learn about how they affected water and wastewater management in each country. The study thus aims to provide an evaluation and comparative analysis of the transformation of water and wastewater management in Poland and Ukraine since the early 1990s taking into account the two countries' different various socio-economic and political conditions.

2. Methods

The analysis and assessment of changes in water and wastewater management in Poland and Ukraine was based on data and information provided by Statistics Poland (http://www.stat.gov.pl) and the State Statistics Service of Ukraine (http://www.ukrstat.gov.ua/). In each case, the data was obtained from the cited institution's website.

The frequent differences in statistical methods between the countries meant that only those variables that could be used in a comparative analysis were used. Moreover, for each variable, the longest possible time period was analysed. Ultimately, a database containing the following elements was built:

- water consumption, by economic sector,
- *per capita* water consumption,
- number of wastewater treatment plants, by type,
- amount of treated and untreated wastewater,
- pollutant load in treated wastewater,
- residences equipped with water supply, sewerage and hot water (broken down into urban and rural areas).

The study also includes studies and reports on water and wastewater management in Poland and Ukraine issued by state and international institutions.

3. Results and discussion

Poland, like Ukraine, has relatively scarce water resources. In the years for which average sums of precipitation are recorded, they amount to 60 billion m^3 in Poland, and 95 billion m^3 in Ukraine. However, in dry years, these values drop to 40 billion m^3 and 57 billion m^3, respectively. Water shortages are seen across Ukraine, especially in the basins of the Lower Dnieper, Doniec Siewierski, Southern Bug, Inguła and Azov (Skrypchuk & Suduk, 2014; Hadzalo, 2015). Per capita water resources amount to 1,839 m^3 per year in Poland (Gutry-Korycka et al., 2014) and 2,000 m^3 per year in Ukraine (Yara et al., 2018). These values clearly show the importance of sustainable water management in both countries. Water consumption has decreased significantly in Poland and Ukraine since the early 1990s. In 1990, water consumption was more than twice as high in Ukraine as in Poland. Currently, each year, Ukraine's water consumption is about a quarter of what it was in 1990 (Fig. 1).

In both countries, water consumption is also dominated by industry. However, a detailed analysis of the water consumption breakdowns in the two countries showed that the values are very difficult to draw direct comparisons between. In Poland, energy generation is the largest consumer of water, as the energy sector uses it, among other things, as a coolant. In Poland, the energy sector accounts for over 85% of all industrial water consumption. In Ukraine, not all of the water consumption of power plants is accounted for in the statistics. This should be borne in mind when analysing the data in Fig. 1.

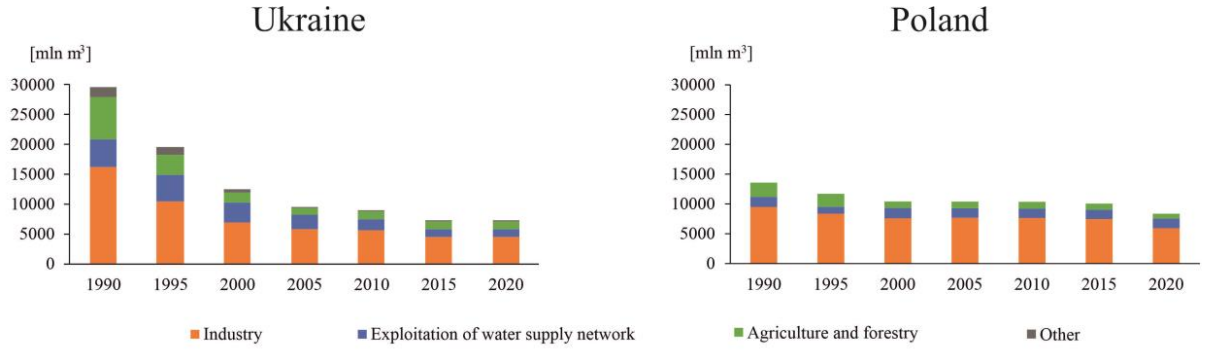

Fig. 1. Breakdown of water consumption in Poland and Ukraine, 1995–2020
Source: own evaluation

Another point worthy of note is the similarity in amounts of water each country uses in agriculture and forestry; this is particularly interesting considering that Ukraine has over 41.3 million ha of agricultural land (much of which requires irrigation) while Poland has only 14.4 million (Świdyński, 2016). In Poland, about 95% of water in this category is used to fill fishponds. In Ukraine, the dominant use in this category (around 90%) is the irrigation of arable land.

The two countries have a similar breakdown of water consumption, which is dominated by industry. Annual water consumption in both countries has stabilised in the last few years and is not changing majorly. Despite this, in Ukraine, *per capita* water consumption has steadily been falling (Fig. 2). In Poland, this indicator has been relatively constant for several years. The reason for these differences is the very heavy decrease in population in Ukraine caused by both a low birth rate and increased emigration. According to World Bank data, Ukraine had a population of approximately 52 million in 1990. By 2020, this number had fallen to 44 million (www.worldbank.org). According to the same data source, the number of inhabitants in Poland at that time also decreased, but only by 150,000 (from 38.1 million to 37.95 million).

The decrease in water consumption in the two countries was caused by many factors, including (Gorączko & Pasela, 2015; Lewandowska & Piasecki, 2020):

- the closure of many water-consuming industrial plants,
- the modernisation of the water supply network in cities, reducing water losses,
- changes in methods of billing for used water; the introduction of water meters,
- increases in water prices,
- the spread of water-saving household appliances (washing machines, dishwashers),
- the installation of water-saving sanitary systems and bathroom fittings.

Other extremely important parameters relating to water and sewage management are the amount of sewage discharged into water and soil and the method and effectiveness of their treatment. Wastewater quantities have decreased significantly in Poland and Ukraine since the early 1990s. In both countries the amount of untreated sewage has been reduced effectively. In 1995, the amount of sewage requiring treatment in Ukraine was double that in Poland. At the same time, the amount of untreated sewage in Ukraine was more than double that of treated sewage. By comparison, in Poland, the percentage of sewage that was untreated in 1995 was much lower, amounting to 23% (Fig. 3). In subsequent years, there has been a systematic decrease in the amount of untreated sewage. In 2020, untreated sewage accounted for 26% of all discharged sewage in Ukraine, and 5.5% in Poland. Both countries have significantly increased

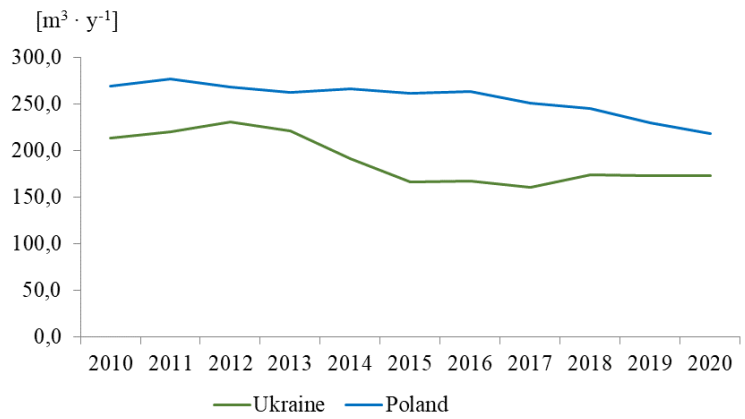

Fig. 2. Water consumption per capita in Poland and Ukraine, 2010–2020
Source: own evaluation

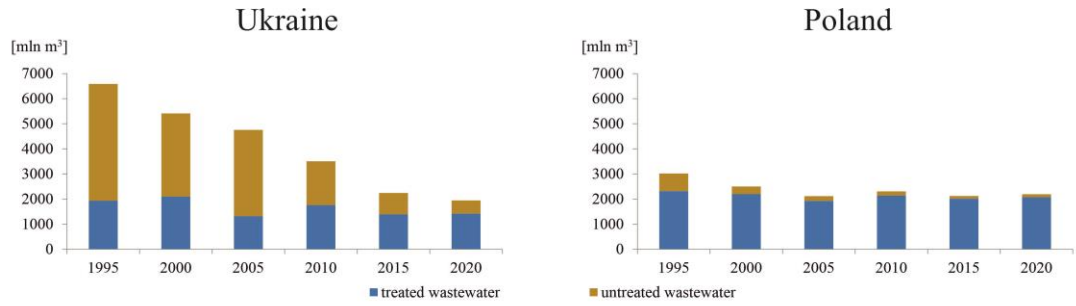

Fig. 3. Amounts of treated and untreated wastewater discharged into water and soils in Poland and Ukraine, 1995–2020
Source: own evaluation

the amount of untreated sewage through the simultaneous influence of several factors, including:

- decreased water consumption,
- the adoption of new, stricter environmental standards,
- increased public ecological awareness,
- the construction and modernisation of sewage treatment plants,
- the expansion of the sewerage network,
- the closure of many industrial plants (mainly due to lack of profitability, but often also for environmental reasons),
- the modernisation of water and sewage management in industrial plants (the introduction of the closed water cycle).

It should be emphasised that the roles that these factors play in improving wastewater management differ between the two countries. In Poland, EU accession requirements and EU law provided the main impetus for change. As a result, the water and sewerage infrastructure was expanded and modernised. This is especially true of sewage treatment plants. Treatment plants with a basic standard of treatment (mechanical) have in many cases been replaced by highly efficient modern technologies providing greater nutrient removal. As a result, in 2020, 56% of wastewater in Poland was treated with this technology, which is among the most effective methods known. This translated directly into an increased wastewater treatment standard, and a concomitant reduction in the amount of hazardous substances introduced into the environment, and nutrients in particular.

This meant that, between 2010 and 2020, the nitrogen and phosphorus loads in sewage discharged into water or soil in Poland fell by 24% and 15%, respectively. In the same period in Ukraine, there was also a similar percentage decrease in the amount of nitrogen and phosphorus in the wastewater

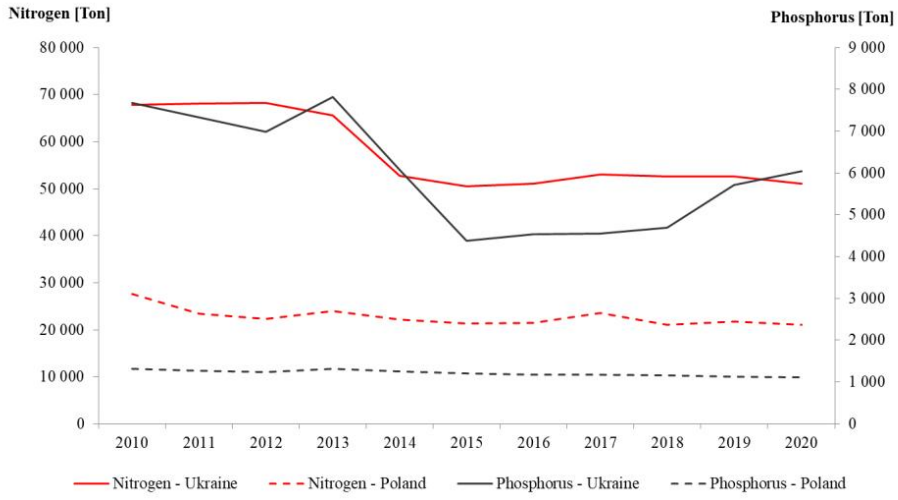

Fig. 4. Pollutant loads in sewage discharged to waters or soils
Source: own evaluation

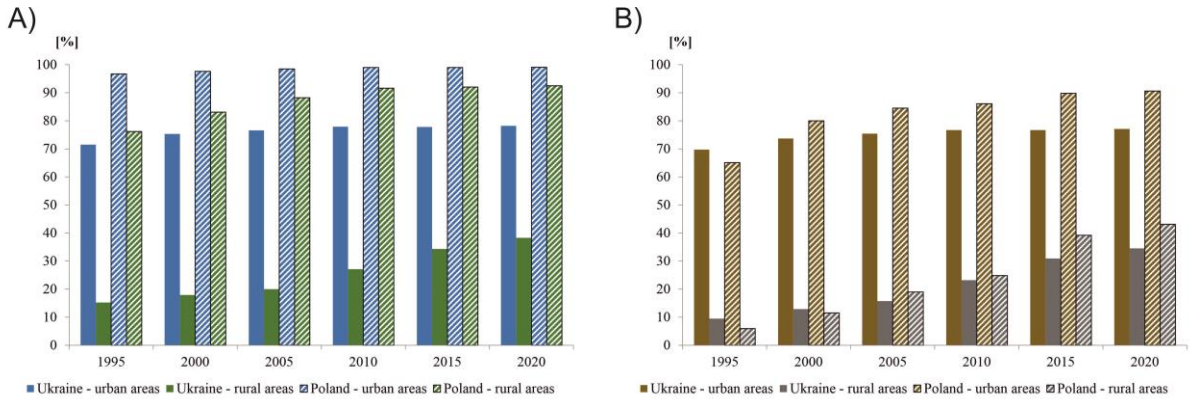

Fig. 5. Population with access to mains water (A) and sewerage systems (B) in Poland and Ukraine (divided into urban and rural areas), 1995–2020
Source: own evaluation

discharged to receivers (nitrogen 24%, phosphorus 21%). However, it should be noted that, in absolute terms, the amounts of nitrogen and phosphorus in discharged wastewater are several times higher in Ukraine than in Poland. In 2020, six times more phosphorus and three times more total nitrogen were discharged (Fig. 4). Such large differences in pollutant loads directly affect the quality of surface waters in each country. Nitrogen and phosphorus compound contents in the estuary sections of Ukraine's main rivers (the Desna, Dnipro, Dniester, Prut and Tisa) are in the ranges 2–4 mg NO_3/L and 0.1–0.5 mg P/L. In Poland, these values for the two main rivers (the Vistula and Odra) are lower, amount to 2–3 mg NO_3/L and 0.15 mg P/L. The improvement in wastewater management in Ukraine resulted mainly from reduced production and the closure of many industrial plants. As a result, the amount of untreated sewage decreased ninefold over the period 1995–2020, alongside a 27% decrease in the amount of treated sewage. The decrease in amount of wastewater treated in Ukraine was mainly due to a drop in water consumption for municipal purposes.

An important feature in the development of water and sewage management is the increased availability of water and sewage infrastructure for residents. There has been an improvement in this respect both in Poland and in Ukraine. In both countries, the changes have been most positive in rural areas. The water supply network extended its reach from 76.2 to 92.5% in Poland, and in Ukraine from 15.2 to 38.3% (Fig. 5). In cities, access to the water supply network also increased, but to a lesser extent (by a few percentage points). In both countries, access to the sewerage network increased more than did access to the water supply network, in rural areas and cities alike. This was because of the very large disproportion between the length of the sewerage network and the length of the water supply network in each country. The implemented projects decreased the difference between the length of the sewerage network and the water supply network. Nevertheless, the water supply network is still much longer. There are many reasons why the discrepancy between the two types of infrastructure is so large, the most important being economic, technical and social. A water supply system is significantly less costly to build than a sewerage system. In addition, in many rural areas of very low-density construction, technical considerations limit the construction and proper functioning of a sewerage network (low flow volumes cause sewage to build up in pipes) (Kłos, 2013). The drinking water infrastructure expands first due also to social pressure (Kłos, 2011). Initially, the need for clean, treated water is much higher in the public hierarchy of needs (especially in rural areas) than the need for waste disposal. This is partly explained by insufficient public environmental education (Piasecki, 2018).

In Poland, housing development in rural areas has increased dramatically in recent years. This mainly applies to suburban areas of large cities (Hołowiecka & Szymańska, 2008; Biegańska & Szymańska 2013). The intensification of development in these areas, often combined with a lack of local spatial development plans, often makes equipping

these areas with technical infrastructure extremely difficult and expensive, mainly because of the aforementioned difficulties in executing a sewerage network in areas of low-density population. These areas are thus dominated by two forms of sewage collection and disposal. The most common form is currently the septic tank, which is emptied on request by appropriate services or companies. This solution is widely criticised because sewage stored in this way often seeps into groundwater, despite the requirement that tanks be sealed (Pryszcz & Mrowiec, 2015). Septic tanks are now often being replaced by household sewage treatment facilities. The reason is primarily economic, as these are cheaper to operate. Unfortunately, wastewater treatment plants with filtration drainage are the most popular, and these have a poor treatment performance (Piasecki, 2018).

In Ukraine, a significant threat to water resources in non-urban areas is posed by summer houses, known as "Dachas". Dachas are summer houses on a small plot of land (about 0.06–0.1 ha) outside cities, often in the vicinity of a river or lake. Dachas are very popular in former Soviet countries. In Ukraine, they constitute a weekend or holiday destination for millions. In addition, some also use them to produce vegetables and fruit for their own needs. The problem is that these places do not have water and sewerage infrastructure. Because of the number of people who often spend a lot of time in these locations (mainly retirees and pensioners), these places pose a significant threat to local aquatic ecosystems. The situation is further aggravated by the lack of local authority monitoring and control of these areas (Pidlisnyuk et al., 2004).

Despite the indicated positive changes in water and sewage management in Ukraine, the condition of rivers, lakes and groundwater in the country is deteriorating each year. One reason is frequent failures in industrial plants that result in large amounts of untreated wastewater going directly to surface waters. Many economic entities engaged in environmentally hazardous activities do not comply with environmental protection legal requirement (Yara et al., 2018). Ukrainian law provides for penalties and compensation for damages caused by environmental pollution. However, they are neither large enough nor enforced sufficiently to prevent the negative consequences of some industrial plants' operations (Ladychenko & Golovko, 2017). One example is the almost uncontrolled industrial activity of the AzovSteel and Illich factories in Mariupol in south-eastern Ukraine. The activities of these entities degrade water quality in the region (Dan et al., 2017; Neverova-Dziopak & Dan, 2018). Due to its harmfulness to human health, medical authorities and the city council of Mariupol have advised inhabitants not to drink raw tap water or even to brush their teeth in it (Khmelko, 2012).

When assessing the water and sewage management of the two countries, their recent pasts should be taken into account. Despite several decades having passed, the influence of the communist ideology on the natural environment is still evident in many parts of both countries. Ukraine's water resources were particularly hard hit, as human impact and degradation were more severe there. For a long time, the Soviet Union heavily exploited the natural resources of what is today Ukraine. About 70% of the raw materials used by the Soviet Union came from this area. The best example of this is logging. In the early 20th century, 45% of Ukraine was covered by forest. Currently, forests account for just over 14% (Khmelko, 2012). Such extensive deforestation significantly changed the water resources, disrupting the natural water cycle in the area. By comparison, in Poland, forest cover was 20.7% after the Second World War (Polna, 2017) but is now about 30% (Cebrykow & Kałamucka, 2021).

Ukrainian independence did not initially bring positive changes in the field of environmental protection such as those seen in Poland. Some scientists indicate that in the early years of independence, the ecological situation in Ukraine in many cases deteriorated even further. This was mainly because of the almost uncontrolled activity of large industrial enterprises and factories (Khmelko, 2012). In recent years, attention has also been paid to the increase in illegally harvested timber in Ukraine. According to the international organisation Earthsight, 60–70% of logging is conducted in contravention of restrictions imposed by Ukrainian law (Earthsight, 2018). The vast majority of this wood goes to sawmills operating in the shadow economy. There are an estimated 12,000 such sawmills, and these are estimated to account for approximately three quarters of all sawn

timber production in Ukraine. Wood from Ukraine is mainly exported to EU countries (Czaplińska & Kibych 2019).

As already mentioned, one of the main reasons for the rapid changes in the field of water and sewage management in Poland was the country's desire to join the EU. Poland's accession to the EU was conditional on the fulfilment of certain requirements. Poland received specific guidelines and deadlines for improving environmental conditions in the country, especially for water and sewage management. However, importantly, the country also obtained significant financial support to implement the requirements. That financial aid was provided mainly from the European Union's Cohesion Fund, LIFE+ Financial Instrument, PHARE Programme, and from the Norwegian Financial Mechanism and the European Economic Area Financial Mechanism. In 1989–2014, these funds co-financed Polish environmental protection projects in Poland to the tune of EUR 5.4 billion (Marszelewski & Piasecki, 2020). In subsequent years, the amount of co-financing (per year) increased further, totalling over EUR 5.1 billion for 2015–2020 alone. The largest funds were allocated to financing the transformation of the water and sewage management system.

In the case of Ukraine, mainly for political reasons, only in recent years have relations with the EU have become closer. As a result, in 2014, the first chapters of an association agreement between the EU and Ukraine were signed. Under the association agreement, Ukraine undertook to introduce European standards and norms in the field of environmental protection. However, the adaptation of Ukrainian legislation to EU law in the WFD is quite slow and significant differences and shortcomings are still indicated in many areas. Ukraine receives foreign financial support to implement a series of urgent economic reforms. The support from the EU, the European Investment Bank, the European Bank for Reconstruction and Development and the International Monetary Fund (among others) includes funds for environmental protection, including water and sewage management. These funds are nonetheless smaller than the funding that Poland received for the same purposes.

Despite the progress identified, in the coming years, both countries will have to work further on improving water and wastewater management. However, the challenges and the scope of work to be done differ between countries. With this in mind, the following recommendations are made:

A) Poland
- extension of the sewerage network in suburban areas,
- ending the use of sealed septic tanks for sewage,
- introducing additional requirements for domestic sewage treatment plants or subsidising systems that more effectively neutralise pollutants.
- reducing the use of fertilisers in agriculture,

B) Ukraine
- continuing legislative work to fully implement the WDW,
- extending the water and sewerage network in cities and rural areas,
- building or modernising sewage treatment plants for increased levels of wastewater treatment,
- improving water quality in the water supply system,
- strict enforcement of environmental pollutant emission standards – especially for industrial plants,
- urgent regulation of sewage disposal and neutralisation in areas where summer houses (dachas) are popular.

4. Summary

The analysis showed significant changes in the scope of water and sewage management in both Poland and Ukraine. The processes of transformation of water and wastewater management in the two countries, although they began at similar times, are currently at different levels. Poland used EU funds to modernise its economy, including investing heavily in water and sewerage infrastructure. The country also implemented EU law, and thus certain solutions in the field of management and protection of the natural environment. As a result, there has been a significant improvement in the quality of drinking water supplied to households, increased

access to water and sewage infrastructure, increased wastewater treatment capacity and quality (along with a reduction in wastewater discharged to the environment), and improved quality of most surface waters. In Poland, certain aspects of water and wastewater management still require improvement, mainly in rural areas. In Ukraine, as has been shown, there have also been very significant changes in water and sewage management. However, these are significantly smaller than those in Poland. The most important problems are now to limit the amount of untreated sewage discharged to waters and soils and to increase the quality of sewage treatment (improving nutrient reduction in particular). In addition, issues relating to environmental legislation and the lack of proper enforcement are still extremely important.

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