JEE Journal of Ecological Engineering

*Journal of Ecological Engineering* 2024, 25(9), 340–353
https://doi.org/10.12911/22998993/191640
ISSN 2299–8993, License CC-BY 4.0

Received: 2024.06.24
Accepted: 2024.07.24
Published: 2024.08.01

# Classification of Municipalities Located in National Parks in Poland with Respect to the Wastewater and Waste Management

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## ABSTRACT

The study concerns waste and wastewater management in municipalities located within borders of national parks in Poland. In the case, the desired direction of development is understood as undertaking pro-environmental measures, such as: the development of a collective sewage network and household sewage treatment facilities in place of holding tanks, and organized waste management, effective segregation of generated waste for future reutilization. The analysis is based on statistical data for the years 2019–2022 obtained from the local data bank. The multi-criteria analysis involved following stages: calculation of selected diagnostic variables for each municipality, normalization of indicators for the selected features to achieve their comparability, designation of a synthetic indicators describing the rate of wastewater and waste management. The obtained synthetic indictors enable to determine groups and types of municipalities related to the level of waste and wastewater management and to set up their spatial distribution within national parks. Six administrative units (11,7%) exhibit high-level waste management and above-average wastewater management. The largest group of the municipalities (57%) consists of units rated as average. No correlation can be observed between the level of waste and sewage management in individual municipalities and their location within the boundaries of a particular national park.

**Keywords:** technical infrastructure, nature protection, multi-criteria analysis, zero unitarization method, sustainable development.

## INTRODUCTION

Technical infrastructure, especially wastewater and waste management is an important element in reducing pressure on the natural environment and ensuring sanitary and epidemiological safety of various users (Kulczyk-Dynowska and Stacherzak 2020). Activities related to the planning, implementation, organisation of service, and maintenance of the technical infrastructure and related facilities belong to the so-called own tasks of municipalities (Journal of Laws 1990 No. 16 item 95 as amended Art. 7.1). They are associated with the requirement to meet the key needs of the local community (Białas 2018). Proper development of technical infrastructure is the basis for multifunctional (Kudłacz 2015) and sustainable development (Podawca and Karsznia 2017, Podawca and Pawłat-Zawrzykraj 2017). It determines socio-economic development of municipalities, affects investment attractiveness – foster or limit the development of housing estates, tourist facilities, production and services-related development (Pawłat-Zawrzykraj and Podawca 2020).

Three basic systems can be distinguished within technical infrastructure: communication infrastructure – subdivided into transport and telecommunications; sanitation infrastructure – water supply and sewage network, facilities for the removal, storage and disposal of waste and sewage; energy infrastructure – the electricity, district heating and gas subsystem (Stawasz, 2005). Technological progress has greatly facilitated the implementation of technical infrastructure. Its development is most often described by relatively

easily accessible parameters, such as network length, availability or investment costs (Podawca 2014; Podawca 2015; Paluch and Zuzek 2017, Śleszyński 2018).

In the case of municipalities located within the boundaries of national parks, the problem of technical infrastructure development is complex. It raises the living standards and comfort of their inhabitants but also provides conditions for developing of new investment areas. This is beneficial for the municipality's economy and, at the same time, it may be regarded as a threat to landscape and natural values of a national park. Therefore, quoting Zawilińska and Mika (2013) 'it is necessary to see a national park as a system linked to the socio-economic environment and to take planning actions based on a holistic look at natural, social and economic issues of a national park and its neighborhood'.

The scope of analysis regarding technical infrastructure in National Parks and municipalities located within their boundaries was restricted to sewage and waste management. It was considered that in the case of these two types of spatial units, the needs and objectives are particularly consistent. The appropriate actions in this respect help to reduce the negative environmental impact of progressive residential and tourist development and ensure sanitary safety of various users, which is important both for the functioning of the national park and for the proper development of the municipalities located in its area. The desired direction of development in terms of sewage and waste management is understood as undertaking pro-environmental measures, such as: the development of a collective sewage network and household sewage treatment facilities in place of holding tanks, organized waste management, effective segregation of generated waste for future reutilization.

Wastewater management in Poland should receive particular attention. When joining the EU, Poland, has undertaken to achieve a level of wastewater management in compliance with the requirements of Directive 91/271/EEC concerning urban wastewater (Council Directive 91/271/EEC) by 31.12.2015. The adoption of this Directive was primarily associated with the need to build, expand and modernise the collective sewage systems. The scope of investment activities needed and the sources of their financing are established in the National Urban Wastewater Treatment Plan (KPOŚK 2003). The Plan was adopted in 2003 and has been updated six times (most recently in 2022). It concerns municipalities that are part of so-called agglomerations, defined as „area where the population and/or economic activities are sufficiently concentrated for urban wastewater to be collected and conducted to an urban waste water treatment plant or to a final discharge point". According to the research on the effectiveness of the implementation of the KPOŚK for 2002–2022, the development of wastewater infrastructure in Poland, both in terms of quantity and quality, was significant (Stachowicz 2023). Unfortunately, the requirements of EU law, despite many investments, are not yet fulfilled. At the end of 2020, in 675 out of 1,524 agglomerations (44.3%), the sewerage infrastructure was insufficient or the existing combined sewerage systems and treatment plants still did not meet the requirements of the Directive. Similar conclusions have been drawn with respect to rural wastewater infrastructure for the period 2008–2017 (Piasecki 2019). Many of these areas face the problem of serving the scattered building network. In many cases, economic and technical problems make individual sewage management systems the only available solution. These include: (i) the storage of wastewater in non-drainage tanks, which unfortunately can pose a severe threat to surface and groundwater or land due to leakage; (ii) domestic wastewater treatment plants (sand filters, hydrobotanical beds, filter drains (Bugajski et al. 2016, Wałega et al. 2018). In the years 2008–2017 the number of holding tanks in rural areas decreased by 8,7%, whereas number of independent wastewater treatment facilities increased by 373.7% (Piasecki 2018). The latter solution is considered a better alternative, but the environmental impact depends on the technology used.

The condition of municipal waste management results from two main factors: the organisational, regulatory, and investment activities of the municipal authorities and the inhabitants' attitude. Due to tourist attractiveness of municipalities located in vicinity of national parks, responsible attitude of tourists is also significant (Podawca and Pawłat-Zawrzykraj 2017, Podawca and Pawłat-Zawrzykraj 2018). Municipal waste management includes the following activities: waste collection and disposal, street and property cleaning, and waste storage and treatment. The obligations of municipalities are regulated by legal acts, such as The Waste Act (Journal of Laws 2013, item 21 as amended) and the Act on Maintaining Cleanliness

and Order in Municipalities (Journal of Laws 1996 No 132, item 622 as amended). The municipality is currently obliged to:

- lay down rules and principles for permanent and short-term residents regarding collection and disposal of waste,
- charge a fee from residents for municipal waste management,
- commission entrepreneurs to collect waste from residents and transport it to regional municipal waste treatment facilities,
- organise the construction, maintenance, and operation of local waste facilities.

For this issue, one of the key pro-environmental measures is waste treatment. In accordance with Article 3b. 1 of the Act on Maintaining Cleanliness and Order in Municipalities (Journal of Laws 1996 No 132, item 622 as amended), there will be progressive reinforcement of the requirements relating to the share of recycled and reused waste (excluding non-hazardous construction and demolition municipal waste). It should be at least 50% by weight of total waste for each year in 2020–2024, and respectively 55% – in 2025–2029, 60% – in 2030–2034, 65% – for 2035, and for each subsequent year. A study on waste management in Poland for the years 2013–2022 conducted by Kotlińska and Żukowska (2023) indicated that local government units generally fulfil the task of municipal waste management properly although it still needs some improvement in order to meet the European Union's requirements. The main achievements are: the decrease in the number of active landfills, reduction of mass of municipal waste generated, including by households, growing the ratio of segregated municipal waste (in 2013 it was 13.5%, in 2017 – 27% and in 2022 – 39.9%). Moreover, waste collected separately constitutes a significant part intended for storage. The municipal waste management system is more effective in cities and the least in rural communes.

As mentioned earlier, waste treatment efficiency also depends on the active participation of the municipality's and temporary residents. This opinion seems to be confirmed by recent survey results (Tuszyńska 2013, Kłos 2015, Stefaniuk 2021). According to the Poles surveyed, the state of the environment depends primarily on each citizen's activity. Institutional factors (good laws, actions of the authorities, etc.) are considered less significant. For several years, the Ministry of the Environment has been conducting surveys on the environmental awareness and behaviour of the Polish population with regard to waste management. The survey results indicate favourable trends (Report on the survey of environmental awareness 2022). In 2022, regular segregation of household waste was declared by almost 96% of respondents. In previous years, this was respectively: 62% – in 2018, 68% – in 2014, 54% – in 2013, 44% – in 2012. However, declarations are not always in line with reality. The authors of this research believe that the very good result of the recent survey is less due to raising society's ecological concerns, but more due to the amendment of the law, which introduced a general obligation to separate waste (National Environmental Policy 2019).

The subject of the study is to assess the diversity of municipalities located within the boundaries of national parks in terms of waste and wastewater management. It was assumed that the analysed administrative units, due to their unique location, represent a model directed to the maximum extent towards environmentally friendly solutions. The additional question of the study is whether the municipalities spatially related to a given national park represent a similar level (effectiveness) of activities in terms of wastewater and waste management.

## STUDY AREA

There are 23 national parks (NP) in Poland (Fig. 1) and 114 municipalities located within their borders (4.5% of all municipalities). The share of NPs in the total area of such municipalities varies. It covers up to 10% of the area of the municipality in case of 49 units; 11–30% of the municipality's area – 43 units, 31-50% – 11 units; more than 50% – 11 units. The latter group of municipalities includes: Zwierzyniec (52% of its area located in the Roztocze NP, Karpacz (53%) in the Karkonosze NP, Goniądz (59%) in the Biebrzański NP, Smołdzino (57%) in the Słowiński NP, Zakopane (60%) and Kościelisko (60%) in the Tatra NP, Krempna (62%) in the Magura NP, Międzyzdroje (63%) in the Woliński NP, Leoncin (62%) and Izabelin (86%) in the Kampinos NP (Podawca 2006). 11 urban municipalities were excluded from the study due to their different characteristics in terms of wastewater and waste management. They are mostly areas with a combined sewerage system and more favourable waste management level compared to less

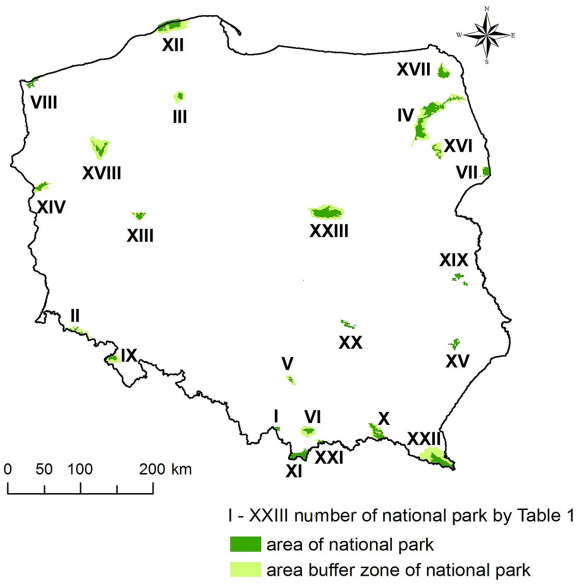


**Figure 1.** Location of national parks in Poland: I – Babia Góra NP, II – Karkonosze NP, III – Bory Tucholskie NP, IV – Biebrza NP, V – Ojców NP, VI – Gorce NP, VII – Białowieża NP, VIII – Wolin, IX – Góry Stołowe NP, X – Magura NP, XI – Tatra NP, XII – Słowiński NP, XIII – Wielkopolski NP, NP XIV – Ujście Warty NP, XV – Roztocze NP, XVI – Narew NP, XVII – Wigry NP, XVIII – Drawa NP, XIX – Polesie NP, XX – Świętokrzyski NP, XXI – Pieniny NP, XXII – Bieszczady NP, XXIII – Kampinos NP.

urbanized areas. The indicators obtained for urban municipalities might disturb the accurate statistical picture of the other units. In the absence of complete input data, the municipality of Cisna was also excluded. The final spatial scope of the assessment covered 102 rural and urban-rural municipalities (Table 1).

## METHODS

The study relies on comparable analysis using specific indicators, that are unable to describe the intensity of the phenomena in absolute or relative values (Zielińska 2006). It is particularly useful for the evaluation of various sets of spatial units in terms of social, environmental, infrastructural and economic development (Rosner 1999, Zielińska 2006, Kruk 2015, Śleszyński 2013). A key point here seems to be an appropriate selection of variables and access to statistical data on particular issue. In this case, statistical data were obtained from the Local Data Bank (BDL). The data for the years 2019–2022 covered the fields of: housing and public utilities, the condition and protection of the environment, population, and territorial division. The multi-criteria analysis involved the following stages:

- calculation of selected diagnostic variables for each municipality;
- normalization of indicators for the selected features to achieve their comparability
- designation of a synthetic indicators describing the rate of wastewater and waste management

In order to assess the diversification of the municipalities located within national parks in terms of waste management, the following variables were indicated:

- the amount of waste generated from households in relation to average number of inhabitants [t per capita] – X1;
- the amount of segregated waste in relation to the total amount of waste from households [t] – X2;
- the amount of biodegradable waste in relation to the total amount of waste from households [t] – X3;
- the amount of segregated waste (paper, glass, metals, plastics) in relation to the total amount of waste from households per capita[t per capita] – X4;
- the amount of biodegradable waste from households per capita [t per capita] – X5.

Diversification of the municipalities in terms of wastewater management was established on the basis of the following variables:

- The average volume of municipal (domestic) waste water collected from individual sewage collection facilities per 1 inhabitant living in buildings without collective sewerage system [$m^3$ per capita] – X6;
- the number of sewage connections for residential buildings to an average number of inhabitants [pcs. per capita] – X7
- the number of household sewage treatment plants in relation to the number of septic tanks [pcs.] – X8;
- the number of septic tanks per capita in buildings without collective sewage system [pcs. per capita] – X9;
- the number of household sewage treatment plants per capita in buildings without collective sewage system [pcs. per capita] – X10.

The obtained values of the individual variables, expressed in different units, were transformed into a comparable form using the of zero unitarisation method. It is regarded as one of the

best normalization methods used for building a ranking of complex phenomena (Kukuła 1999, Kukuła and Luty 2015; Kądziołka 2021). In the first step minimum and maximum values were determined for each variable. Then in the case of variables that have a stimulant character (x6-x8, x10), the values were normalized by using the Equation 1 and in the case of variables that have a destimulant character (x1, x9), their values were normalized according to the Equation 2:

$$Z_{ij} = \frac{x_{ij} - min_i x_{ij}}{max_i x_{ij} - min_i x_{ij}} \cdot 100 \quad (1)$$

$$Z_{ij} = \frac{max_i x_{ij} - x_{ij}}{max_i x_{ij} - min_i x_{ij}} \cdot 100 \quad (2)$$

where: $x_{ij}$ – the value of $j_{\text{th}}$ variable for the $i_{\text{th}}$ municipality; $max\ x_{ij}$ – the maximum value of $j_{\text{th}}$ variable; $min\ x_{ij}$ – the minimum value of $j_{\text{th}}$ variable; $z_{ij}$ – the normalized value of $x_{ij}$.

A synthetic picture of wastewater and waste management in the studied municipalities was obtained by aggregating the normalised variables ($z_i$) using the non-model based method. In this method, the normalised values of the diagnostic characteristics are averaged according to formula 3:

$$W_{WM(WWM)} = \frac{1}{n}\sum_{j=1}^{n} z_{ij} \quad (3)$$

where: $W_{WM(WWM)}$ – the synthetic indicator of the waste (wastewater) management level for the analyzed municipalities; $z_{ij}$ – the normalized value of the $j_{th}$ diagnostic variable for the $i_{\text{th}}$ municipality; $j = 1, 2, ..., n$; $n$ – number of diagnostic variables.

The values calculated for the synthetic indicators range between 0 and 1. The overall classification of the analyzed municipalities regarding the level of waste and wastewater management was developed on the basis of the standard deviation.

## RESULTS

The detailed summary of the calculated variables, the results of their normalization, and the value of the synthetic indicator characterizing the level of waste and sewage management for the analyzed municipalities are presented in Tables 1 and 2. In order to obtain general typology and spatial distribution of the analyzed municipalities regarding pro-environmental waste and sewage management level, they were divided into groups and types according to the synthetic indicators $W_{WM}$ and $W_{WWM}$. The classification was based on standard deviation. In the case of waste management, the analyzed municipalities were assigned to one of the following groups:

- Group A (high level), where the synthetic indicator exceeds the sum of the mean value and the standard deviation $W_{WM} > XP_{WM} + SP_{WM}$, i.e., 0.4006;
- Group B (above average level), where $XP_{WM} + SP_{WM} \leq WP_{WM} \geq XP_{WM}$, i.e., in the range <0.3220; 0.4006>;
- Group C (average level), where the indicator $WP_{WM}$ meets the condition $XP_{WM} < WP_{WM} \geq XP_{WM} - SP_{WM}$, i.e. <0.2434; 0.3220>;
- Group D (low level), where the synthetic indicator is less than 0.2434, i.e. $WP_{WM} < XP_{WM} - SP_{WM}$.

The spatial distribution of the individual groups of municipalities located within certain national parks is presented in Figure 2.

A similar division of the municipalities was applied with regard to the state of wastewater management. The following types of municipalities were identified:

- Type 1 (high level), where the synthetic indicator exceeds the sum of the mean value and the standard deviation, i.e. $W_{WWM} > X_{WWM} + S_{WWM}$, i.e. 0.31495;
- Type 2 (above average level), where $X_{WWM} + S_{WWM} \leq W_{WWM} \geq X_{WWM}$, i.e. in the range <0.23243; 0.31495>;
- Type 3 (average level), where the indicator $W_{WWM}$ meets the condition $X_{WWM} < W_{WWM} \geq X_{WWM} - S_{WWM}$, i.e. <0.14991; 0.23243);
- Type 4 (low level), where the synthetic indicator is less than 0,14991, i.e. $W_{WWM} < X_{WWM} - S_{WWM}$.

The spatial distribution of the individual types of municipalities is presented in Figure 3. A comprehensive analysis of the situation in municipalities regarding wastewater and waste management has identified 12 outstanding municipalities (Table 3). The clear leader is the Dopiewo municipality in the Wielkopolski National Park (Group A, Type 1). Six administrative units exhibit high-level waste management (Group A) and above-average wastewater management (Type 2), which include the municipality of Komorniki in the Wielkopolski NP; Izabeli, Leszno, and Stare Babice in the Kampinos NP; Łapy in the Narew NP; and Ustka in the Słowiński NP. Five municipalities represent high-level wastewater management (Type

**Table 1.** Values of variables concerning waste management in the analyzed municipalities ($x_1$–$x_5$), normalized values of the variables ($z_1$–$z_5$), and the synthetic indicator ($W_{WM}$)

| No. | Municipality* | NP** | $x_1$*** | $x_2$ | $x_3$ | $x_4$ | $x_5$ | $z_1$ | $z_2$ | $z_3$ | $z_4$ | $z_5$ | $W_{WM}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Lipnica Wielka | I | 0.1520 | 26.1225 | 0.8236 | 39.7046 | 1.2518 | 0.9115 | 0.4187 | 0.0230 | 0.2477 | 0.0076 | 0.3217 |
| 2 | Zawoja | | 0.1911 | 40.0498 | 1.3929 | 76.5230 | 2.6614 | 0.8477 | 0.6607 | 0.0388 | 0.5154 | 0.0162 | 0.4158 |
| 3 | Podgórzyn | II | 0.3713 | 20.7302 | 16.3275 | 76.9681 | 60.6214 | 0.5533 | 0.3251 | 0.4551 | 0.5186 | 0.3683 | 0.4441 |
| 4 | Chojnice | III | 0.2797 | 13.0604 | 5.8829 | 36.5314 | 16.4551 | 0.7029 | 0.1918 | 0.1640 | 0.2246 | 0.1000 | 0.2767 |
| 5 | Wizna | IV | 0.1652 | 17.1107 | 2.8718 | 28.2585 | 4.7427 | 0.8900 | 0.2622 | 0.0801 | 0.1644 | 0.0288 | 0.2851 |
| 6 | Nowy Dwór | | 0.1110 | 21.7496 | 0.0000 | 24.1477 | 0.0000 | 0.9784 | 0.3428 | 0.0000 | 0.1345 | 0.0000 | 0.2911 |
| 7 | Bargłów Kościelny | | 0.1280 | 21.0476 | 0.0000 | 26.9358 | 0.0000 | 0.9507 | 0.3306 | 0.0000 | 0.1548 | 0.0000 | 0.2872 |
| 8 | Jedwabne | | 0.1989 | 12.3137 | 1.8627 | 24.4955 | 3.7054 | 0.8348 | 0.1788 | 0.0519 | 0.1371 | 0.0225 | 0.2450 |
| 9 | Grajewo | | 0.1413 | 22.6321 | 1.1479 | 31.9757 | 1.6218 | 0.9290 | 0.3581 | 0.0320 | 0.1915 | 0.0099 | 0.3041 |
| 10 | Jaświły | | 0.1467 | 26.2761 | 3.6894 | 38.5580 | 5.4139 | 0.9201 | 0.4214 | 0.1028 | 0.2393 | 0.0329 | 0.3433 |
| 11 | Rajgród | | 0.2362 | 23.0626 | 12.9220 | 54.4673 | 30.5179 | 0.7740 | 0.3656 | 0.3602 | 0.3550 | 0.1854 | 0.4080 |
| 12 | Lipsk | | 0.1745 | 22.8462 | 16.6646 | 39.8667 | 29.0797 | 0.8747 | 0.3618 | 0.4645 | 0.2488 | 0.1767 | 0.4253 |
| 13 | Dąbrowa Białostocka | | 0.1679 | 19.8846 | 5.7888 | 33.3811 | 9.7178 | 0.8856 | 0.3104 | 0.1614 | 0.2017 | 0.0590 | 0.3236 |
| 14 | Suchowola | | 0.1589 | 22.3701 | 9.7467 | 35.5406 | 15.4851 | 0.9003 | 0.3535 | 0.2717 | 0.2174 | 0.0941 | 0.3674 |
| 15 | Radziłów | | 0.1322 | 12.0135 | 0.0000 | 15.8771 | 0.0000 | 0.9439 | 0.1736 | 0.0000 | 0.0744 | 0.0000 | 0.2384 |
| 16 | Sztabin | | 0.1514 | 26.7031 | 1.6543 | 40.4239 | 2.5043 | 0.9125 | 0.4288 | 0.0461 | 0.2529 | 0.0152 | 0.3311 |
| 17 | Trzcianne | | 0.1514 | 16.7904 | 2.4545 | 25.4154 | 3.7153 | 0.9125 | 0.2566 | 0.0684 | 0.1438 | 0.0226 | 0.2808 |
| 18 | Goniądz | | 0.2180 | 16.4269 | 12.3647 | 35.8141 | 26.9577 | 0.8036 | 0.2503 | 0.3447 | 0.2194 | 0.1638 | 0.3564 |
| 19 | Wielka Wieś | V | 0.3639 | 16.4078 | 12.4606 | 59.7125 | 45.3478 | 0.5653 | 0.2500 | 0.3473 | 0.3932 | 0.2755 | 0.3663 |
| 20 | Jerzmanowice-Przeginia | | 0.2352 | 12.9326 | 9.2547 | 30.4148 | 21.7652 | 0.7756 | 0.1896 | 0.2580 | 0.1801 | 0.1322 | 0.3071 |
| 21 | Sułoszowa | | 0.1886 | 12.0978 | 0.0157 | 22.8156 | 0.0295 | 0.8517 | 0.1751 | 0.0004 | 0.1249 | 0.0002 | 0.2305 |
| 22 | Skała | | 0.3541 | 9.3436 | 12.9630 | 33.0865 | 45.9033 | 0.5813 | 0.1272 | 0.3614 | 0.1995 | 0.2789 | 0.3097 |
| 23 | Nowy Targ | VI | 0.1807 | 12.9366 | 7.0826 | 23.3784 | 12.7994 | 0.8646 | 0.1897 | 0.1974 | 0.1290 | 0.0778 | 0.2917 |
| 24 | Ochotnica Dolna | | 0.1598 | 7.8748 | 0.0296 | 12.5844 | 0.0474 | 0.8987 | 0.1017 | 0.0008 | 0.0505 | 0.0003 | 0.2104 |
| 25 | Mszana Dolna | | 0.1393 | 20.3195 | 1.6733 | 28.2988 | 2.3303 | 0.9323 | 0.3179 | 0.0466 | 0.1647 | 0.0142 | 0.2951 |
| 26 | Kamienica | | 0.1291 | 23.8598 | 0.1931 | 30.8007 | 0.2493 | 0.9489 | 0.3794 | 0.0054 | 0.1829 | 0.0015 | 0.3036 |
| 27 | Niedźwiedź | | 0.1734 | 10.6118 | 0.3240 | 18.4048 | 0.5620 | 0.8765 | 0.1493 | 0.0090 | 0.0928 | 0.0034 | 0.2262 |
| 28 | Narewka | VII | 0.1798 | 14.2767 | 4.6676 | 25.6617 | 8.3898 | 0.8662 | 0.2129 | 0.1301 | 0.1456 | 0.0510 | 0.2812 |
| 29 | Białowieża | | 0.2209 | 16.8570 | 4.9899 | 37.2402 | 11.0236 | 0.7989 | 0.2578 | 0.1391 | 0.2297 | 0.0670 | 0.2985 |
| 30 | Wolin | VIII | 0.2692 | 20.5973 | 15.8496 | 55.4543 | 42.6720 | 0.7200 | 0.3228 | 0.4418 | 0.3622 | 0.2592 | 0.4212 |
| 31 | Międzyzdroje | | 0.7100 | 20.1645 | 12.9027 | 143.1662 | 91.6083 | 0.0000 | 0.3152 | 0.3597 | 1.0000 | 0.5565 | 0.4463 |
| 32 | Lewin Kłodzki | IX | 0.2491 | 19.8572 | 9.2172 | 49.4626 | 22.9593 | 0.7529 | 0.3099 | 0.2569 | 0.3186 | 0.1395 | 0.3556 |
| 33 | Szczytna | | 0.2640 | 16.4315 | 8.3720 | 43.3775 | 22.1011 | 0.7286 | 0.2504 | 0.2334 | 0.2744 | 0.1343 | 0.3242 |
| 34 | Radków | | 0.3101 | 14.8990 | 2.4563 | 46.1952 | 7.6159 | 0.6533 | 0.2238 | 0.0685 | 0.2949 | 0.0463 | 0.2574 |
| 35 | Osiek Jasielski | X | 0.1259 | 12.7035 | 0.0000 | 15.9892 | 0.0000 | 0.9542 | 0.1856 | 0.0000 | 0.0752 | 0.0000 | 0.2430 |
| 36 | Sękowa | | 0.1647 | 26.7454 | 0.6250 | 44.0439 | 1.0293 | 0.8908 | 0.4296 | 0.0174 | 0.2792 | 0.0063 | 0.3247 |
| 37 | Lipinki | | 0.1458 | 21.2865 | 0.9446 | 31.0451 | 1.3776 | 0.9215 | 0.3347 | 0.0263 | 0.1847 | 0.0084 | 0.2951 |
| 38 | Nowy Żmigród | | 0.1070 | 16.1690 | 0.0418 | 17.2927 | 0.0447 | 0.9851 | 0.2458 | 0.0012 | 0.0847 | 0.0003 | 0.2634 |
| 39 | Dębowiec | | 0.1435 | 10.5541 | 0.1142 | 15.1481 | 0.1639 | 0.9253 | 0.1483 | 0.0032 | 0.0691 | 0.0010 | 0.2294 |
| 40 | Krempna | | 0.1291 | 15.4185 | 0.0503 | 19.9082 | 0.0650 | 0.9489 | 0.2328 | 0.0014 | 0.1037 | 0.0004 | 0.2574 |
| 41 | Poronin | XI | 0.3191 | 10.2343 | 9.1720 | 32.6620 | 29.2718 | 0.6385 | 0.1427 | 0.2557 | 0.1965 | 0.1778 | 0.2822 |
| 42 | Bukowina Tatrzańska | | 0.3466 | 18.3549 | 4.1113 | 63.6117 | 14.2483 | 0.5937 | 0.2838 | 0.1146 | 0.4215 | 0.0866 | 0.3000 |
| 43 | Kościelisko | | 0.3029 | 13.8951 | 6.0156 | 42.0859 | 18.2201 | 0.6650 | 0.2063 | 0.1677 | 0.2650 | 0.1107 | 0.2829 |
| 44 | Ustka | XII | 0.3582 | 23.7766 | 10.5952 | 85.1763 | 37.9557 | 0.5746 | 0.3780 | 0.2953 | 0.5783 | 0.2306 | 0.4114 |
| 45 | Główczyce | | 0.1968 | 17.9353 | 13.5285 | 35.2963 | 26.6238 | 0.8383 | 0.2765 | 0.3771 | 0.2156 | 0.1617 | 0.3738 |
| 46 | Wicko | | 0.3319 | 9.4710 | 13.2399 | 31.4348 | 43.9439 | 0.6176 | 0.1295 | 0.3691 | 0.1875 | 0.2670 | 0.3141 |
| 47 | Smołdzino | | 0.2592 | 24.1941 | 12.2108 | 62.7210 | 31.6553 | 0.7363 | 0.3852 | 0.3404 | 0.4150 | 0.1923 | 0.4138 |
| 48 | Dopiewo | XIII | 0.4106 | 17.7882 | 21.1236 | 73.0374 | 86.7323 | 0.4891 | 0.2740 | 0.5888 | 0.4901 | 0.5269 | 0.4738 |
| 49 | Mosina | | 0.2796 | 2.0191 | 3.2792 | 5.6458 | 9.1691 | 0.7030 | 0.0000 | 0.0914 | 0.0000 | 0.0557 | 0.1700 |
| 50 | Komorniki | | 0.2225 | 32.0255 | 32.1913 | 71.2501 | 71.6191 | 0.7964 | 0.5213 | 0.8974 | 0.4771 | 0.4351 | 0.6255 |
| 51 | Stęszew | | 0.3910 | 16.1363 | 14.7330 | 63.0963 | 57.6091 | 0.5210 | 0.2453 | 0.4107 | 0.4178 | 0.3500 | 0.3890 |
| 52 | Górzyca | XIV | 0.3146 | 14.3818 | 11.5405 | 45.2455 | 36.3067 | 0.6459 | 0.2148 | 0.3217 | 0.2880 | 0.2206 | 0.3382 |
| 53 | Witnica | | 0.3963 | 6.2283 | 18.6073 | 24.6826 | 73.7406 | 0.5124 | 0.0731 | 0.5187 | 0.1384 | 0.4480 | 0.3381 |
| 54 | Słońsk | | 0.2949 | 23.5262 | 8.2707 | 69.3877 | 24.3936 | 0.6780 | 0.3736 | 0.2306 | 0.4635 | 0.1482 | 0.3788 |

**Cont. Table 1.**

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 55 | Zamość | XV | 0.1794 | 26.9690 | 9.1828 | 48.3766 | 16.4719 | 0.8668 | 0.4334 | 0.2560 | 0.3107 | 0.1001 | 0.3934 |
| 56 | Józefów | | 0.1869 | 16.2851 | 2.2009 | 30.4429 | 4.1144 | 0.8544 | 0.2478 | 0.0614 | 0.1803 | 0.0250 | 0.2738 |
| 57 | Adamów | | 0.1239 | 17.3440 | 1.1383 | 21.4880 | 1.4102 | 0.9574 | 0.2662 | 0.0317 | 0.1152 | 0.0086 | 0.2758 |
| 58 | Zwierzyniec | | 0.1759 | 16.5174 | 3.4460 | 29.0574 | 6.0622 | 0.8724 | 0.2519 | 0.0961 | 0.1702 | 0.0368 | 0.2855 |
| 59 | Tykocin | XVI | 0.2330 | 14.4484 | 0.3418 | 33.6655 | 0.7964 | 0.7792 | 0.2159 | 0.0095 | 0.2038 | 0.0048 | 0.2426 |
| 60 | Kobylin-Borzymy | | 0.1268 | 13.0668 | 0.0876 | 16.5715 | 0.1111 | 0.9526 | 0.1919 | 0.0024 | 0.0795 | 0.0007 | 0.2454 |
| 61 | Suraż | | 0.1950 | 10.6029 | 6.4396 | 20.6769 | 12.5580 | 0.8412 | 0.1491 | 0.1795 | 0.1093 | 0.0763 | 0.2711 |
| 62 | Sokoły | | 0.1983 | 13.1210 | 0.6668 | 26.0172 | 1.3222 | 0.8359 | 0.1929 | 0.0186 | 0.1481 | 0.0080 | 0.2407 |
| 63 | Turośń Kościelna | | 0.2240 | 12.8646 | 6.7758 | 28.8145 | 15.1768 | 0.7939 | 0.1884 | 0.1889 | 0.1685 | 0.0922 | 0.2864 |
| 64 | Choroszcz | | 0.2862 | 7.0146 | 14.1969 | 20.0752 | 40.6306 | 0.6923 | 0.0868 | 0.3957 | 0.1049 | 0.2468 | 0.3053 |
| 65 | Łapy | | 0.2178 | 10.2626 | 24.1691 | 22.3555 | 52.6487 | 0.8040 | 0.1432 | 0.6737 | 0.1215 | 0.3198 | 0.4124 |
| 66 | Krasnopol | XVII | 0.1497 | 19.2323 | 0.1058 | 28.7808 | 0.1583 | 0.9153 | 0.2990 | 0.0030 | 0.1682 | 0.0010 | 0.2773 |
| 67 | Nowinka | | 0.2132 | 30.5216 | 4.9188 | 65.0714 | 10.4867 | 0.8115 | 0.4952 | 0.1371 | 0.4321 | 0.0637 | 0.3879 |
| 68 | Giby | | 0.1753 | 18.0617 | 0.2955 | 31.6561 | 0.5180 | 0.8735 | 0.2787 | 0.0082 | 0.1891 | 0.0032 | 0.2705 |
| 69 | Suwałki | | 0.1946 | 12.2055 | 4.9241 | 23.7489 | 9.5810 | 0.8419 | 0.1770 | 0.1373 | 0.1316 | 0.0582 | 0.2692 |
| 70 | Bierzwnik | XVIII | 0.2363 | 10.4608 | 0.0066 | 24.7195 | 0.0156 | 0.7738 | 0.1467 | 0.0002 | 0.1387 | 0.0001 | 0.2119 |
| 71 | Krzyż Wielkopolski | | 0.2982 | 11.6173 | 5.7480 | 34.6418 | 17.1402 | 0.6727 | 0.1667 | 0.1602 | 0.2109 | 0.1041 | 0.2629 |
| 72 | Tuczno | | 0.2365 | 9.4363 | 8.8780 | 22.3205 | 20.9998 | 0.7734 | 0.1289 | 0.2475 | 0.1213 | 0.1276 | 0.2797 |
| 73 | Drawno | | 0.2759 | 14.3605 | 3.6166 | 39.6201 | 9.9780 | 0.7091 | 0.2144 | 0.1008 | 0.2471 | 0.0606 | 0.2664 |
| 74 | Człopa | | 0.2792 | 7.8835 | 1.1155 | 22.0133 | 3.1148 | 0.7037 | 0.1019 | 0.0311 | 0.1190 | 0.0189 | 0.1949 |
| 75 | Dobiegniew | | 0.3410 | 11.8415 | 7.1215 | 40.3764 | 24.2827 | 0.6028 | 0.1706 | 0.1985 | 0.2526 | 0.1475 | 0.2744 |
| 76 | Ludwin | XIX | 0.1247 | 22.8254 | 0.0136 | 28.4598 | 0.0169 | 0.9561 | 0.3615 | 0.0004 | 0.1659 | 0.0001 | 0.2968 |
| 77 | Stary Brus | | 0.0978 | 25.1647 | 1.7683 | 24.6145 | 1.7296 | 1.0000 | 0.4021 | 0.0493 | 0.1379 | 0.0105 | 0.3200 |
| 78 | Hańsk | | 0.1133 | 21.4139 | 7.1479 | 24.2609 | 8.0982 | 0.9747 | 0.3369 | 0.1993 | 0.1354 | 0.0492 | 0.3391 |
| 79 | Wierzbica | | 0.1425 | 13.0104 | 4.6078 | 18.5416 | 6.5668 | 0.9270 | 0.1909 | 0.1285 | 0.0938 | 0.0399 | 0.2760 |
| 80 | Sosnowica | | 0.1282 | 23.8832 | 5.9164 | 30.6190 | 7.5850 | 0.9504 | 0.3798 | 0.1649 | 0.1816 | 0.0461 | 0.3446 |
| 81 | Urszulin | | 0.1853 | 15.6157 | 9.0345 | 28.9294 | 16.7373 | 0.8572 | 0.2362 | 0.2518 | 0.1693 | 0.1017 | 0.3232 |
| 82 | Górno | XX | 0.1363 | 30.6400 | 2.4729 | 41.7757 | 3.3717 | 0.9371 | 0.4972 | 0.0689 | 0.2627 | 0.0205 | 0.3573 |
| 83 | Masłów | | 0.2244 | 16.2033 | 13.5430 | 36.3588 | 30.3892 | 0.7932 | 0.2464 | 0.3775 | 0.2233 | 0.1846 | 0.3650 |
| 84 | Łączna | | 0.1867 | 17.9316 | 0.2511 | 33.4794 | 0.4688 | 0.8548 | 0.2764 | 0.0070 | 0.2024 | 0.0029 | 0.2687 |
| 85 | Bieliny | | 0.1087 | 25.9790 | 0.1302 | 28.2293 | 0.1415 | 0.9823 | 0.4162 | 0.0036 | 0.1642 | 0.0009 | 0.3134 |
| 86 | Nowa Słupia | | 0.1304 | 32.1328 | 0.2979 | 41.8988 | 0.3884 | 0.9468 | 0.5232 | 0.0083 | 0.2636 | 0.0024 | 0.3489 |
| 87 | Bodzentyn | | 0.1541 | 19.0531 | 4.6988 | 29.3673 | 7.2425 | 0.9080 | 0.2959 | 0.1310 | 0.1725 | 0.0440 | 0.3103 |
| 88 | Łapsze Niżne | XXI | 0.1922 | 11.8813 | 2.6863 | 22.8329 | 5.1623 | 0.8459 | 0.1713 | 0.0749 | 0.1250 | 0.0314 | 0.2497 |
| 89 | Szczawnica | | 0.2735 | 26.7330 | 0.7059 | 73.1255 | 1.9310 | 0.7130 | 0.4293 | 0.0197 | 0.4907 | 0.0117 | 0.3329 |
| 90 | Krościenko nad Dunajcem | | 0.1710 | 15.4737 | 0.1004 | 26.4572 | 0.1716 | 0.8805 | 0.2337 | 0.0028 | 0.1513 | 0.0010 | 0.2539 |
| 91 | Czorsztyn | | 0.1487 | 59.581[illegible] | 0.0000 | 88.6206 | 0.0000 | 0.9168 | 1.0000 | 0.0000 | 0.6034 | 0.0000 | 0.5040 |
| 92 | Czarna | XXII | 0.1064 | 53.2018 | 0.0000 | 56.5985 | 0.0000 | 0.9860 | 0.8892 | 0.0000 | 0.3705 | 0.0000 | 0.4491 |
| 93 | Lutowiska | | 0.2044 | 16.6380 | 0.0000 | 34.0074 | 0.0000 | 0.8259 | 0.2540 | 0.0000 | 0.2062 | 0.0000 | 0.2572 |
| 94 | Tomaszów Mazowiecki | XXIII | 0.2752 | 17.4776 | 2.6492 | 48.0972 | 7.2905 | 0.7103 | 0.2686 | 0.0739 | 0.3087 | 0.0443 | 0.2812 |
| 95 | Łomianki | | 0.3399 | 15.1462 | 12.5221 | 51.4808 | 42.5619 | 0.6046 | 0.2281 | 0.3491 | 0.3333 | 0.2586 | 0.3547 |
| 96 | Stare Babice | | 0.4422 | 11.5904 | 29.5300 | 51.2548 | 130.5866 | 0.4374 | 0.1663 | 0.8232 | 0.3317 | 0.7933 | 0.5104 |
| 97 | Kampinos | | 0.2629 | 22.5501 | 13.1316 | 59.2842 | 34.5230 | 0.7303 | 0.3567 | 0.3661 | 0.3900 | 0.2097 | 0.4106 |
| 98 | Brochów | | 0.2287 | 18.2500 | 3.4998 | 41.7306 | 8.0026 | 0.7863 | 0.2820 | 0.0976 | 0.2624 | 0.0486 | 0.2954 |
| 99 | Izabelin | | 0.4589 | 9.5843 | 35.8740 | 43.9774 | 164.6073 | 0.4103 | 0.1314 | 1.0000 | 0.2787 | 1.0000 | 0.5641 |
| 100 | Czosnów | | 0.3055 | 12.3512 | 17.6658 | 37.7348 | 53.9718 | 0.6607 | 0.1795 | 0.4924 | 0.2333 | 0.3279 | 0.3788 |
| 101 | Leszno | | 0.4220 | 10.2359 | 23.4988 | 43.1996 | 99.1741 | 0.4704 | 0.1427 | 0.6550 | 0.2731 | 0.6025 | 0.4287 |
| 102 | Leoncin | | 0.2358 | 9.5132 | 0.7685 | 22.4309 | 1.8120 | 0.7746 | 0.1302 | 0.0214 | 0.1221 | 0.0110 | 0.2119 |

**Note:** *According to the methodology, urban municipalities were not included in the study. **I – Babia Góra NP, II – Karkonosze NP, III – Bory Tucholskie NP, IV – Biebrza NP, V – Ojców NP, VI–Gorce NP, VII – Białowieża NP, VIII – Wolin, IX – Góry Stołowe NP, X – Magura NP, XI – Tatra NP, XII–Słowiński NP, XIII – Wielkopolski NP, NP XIV – Ujście Warty NP, XV – Roztocze NP, XVI –Narew NP, XVII – Wigry NP, XVIII – Drawa NP, XIX – Polesie NP, XX – Świętokrzyski NP, XXI –Pieniny NP, XXII – Bieszczady NP, XXIII – Kampinos NP. ***Cells containing minimum values are highlighted in light grey, while maximum values are marked in dark grey.

**Table 2.** Values of variables concerning wastewater management in the analyzed municipalities ($x_6$-$x_{10}$), normalized values of the variables ($z_6$-$z_{10}$), and the synthetic indicator ($W_{WWM}$)

| No. | Municipality | NP | $x_6$ | $x_7$ | $x_8$ | $x_9$ | $x_{10}$ | $z_6$ | $z_7$ | $z_8$ | $z_9$ | $z_{10}$ | $W_{WWM}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Lipnica Wielka | I | 0.3650 | 0.2237 | 0.0000 | 0.2363 | 0.0000 | 0.0084 | 0.3595 | 0.0000 | 0.6118 | 0.0000 | 0.1959 |
| 2 | Zawoja | | 1.2810 | 0.1257 | 0.0188 | 0.3208 | 0.0060 | 0.0296 | 0.2020 | 0.0022 | 0.4614 | 0.0234 | 0.1437 |
| 3 | Podgórzyn | II | 2.4815 | 0.2088 | 0.1113 | 0.4972 | 0.0554 | 0.0573 | 0.3355 | 0.0132 | 0.1476 | 0.2154 | 0.1538 |
| 4 | Chojnice | III | 2.5454 | 0.0213 | 0.9437 | 0.0852 | 0.0804 | 0.0588 | 0.0342 | 0.1120 | 0.8805 | 0.3128 | 0.2797 |
| 5 | Wizna | IV | 0.7633 | 0.0896 | 0.0546 | 0.2332 | 0.0127 | 0.0176 | 0.1439 | 0.0065 | 0.6172 | 0.0495 | 0.1669 |
| 6 | Nowy Dwór | | 5.4049 | 0.0655 | 0.0630 | 0.2240 | 0.0141 | 0.1248 | 0.1052 | 0.0075 | 0.6335 | 0.0550 | 0.1852 |
| 7 | Bargłów Kościelny | | 0.2548 | 0.0291 | 0.4265 | 0.1321 | 0.0563 | 0.0059 | 0.0468 | 0.0506 | 0.7971 | 0.2192 | 0.2239 |
| 8 | Jedwabne | | 0.9269 | 0.0668 | 0.1097 | 0.1415 | 0.0155 | 0.0214 | 0.1074 | 0.0130 | 0.7803 | 0.0604 | 0.1965 |
| 9 | Grajewo | | 0.0695 | 0.0003 | 0.5065 | 0.1625 | 0.0823 | 0.0016 | 0.0004 | 0.0601 | 0.7429 | 0.3203 | 0.2251 |
| 10 | Jaświły | | 0.2321 | 0.0997 | 0.0548 | 0.2089 | 0.0115 | 0.0054 | 0.1602 | 0.0065 | 0.6605 | 0.0445 | 0.1754 |
| 11 | Rajgród | | 0.0013 | 0.0867 | 0.2402 | 0.1488 | 0.0358 | 0.0000 | 0.1393 | 0.0285 | 0.7674 | 0.1391 | 0.2149 |
| 12 | Lipsk | | 0.9215 | 0.0582 | 0.0473 | 0.1757 | 0.0083 | 0.0213 | 0.0935 | 0.0056 | 0.7195 | 0.0323 | 0.1744 |
| 13 | Dąbrowa Białostocka | | 0.3466 | 0.0670 | 1.2855 | 0.0748 | 0.0962 | 0.0080 | 0.1077 | 0.1525 | 0.8989 | 0.3742 | 0.3083 |
| 14 | Suchowola | | 0.9681 | 0.0939 | 0.1809 | 0.0868 | 0.0157 | 0.0224 | 0.1508 | 0.0215 | 0.8777 | 0.0611 | 0.2267 |
| 15 | Radziłów | | 0.6626 | 0.1036 | 0.4713 | 0.1448 | 0.0682 | 0.0153 | 0.1665 | 0.0559 | 0.7745 | 0.2655 | 0.2556 |
| 16 | Sztabin | | 0.0510 | 0.0582 | 0.3119 | 0.2311 | 0.0721 | 0.0012 | 0.0935 | 0.0370 | 0.6209 | 0.2805 | 0.2066 |
| 17 | Trzcianne | | 0.5422 | 0.0921 | 0.1778 | 0.1498 | 0.0266 | 0.0125 | 0.1479 | 0.0211 | 0.7655 | 0.1037 | 0.2102 |
| 18 | Goniądz | | 0.9456 | 0.0903 | 0.2248 | 0.2064 | 0.0464 | 0.0218 | 0.1450 | 0.0267 | 0.6649 | 0.1805 | 0.2078 |
| 19 | Wielka Wieś | V | 1.0480 | 0.2759 | 0.3248 | 0.0589 | 0.0191 | 0.0242 | 0.4433 | 0.0385 | 0.9272 | 0.0745 | 0.3015 |
| 20 | Jerzmanowice-Przeginia | | 1.0352 | 0.1069 | 0.0838 | 0.2454 | 0.0206 | 0.0239 | 0.1718 | 0.0100 | 0.5956 | 0.0800 | 0.1763 |
| 21 | Sułoszowa | | 0.3396 | 0.2255 | 0.0647 | 0.1090 | 0.0071 | 0.0078 | 0.3623 | 0.0077 | 0.8382 | 0.0274 | 0.2487 |
| 22 | Skała | | 1.3033 | 0.2484 | 0.1019 | 0.1758 | 0.0179 | 0.0301 | 0.3992 | 0.0121 | 0.7193 | 0.0697 | 0.2461 |
| 23 | Nowy Targ | VI | 1.4984 | 0.1350 | 0.0211 | 0.1733 | 0.0037 | 0.0346 | 0.2170 | 0.0025 | 0.7238 | 0.0142 | 0.1984 |
| 24 | Ochotnica Dolna | | 0.2430 | 0.2456 | 0.0247 | 0.0799 | 0.0020 | 0.0056 | 0.3946 | 0.0029 | 0.8899 | 0.0077 | 0.2602 |
| 25 | Mszana Dolna | | 0.5057 | 0.1168 | 0.0359 | 0.1929 | 0.0069 | 0.0117 | 0.1876 | 0.0043 | 0.6890 | 0.0269 | 0.1839 |
| 26 | Kamienica | | 0.1158 | 0.1687 | 0.0869 | 0.1310 | 0.0114 | 0.0027 | 0.2711 | 0.0103 | 0.7991 | 0.0443 | 0.2255 |
| 27 | Niedźwiedź | | 0.4724 | 0.0792 | 0.0328 | 0.2262 | 0.0074 | 0.0109 | 0.1273 | 0.0039 | 0.6297 | 0.0289 | 0.1601 |
| 28 | Narewka | VII | 0.8630 | 0.3438 | 1.4072 | 0.1194 | 0.1680 | 0.0199 | 0.5524 | 0.1670 | 0.8197 | 0.6536 | 0.4425 |
| 29 | Białowieża | | 0.0963 | 0.3710 | 0.0102 | 0.1517 | 0.0016 | 0.0022 | 0.5961 | 0.0012 | 0.7622 | 0.0060 | 0.2735 |
| 30 | Wolin | VIII | 4.2688 | 0.0642 | 0.0242 | 0.2148 | 0.0052 | 0.0985 | 0.1032 | 0.0029 | 0.6499 | 0.0202 | 0.1750 |
| 31 | Międzyzdroje | | 2.3415 | 0.1192 | 0.0120 | 0.5802 | 0.0069 | 0.0541 | 0.1916 | 0.0014 | 0.0000 | 0.0270 | 0.0548 |
| 32 | Lewin Kłodzki | IX | 1.8383 | 0.1602 | 3.4925 | 0.0212 | 0.0739 | 0.0424 | 0.2574 | 0.4144 | 0.9944 | 0.2876 | 0.3992 |
| 33 | Szczytna | | 0.5970 | 0.0470 | 0.1729 | 0.2453 | 0.0424 | 0.0138 | 0.0755 | 0.0205 | 0.5957 | 0.1651 | 0.1741 |
| 34 | Radków | | 1.2966 | 0.1276 | 0.5959 | 0.0404 | 0.0241 | 0.0299 | 0.2050 | 0.0707 | 0.9601 | 0.0938 | 0.2719 |
| 35 | Osiek Jasielski | X | 0.1394 | 0.1149 | 0.0000 | 0.2265 | 0.0000 | 0.0032 | 0.1846 | 0.0000 | 0.6291 | 0.0000 | 0.1634 |
| 36 | Sękowa | | 0.7429 | 0.1689 | 1.3390 | 0.0901 | 0.1207 | 0.0172 | 0.2714 | 0.1589 | 0.8717 | 0.4695 | 0.3577 |
| 37 | Lipinki | | 0.1718 | 0.1727 | 0.4717 | 0.0524 | 0.0247 | 0.0040 | 0.2774 | 0.0560 | 0.9389 | 0.0961 | 0.2745 |
| 38 | Nowy Żmigród | | 0.2233 | 0.1516 | 0.0002 | 0.2590 | 0.0001 | 0.0052 | 0.2436 | 0.0000 | 0.5714 | 0.0002 | 0.1641 |
| 39 | Dębowiec | | 0.0303 | 0.1093 | 0.2041 | 0.2883 | 0.0589 | 0.0007 | 0.1757 | 0.0242 | 0.5192 | 0.2290 | 0.1898 |
| 40 | Krempna | | 0.2831 | 0.0791 | 1.2314 | 0.1237 | 0.1523 | 0.0065 | 0.1271 | 0.1461 | 0.8120 | 0.5927 | 0.3369 |
| 41 | Poronin | XI | 2.1351 | 0.1489 | 0.0459 | 0.3007 | 0.0138 | 0.0493 | 0.2393 | 0.0054 | 0.4972 | 0.0537 | 0.1690 |
| 42 | Bukowina Tatrzańska | | 3.4833 | 0.1124 | 0.0117 | 0.3944 | 0.0046 | 0.0804 | 0.1807 | 0.0014 | 0.3304 | 0.0180 | 0.1222 |
| 43 | Kościelisko | | 4.8489 | 0.1557 | 0.0213 | 0.4211 | 0.0090 | 0.1119 | 0.2502 | 0.0025 | 0.2830 | 0.0348 | 0.1365 |
| 44 | Ustka | XII | 2.1896 | 0.2010 | 0.5565 | 0.0768 | 0.0428 | 0.0505 | 0.3229 | 0.0660 | 0.8954 | 0.1664 | 0.3003 |
| 45 | Główczyce | | 0.5171 | 0.0278 | 0.1188 | 0.1237 | 0.0147 | 0.0119 | 0.0446 | 0.0141 | 0.8120 | 0.0572 | 0.1880 |
| 46 | Wicko | | 1.4665 | 0.1462 | 0.2215 | 0.0463 | 0.0103 | 0.0339 | 0.2348 | 0.0263 | 0.9497 | 0.0399 | 0.2569 |
| 47 | Smołdzino | | 6.7583 | 0.0000 | 0.0966 | 0.1380 | 0.0133 | 0.1560 | 0.0000 | 0.0115 | 0.7865 | 0.0519 | 0.2012 |
| 48 | Dopiewo | XIII | 43.3234 | 0.2255 | 0.0632 | 0.3026 | 0.0191 | 1.0000 | 0.3624 | 0.0075 | 0.4937 | 0.0744 | 0.3876 |
| 49 | Mosina | | 22.0163 | 0.2051 | 0.0367 | 0.4616 | 0.0169 | 0.5082 | 0.3295 | 0.0044 | 0.2111 | 0.0659 | 0.2238 |
| 50 | Komorniki | | 4.2350 | 0.2021 | 0.0167 | 0.0857 | 0.0014 | 0.0978 | 0.3247 | 0.0020 | 0.8795 | 0.0056 | 0.2619 |
| 51 | Stęszew | | 23.3043 | 0.1962 | 0.0837 | 0.4972 | 0.0416 | 0.5379 | 0.3152 | 0.0099 | 0.1476 | 0.1619 | 0.2345 |
| 52 | Górzyca | XIV | 3.4974 | 0.1698 | 0.1577 | 0.2168 | 0.0342 | 0.0807 | 0.2729 | 0.0187 | 0.6464 | 0.1330 | 0.2303 |
| 53 | Witnica | | 4.4648 | 0.1081 | 0.0859 | 0.2469 | 0.0212 | 0.1031 | 0.1738 | 0.0102 | 0.5928 | 0.0826 | 0.1925 |
| 54 | Słońsk | | 1.6545 | 0.1651 | 0.9777 | 0.1418 | 0.1386 | 0.0382 | 0.2653 | 0.1160 | 0.7799 | 0.5393 | 0.3477 |

**Cont. Table 2.**

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 55 | Zamość | XV | 4.8122 | 0.0632 | 0.0619 | 0.1464 | 0.0091 | 0.1111 | 0.1016 | 0.0073 | 0.7717 | 0.0352 | 0.2054 |
| 56 | Józefów | | 0.9743 | 0.1182 | 0.0328 | 0.2139 | 0.0070 | 0.0225 | 0.1899 | 0.0039 | 0.6515 | 0.0273 | 0.1790 |
| 57 | Adamów | | 1.1524 | 0.0012 | 0.0728 | 0.2195 | 0.0160 | 0.0266 | 0.0020 | 0.0086 | 0.6416 | 0.0622 | 0.1482 |
| 58 | Zwierzyniec | | 32.2360 | 0.1358 | 0.0556 | 0.2159 | 0.0120 | 0.7441 | 0.2182 | 0.0066 | 0.6481 | 0.0467 | 0.3327 |
| 59 | Tykocin | XVI | 1.7834 | 0.0468 | 0.0479 | 0.1094 | 0.0052 | 0.0412 | 0.0753 | 0.0057 | 0.8375 | 0.0204 | 0.1960 |
| 60 | Kobylin-Borzymy | | 0.0000 | 0.1420 | 0.0437 | 0.2127 | 0.0093 | 0.0000 | 0.2281 | 0.0052 | 0.6538 | 0.0362 | 0.1847 |
| 61 | Suraż | | 0.1191 | 0.1402 | 2.9918 | 0.0746 | 0.2230 | 0.0028 | 0.2252 | 0.3550 | 0.8994 | 0.8679 | 0.4700 |
| 62 | Sokoły | | 0.5209 | 0.6224 | 0.1478 | 0.2149 | 0.0318 | 0.0120 | 1.0000 | 0.0175 | 0.6498 | 0.1236 | 0.3606 |
| 63 | Turośń Kościelna | | 1.2139 | 0.0896 | 0.1344 | 0.2460 | 0.0331 | 0.0280 | 0.1439 | 0.0160 | 0.5945 | 0.1286 | 0.1822 |
| 64 | Choroszcz | | 7.9609 | 0.1119 | 0.1102 | 0.2877 | 0.0317 | 0.1838 | 0.1798 | 0.0131 | 0.5203 | 0.1234 | 0.2041 |
| 65 | Łapy | | 0.0632 | 0.1717 | 0.0753 | 0.0317 | 0.0024 | 0.0015 | 0.2758 | 0.0089 | 0.9756 | 0.0093 | 0.2542 |
| 66 | Krasnopol | XVII | 0.0119 | 0.0000 | 0.0789 | 0.1972 | 0.0156 | 0.0003 | 0.0000 | 0.0094 | 0.6813 | 0.0605 | 0.1503 |
| 67 | Nowinka | | 0.6561 | 0.2013 | 5.9814 | 0.0430 | 0.2570 | 0.0151 | 0.3234 | 0.7097 | 0.9556 | 1.0000 | 0.6008 |
| 68 | Giby | | 0.9620 | 0.0000 | 0.2041 | 0.4714 | 0.0962 | 0.0222 | 0.0000 | 0.0242 | 0.1935 | 0.3743 | 0.1228 |
| 69 | Suwałki | | 0.8421 | 0.1049 | 0.5960 | 0.1468 | 0.0875 | 0.0194 | 0.1685 | 0.0707 | 0.7708 | 0.3405 | 0.2740 |
| 70 | Bierzwnik | XVIII | 3.0088 | 0.1523 | 0.1643 | 0.3324 | 0.0546 | 0.0695 | 0.2447 | 0.0195 | 0.4408 | 0.2125 | 0.1974 |
| 71 | Krzyż Wielkopolski | | 17.6441 | 0.1186 | 0.0810 | 0.2587 | 0.0209 | 0.4073 | 0.1905 | 0.0096 | 0.5718 | 0.0815 | 0.2521 |
| 72 | Tuczno | | 5.4419 | 0.1138 | 0.1419 | 0.1924 | 0.0273 | 0.1256 | 0.1829 | 0.0168 | 0.6899 | 0.1062 | 0.2243 |
| 73 | Drawno | | 5.3681 | 0.1060 | 0.1898 | 0.1837 | 0.0349 | 0.1239 | 0.1703 | 0.0225 | 0.7053 | 0.1357 | 0.2315 |
| 74 | Człopa | | 0.0632 | 0.1078 | 0.1051 | 0.1428 | 0.0150 | 0.0015 | 0.1732 | 0.0125 | 0.7781 | 0.0584 | 0.2047 |
| 75 | Dobiegniew | | 3.4504 | 0.1250 | 0.3235 | 0.1022 | 0.0331 | 0.0796 | 0.2009 | 0.0384 | 0.8503 | 0.1286 | 0.2596 |
| 76 | Ludwin | XIX | 13.7717 | 0.0896 | 0.0889 | 0.1750 | 0.0156 | 0.3179 | 0.1440 | 0.0105 | 0.7208 | 0.0605 | 0.2507 |
| 77 | Stary Brus | | 0.9485 | 0.0577 | 1.6152 | 0.0754 | 0.1218 | 0.0219 | 0.0927 | 0.1917 | 0.8979 | 0.4740 | 0.3356 |
| 78 | Hańsk | | 0.0434 | 0.0617 | 8.4277 | 0.0180 | 0.1517 | 0.0010 | 0.0992 | 1.0000 | 1.0000 | 0.5904 | 0.5381 |
| 79 | Wierzbica | | 0.4376 | 0.0843 | 0.1854 | 0.2016 | 0.0374 | 0.0101 | 0.1355 | 0.0220 | 0.6734 | 0.1455 | 0.1973 |
| 80 | Sosnowica | | 0.4329 | 0.0938 | 0.1144 | 0.1921 | 0.0220 | 0.0100 | 0.1508 | 0.0136 | 0.6903 | 0.0855 | 0.1900 |
| 81 | Urszulin | | 0.8419 | 0.1123 | 0.2273 | 0.1445 | 0.0328 | 0.0194 | 0.1804 | 0.0270 | 0.7751 | 0.1277 | 0.2259 |
| 82 | Górno | XX | 0.8100 | 0.1380 | 0.0369 | 0.2483 | 0.0092 | 0.0187 | 0.2217 | 0.0044 | 0.5905 | 0.0357 | 0.1742 |
| 83 | Masłów | | 2.6816 | 0.2060 | 0.0702 | 0.2202 | 0.0155 | 0.0619 | 0.3310 | 0.0083 | 0.6403 | 0.0602 | 0.2203 |
| 84 | Łączna | | 1.2305 | 0.1239 | 0.0450 | 0.1897 | 0.0085 | 0.0284 | 0.1990 | 0.0053 | 0.6946 | 0.0332 | 0.1921 |
| 85 | Bieliny | | 1.5042 | 0.1408 | 0.0013 | 0.1730 | 0.0002 | 0.0347 | 0.2263 | 0.0002 | 0.7242 | 0.0009 | 0.1973 |
| 86 | Nowa Słupia | | 0.2536 | 0.1020 | 0.0571 | 0.0815 | 0.0047 | 0.0059 | 0.1639 | 0.0068 | 0.8871 | 0.0181 | 0.2164 |
| 87 | Bodzentyn | | 0.5995 | 0.1625 | 0.0569 | 0.0578 | 0.0033 | 0.0138 | 0.2611 | 0.0068 | 0.9292 | 0.0128 | 0.2448 |
| 88 | Łapsze Niżne | XXI | 3.6299 | 0.1845 | 0.1156 | 0.1543 | 0.0178 | 0.0838 | 0.2965 | 0.0137 | 0.7576 | 0.0694 | 0.2442 |
| 89 | Szczawnica | | 3.0579 | 0.2181 | 0.0498 | 0.3201 | 0.0159 | 0.0706 | 0.3504 | 0.0059 | 0.4627 | 0.0620 | 0.1903 |
| 90 | Krościenko nad Dunajcem | | 0.9146 | 0.1823 | 0.0251 | 0.2431 | 0.0061 | 0.0211 | 0.2928 | 0.0030 | 0.5996 | 0.0237 | 0.1881 |
| 91 | Czorsztyn | | 1.3235 | 0.2259 | 0.0215 | 0.3371 | 0.0073 | 0.0306 | 0.3630 | 0.0026 | 0.4324 | 0.0282 | 0.1713 |
| 92 | Czarna | XXII | 0.3282 | 0.0327 | 0.0994 | 0.2508 | 0.0249 | 0.0076 | 0.0526 | 0.0118 | 0.5860 | 0.0970 | 0.1510 |
| 93 | Lutowiska | | 0.3363 | 0.1164 | 0.2581 | 0.1133 | 0.0292 | 0.0078 | 0.1870 | 0.0306 | 0.8305 | 0.1138 | 0.2339 |
| 94 | Tomaszów Mazowiecki | XXIII | 4.4346 | 0.1660 | 0.0844 | 0.2966 | 0.0250 | 0.1024 | 0.2668 | 0.0100 | 0.5045 | 0.0974 | 0.1962 |
| 95 | Łomianki | | 16.5828 | 0.2018 | 0.0007 | 0.3513 | 0.0002 | 0.3828 | 0.3243 | 0.0001 | 0.4072 | 0.0009 | 0.2230 |
| 96 | Stare Babice | | 5.9499 | 0.2961 | 0.0188 | 0.1573 | 0.0030 | 0.1373 | 0.4758 | 0.0022 | 0.7522 | 0.0115 | 0.2758 |
| 97 | Kampinos | | 3.2874 | 0.1588 | 0.0612 | 0.2111 | 0.0129 | 0.0759 | 0.2552 | 0.0073 | 0.6565 | 0.0502 | 0.2090 |
| 98 | Brochów | | 3.2466 | 0.1227 | 0.0201 | 0.1775 | 0.0036 | 0.0749 | 0.1972 | 0.0024 | 0.7162 | 0.0139 | 0.2009 |
| 99 | Izabelin | | 9.9687 | 0.2707 | 0.0025 | 0.2154 | 0.0005 | 0.2301 | 0.4350 | 0.0003 | 0.6489 | 0.0021 | 0.2633 |
| 100 | Czosnów | | 5.8384 | 0.2224 | 0.1080 | 0.1232 | 0.0133 | 0.1348 | 0.3574 | 0.0128 | 0.8129 | 0.0518 | 0.2739 |
| 101 | Leszno | | 16.1049 | 0.0709 | 0.0494 | 0.2174 | 0.0108 | 0.3717 | 0.1139 | 0.0059 | 0.6454 | 0.0418 | 0.2357 |
| 102 | Leoncin | | 4.4629 | 0.0680 | 0.0066 | 0.2732 | 0.0018 | 0.1030 | 0.1092 | 0.0008 | 0.5462 | 0.0070 | 0.1532 |

1) alongside above-average waste management (Group B), which are Lewin Kłodzki in the Góry Stołowe NP, Hańsk in the Poleski NP, Słońsk in the Ujście WartyNP, Sękowa in the Magurski NP, and Nowinka in the Wigry NP. The results indicate the lack of administrative units that are extremely negatively rated, meaning those with low sewage and waste management levels. The least favourable situation is in the municipalities:

- with a low level of sewage management (Type 4) and an average level of waste management (Group C) – 4 municipalities (Adamów

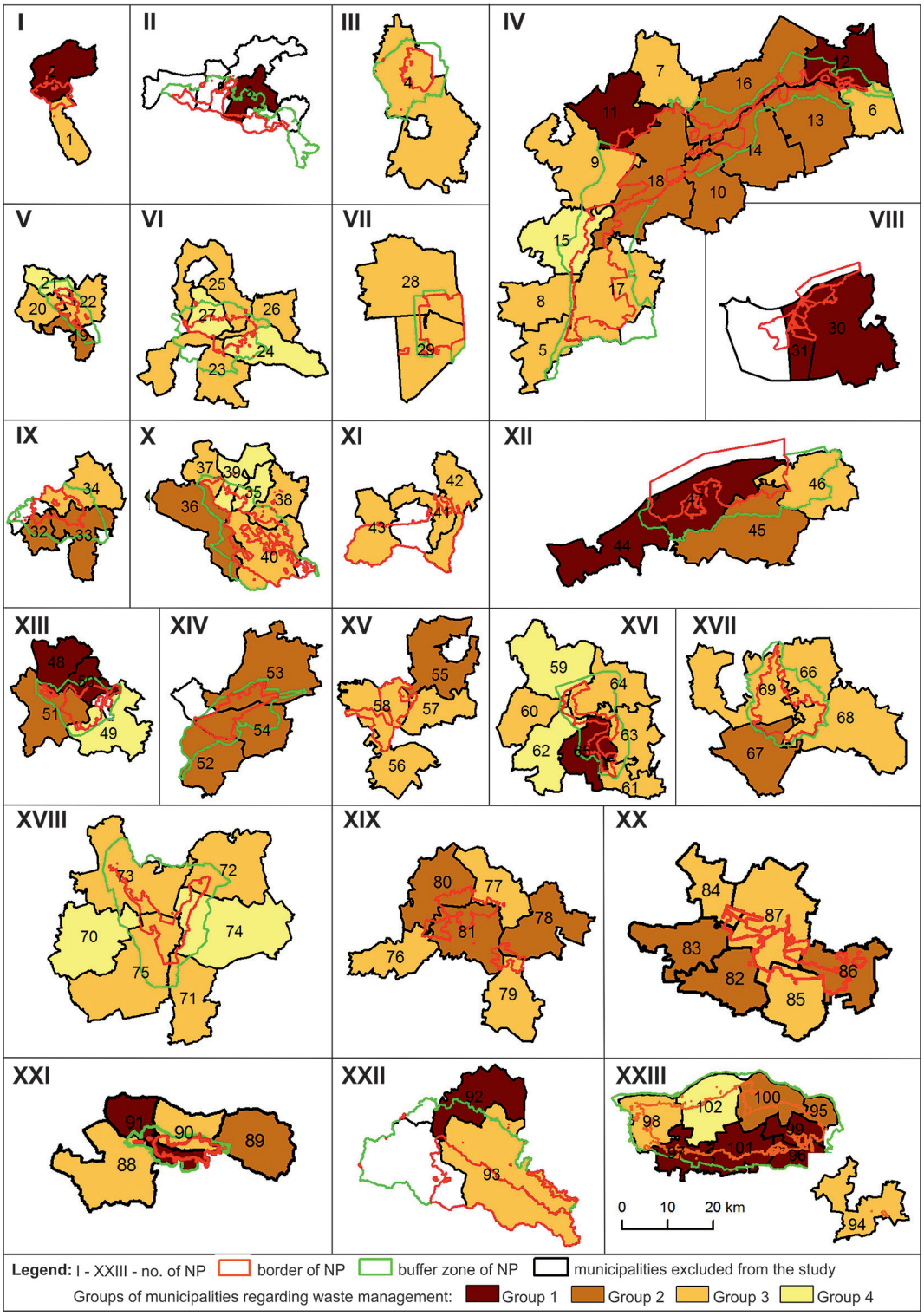


**Figure 2.** Spatial distribution of groups of municipalities regarding waste management level within particular national parks

in Roztocze NP, Bukowina Tatrzańska and Kościelisko in Tatra NP, and Giby in Wigry NP).

- with a low level of waste management (Group 4) and an average level of sewage management (Type 3) – 8 municipalities (Dębowiec and Osiek Jasielski in Magura NP, Człopa and Bierzwnik in Drawa NP, Niedźwiedź in Gorce NP, Leoncin in Kampinos NP, Tykocin in Narew NP, and Mosina in Wielkopolski NP).

The largest group of the municipalities (57%) consists of units rated as average. This is partly

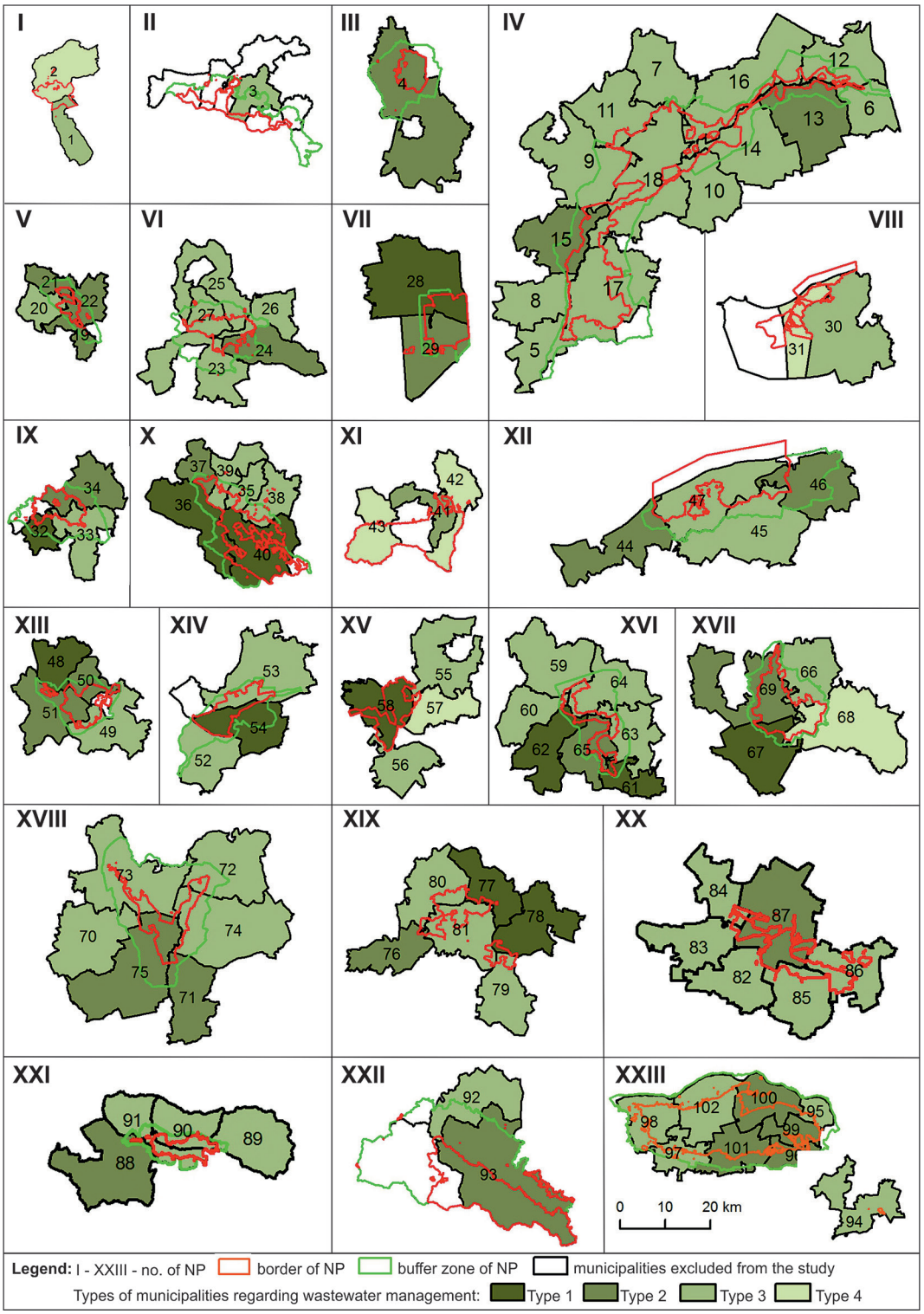


**Figure 3.** Spatial distribution of types of municipalities regarding wastewater management within particular national parks

due to the method of assessment applied, but it may also display that municipalities' authorities and their residents act in a similar, moderately active manner. Survey results also show the municipalities with no correlation between waste management and sewage management activities. These include the municipalities where the waste management was evaluated at a very good level (Group A) and the sewage management at an average or poor level (Type 3 and 4), such as: Zawoja in Babia Góra NP, Międzyzdroje and Wolin in Wolin NP, Rajgród and Lipsk in Biebrza

**Table 3.** The quantitative distribution of the groups and types of municipalities related to the level of waste and wastewater management

| Municipalities | Group A | Group B | Group C | Group D | ∑ |
|---|---|---|---|---|---|
| Type 1 | 48-XIII* | 32-IX; 78-XIX; 54-XIV; 36-X; 67-XVII | 58-XV; 40-X; 61-XVI; 28-VII; 77-XIX | 62-XVI | 12 (11,8%) |
| Type 2 | 96,99,101-XXII; 50-XIII; 65-XVI; 44-XII | 19-V; 100-XXIII; 13-IV; 51-XIII | 34-IX; 76-XIX; 71,75-XVIII; 4-III 22-V; 88-XXI; 93-XXII; 29-VII; 69-XVII; 37-X; 46-XII; 87-XX | 21-V; 24-VI; 15-IV | 26 (25,5%) |
| Type 3 | 3-II; 91-XXI; 47-XII; 11,12-IV; 97-XXIII; 92-XXII; 30-VIII | 33-IX; 95-XXIII; 80,81-XIX; 55-XV; 52,53-XIV; 89-XXI; 45-XII; 10,14,16,18-IV; 82,83,86-XX | 56-XV; 79-XIX; 94,98-XXIII; 1-I; 20-V; 90-XXI; 23,25,26-VI; 38-X; 66-XVII; 5,6,7,8,9,17-IV; 60,63,64-XVI; 84,85-XX; 41-XI; 72,73-XVIII | 27-VI; 49-XIII; 102-XXIII; 35,39-X; 59-XVI, 70,74-XVIII | 58 (56,9%) |
| Type 4 | 2-I, 31-VIII | – | 57-XV; 68-XVII; 42, 43-XI | – | 6 (5,9%) |
| ∑ | 17 (16,7%) | 25 (24,5%) | 48 (47,1%) | 12 (11,8%) | 102 |

**Note:** * The numbers of municipalities and national parks are given in Figure 1 and Table 1.

NP, Podgórzyn in Karkonoski NP, Kampinos in Kampinos NP, Czorsztyn in Pieniny NP, Czarna in Bieszczady NP, and Smołdzino in Słowiński NP. The other group of the municipalities is the one where the level of waste management was assessed as low (Group D), while the level of sewage management was at good or very good level (Type 1 and 2). This particularly refers to the municipalities of Sokoły in Narwia NP, Sułoszowa in Ojcowski NP, Ochotnica Dolna in Gorczański NP, and Radziłów in Biebrza NP.

The percentage distribution of individual municipalities is as follows (Table 3):

- high level of activities regarding waste management – 16.7% of the municipalities, and respectively, in the case of wastewater management - 11.8% of the municipalities;
- above the average level of activities regarding waste management – 24.5% of the municipalities, and in the case of wastewater management – 25.5%;
- average level of activities regarding waste management – 47.1% of the municipalities, in the case of wastewater management – 56.9%;
- low level of activities regarding waste management – 11.8% of the municipalities, in the case of wastewater management – 5.9%.

## CONCLUSIONS

Statistics show that the coefficients of variation for both synthetic indicators range between 20–40%, which signifies moderate variability in the results. However, it should be noted that the similarity is higher in the case of waste management (coefficient of variation equal to 24%) than in sewage management (coefficient of variation over 35%). In the case of waste management, it may be primarily related to a similar positive altitude attitude of residents and tourists towards proenvironmental activities. The level of wastewater management is more dependent on the specific characteristics of municipalities, as well as organizational and investment activities of their local authorities. This results in more significant variability of assessment outcomes. The overall evaluation in this field is also less favourable for some municipalities.

The analysis of individual indicators regarding waste segregation (paper, glass, metals, plastics) indicates significant similarity among municipalities. However, such similarity is not observed in the case of biodegradable waste. When it comes to wastewater management, the variation is considerable. The main similarity between municipalities can be observed in the number of septic tanks per capita. The variation is very large regarding indicators related to more ecological solutions such as collective sewage systems and household sewage treatment plants. Nevertheless, it can be stated that in municipalities located in highly valuable natural areas, the level of pro-ecological actions in the field of wastewater management is still unsatisfactory.

No correlation can be observed between the level of waste and sewage management in individual municipalities and their location within the

boundaries of a particular national park. This clearly indicates that the economic and social factors of the given municipality primarily determine the actions of municipalities in this regard..

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