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THE LIPÓWKA LANDFILLS: A CASE STUDY IN GROUNDWATER QUALITY ASSESSMENT

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ABSTRACT

Aim of the study

Groundwater quality monitoring tests in the area of pollution sources constitute one of the elements of the assessment of groundwater vulnerability. The aim of the present article is to designate a suitable index for the assessment of water quality, and to specify an appropriate value of the hydrochemical background.

Material and methods

The quality of groundwater in the region of the municipal landfills in Dąbrowa Górnicza (southern Poland) was assessed in the context of the content of ammonium, chlorides, sulphates, iron, and electric conductivity values. The level of the contamination of groundwater was determined on the basis of the monitoring data from 2016–2020. The research used the Landfill Water Pollution Index (LWPI) and the Nemerow index (NI). In order to determine the reliability of the methods used, three different values of the hydrochemical background were considered.

Results and conclusions

The results of the analyses show that the values of the Nemerow index are markedly higher than the LWPI index. Additionally, the highest values of the indicators were obtained when comparing the obtained results to the hydrochemical background from the 1980s. The maximum values of the indicators were approx. 156 (LWPI) and approx. 721 (NI) for the PZ4 piezometer located east of the landfills. The differentiated results of the index values, depending on the selection of the background value and the assignment of individual weights, suggest that for this type of transformed area it is problematic to indicate the value of the hydrochemical background for which the index values would be representative.

Keywords: Nemerow index, LWPI index, landfills, groundwater quality

INTRODUCTION

Physical, chemical, and biological parameters all determine the quality of groundwater. The study of these parameters in water is extremely important in the case of pollution sources (Grath et al., 2001; Jousma and Roelofsen, 2004; Nielsen, 2006) such as landfills, coking plants, waste incineration plants, or composting plants. In this context, reliable and representative groundwater monitoring should be performed, and the results should be thoroughly analyzed (Witkowski and Żurek, 2007; Dąbrowska et al., 2018; Rykala and Dąbrowska, 2020). Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste with subsequent changes – the Directive (EU) 2018/850 of the European Parliament and of the Council of 30 May 2018 involves all requirements for groundwater monitoring. These ordinances focus mostly on the provisions

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concerning testing for specific electrical conductivity (EC), pH, total organic carbon (TOC), copper, zinc, lead, mercury, cadmium, chromium, and total polycyclic aromatic hydrocarbons. However, in the case of many landfills, some of these elements – such as mercury or chrome – are found in concentrations below the limit of quantification (Wdowczyk and Szymańska-Pulikowska, 2020; Knopek and Dąbrowska, 2021). Therefore, increasing attention is paid to other parameters that are typical indicators of groundwater pollution in the hazard area (Slack et al., 2007). These elements include chlorides, sulfates, ammonium, and boron, among others (Venkatesan and Swaminathan, 2009). Increased concentrations of these components may indicate a negative impact of the facility on groundwater and pose a risk to human health (Civita, 2010; Mukate et al., 2020).

Determining the impact of, for example, landfills on the quality of groundwater is associated with the assessment of groundwater vulnerability to pollution (Goldscheider, 2003; Witkowski et al., 2003; Kabbour et al., 2006; Boderna, 2011; Oke et al., 2016; Hermanowski and Ignaszak, 2017; Juntunen et al., 2017; Chartres et al., 2019; Dąbrowska and Rykała, 2020).

There are a number of indicator methods that can be used to determine groundwater quality and groundwater vulnerability to pollution (Singh et al., 2015). The advantage of these methods is the fact that they can accommodate any set of parameters used to determine the value of individual indicators (Hossain and Patra, 2020). The first water quality indicators appeared in the mid-1800s (Horton, 1965). However, it is the Water Quality Index proposed by Horton (WQI) (Abbasi and Abbasi, 2012) that is considered the first proper measure for determining water quality. Some of the parameters that Horton used (pH, electrical conductivity, temperature, turbidity, total solids, dissolved oxygen, coliforms, biochemical oxygen demand, alkalinity, chloride, total phosphate and nitrate) are further applied to calculate other indicators, such as the heavy metal pollution index, Backman index, heavy metal evaluation index, seasonal quality index, landfill water pollution index (LWPI) or Nemerow index (Nemerow, 1974; Backman et al., 1998; Prasad and Bose, 2001; Tsegaye et al., 2006; Talalaj and Biedka, 2016; Rezaei et al., 2017; Kumar et al., 2019). The possibility of using any parameters, and at the same time having freedom in the selection of weights for the parameters and hydrochemical background in some indicators (Singh et al., 2017; Gorzelak and Dąbrowska, 2021; Karkocha, 2021), admittedly may result in the lack of universal application of such methods.

In order to assess the representativeness of the selected indicator methods for the landfills in question, results of the monitoring of groundwater quality in the area of municipal waste landfills in Dąbrowa Górnicza (southern Poland) from 2016–2020 were taken into account. The groundwater quality was characterized using the LWPI (landfill water pollution index) and the Nemerow index. Data on electrical conductivity, ammonium ion, chlorides, sulphates and iron were used for the calculations. Pollution indicators were calculated for piezometers capturing the Triassic aquifer by relating the monitoring results to different values of hydrochemical background.

STUDY AREA

In administrative terms, the research area is located in the Śląskie Voivodeship (Silesia region), in the Dąbrowa Górnicza poviat in southern Poland. The research covered the area of municipal waste landfill – Lipówka I and Lipówka II (see: Fig. 1). The absolute height of the research area is about 370m above sea level. The area around the landfills is highly urbanized. In the area of the described landfills, there are also other facilities, such as the Lipówka metallurgical waste landfill, the landfill of the coking plant, and the SARPI waste incineration plant (Sołtysiak et al., 2018).

The Lipówka I municipal waste landfill was established in 1992. This landfill is equipped with a liner system consisting of the following elements: native soil, a layer of sand – 15 cm thick, blast furnace slag – 27 cm thick, medium-grained asphalt concrete with a partially closed structure – 4.0 cm thick, fine-grained asphalt concrete with a closed structure – 4.0 cm thick, and asphalt. Drainage pipes are placed on the bottom in a gravel filtration layer, and they capture rainwater generated in the landfill. Wastewater is discharged by gravity through the pipeline to a collecting well from which, using a pump and a discharge pipeline, it goes to a two-chamber retention tank, and from there to

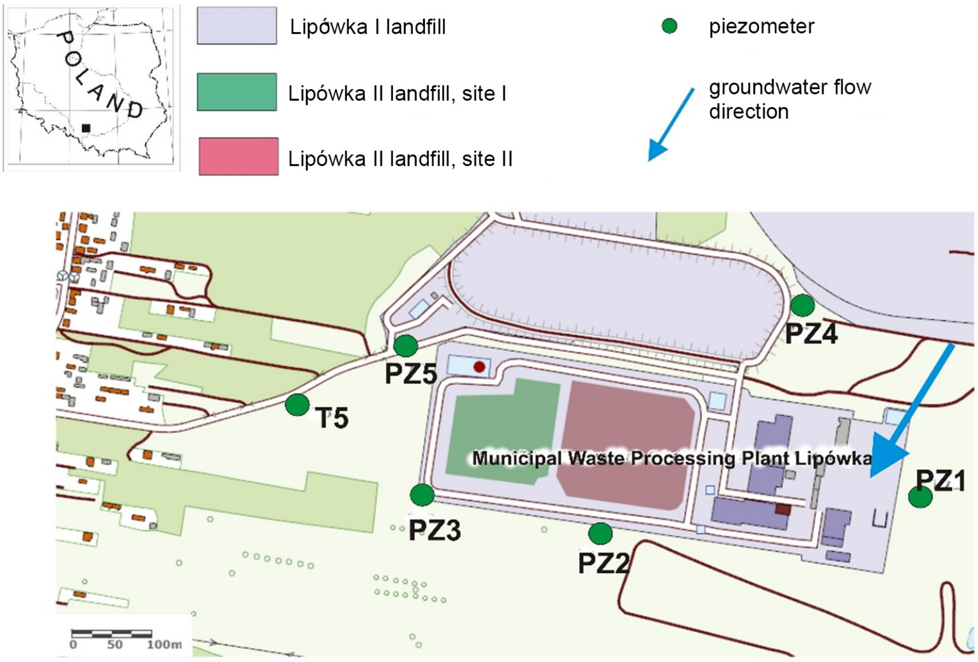

Fig. 1. Study area

a nearby sewage treatment plant. Under the bottom of the landfill basin, a drainage system for collecting water has been fitted, which consists of PVC pipes that transport the water to a reservoir. These waters are temporarily stored for firefighting purposes, sprinkling sewage sludge (leachate return system), and plant watering. The excess water is drained over to the rainwater drainage system.

The Lipówka II landfill was established in 2005. The security system of this landfill consists of the following layers: a bentonite mat with a basis weight of 5000 g/m^2 and the value of hydraulic conductivity $k < 5 \cdot 10^{-11}$ m/s, a PEHD geomembrane – 2.0 mm thick, geotextile > 800 g/m^2 and a barrier made of cohesive soil – 10–15 cm thick. As for the drainage system, it consists of a drainage layer – 0.5 m, with a hydraulic conductivity of 10^{-3} m/s. Collective pipelines are made of PEHD material with a diameter of 176 mm/150 mm, while transport pipelines have a diameter of 235 mm/200 mm. Excess leachate is sent to the sewage treatment plant, similarly to the Lipówka I landfill.

There are six piezometers around the Lipówka II landfill, which collect the waters of the Triassic aquifer – PZ1, PZ2, PZ3, PZ4, PZ5, and T5 (see: Fig. 1). Some of these piezometers also belong to the observation network of the Lipówka I landfill. The water table is located at a depth of about 23 (PZ1), 37 (PZ2), 27 (PZ3), 19 (PZ4), 7 (PZ5), and 14 (T5) meters.

The municipal waste landfills here described are located in the north-eastern part of the Upper Silesian Coal Basin (Stupnicka, 2007). There are Triassic and Quaternary sediments in the geological profile. The Triassic formations are represented by the lower and middle Buntsandstein sediments (conglomerates, sands, sandstones, mudstones and claystones), Roet (dolomite marl, marl dolomite and marl limestone, and the upper part is dolomite and limestone) and locally the Muschelkalk sediments (carbonate formations). Quaternary sediments occur in depressions lying on the Triassic carbonate formations and are composed of silt, clay, and sand (Sołtysiak et al. 2018), (see: Fig. 2).

In the area of the municipal waste landfill, there are two aquifers: Quaternary and Triassic. The Quaternary aquifer is characterized by variable thickness and discontinuity. It is associated with fluvioglacial sands with a thickness of < 6 m. The general direction of

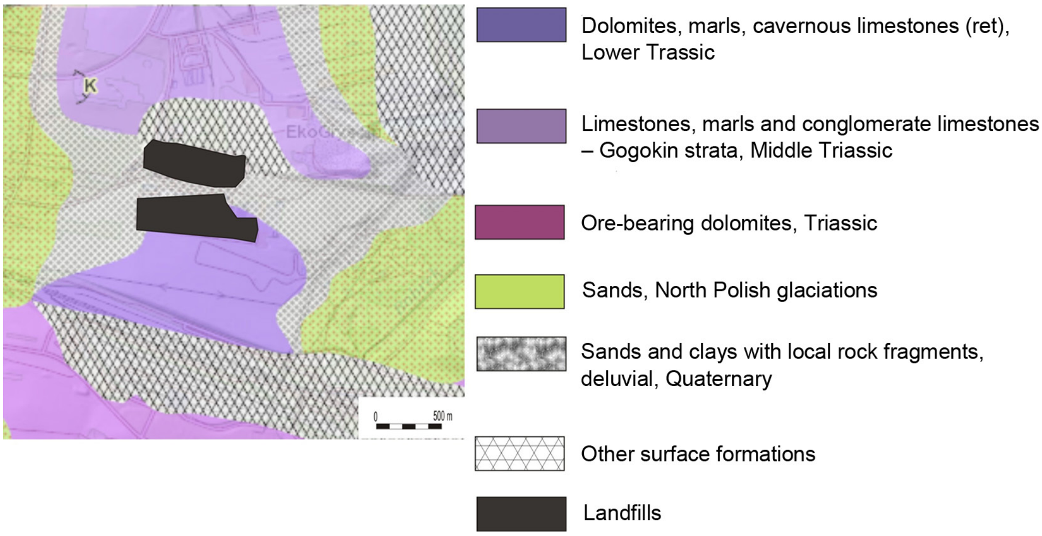

Fig. 2. Geological map of the study area

groundwater flow in this particular aquifer is southerly. The aquifer is recharged by infiltration. The hydraulic conductivity is about $7.1 \cdot 10^{-6}$ m/s (Sołtysiak et al., 2018). The Triassic aquifer is associated with dolomite and limestone. The thickness of this aquifer is 20 m, whereas the hydraulic conductivity is about $1.57 \cdot 10^{-4}$ m/s. The groundwater flow within this aquifer is south-westerly (see: Fig. 1).

The landfill site has been identified as an area of high groundwater vulnerability to pollution. This was described in detail in the work of Sołtysiak et al. (2018), in which the pollution indicators for all neighbouring facilities to the Lipówka I, Lipówka II landfills were determined.

METHODOLOGY

In order to achieve the aim of this paper, i.e., to evaluate the representativeness of the pollution indices, the Nemerow pollution index and the Landfill Water Pollution Index were applied. The choice of the indicators for analysis was due to the simplicity of calculations, coupled with the possibility to select various physicochemical parameters and changes in the value of the hydrochemical background. Furthermore, we should add that both indicators can also be compared with each other. The indices were calculated for such parameters as electrical conductivity, ammonium ion, iron, chlorides and sulphates. The choice of parameters used to calculate the indicators is related to the fact that these are typical groundwater contaminants in the area of landfills, combined with the fact that most of the metals were below the limit of quantification. The samples were evaluated in the accredited laboratory – OBiKŚ Poland in accordance with the PN-EN ISO 11885:2009 standard, and in the case of mercury – in accordance with the PN-EN ISO 17294-2:2016-11 standard. The results of laboratory tests were submitted for the purposes of preparing a report on groundwater monitoring by the Municipal Waste Management Plant in Dąbrowa Górnicza. The full set of data received by the landfill manager counts twenty columns of data with twenty-eight parameters for five piezometers.

The first index – the Nemerow pollution index (NPI) – was developed by Nemerow and Sumitomo in 1971 (Zhang et al., 2018). It is quite a simple method, which can be used to evaluate groundwater quality. It is calculated using the following formula:

$$NPI = \frac{C_i}{L_i}, \qquad (1)$$

where:

C_i – is the measured value of i-th parameter

L_i – is the allowable limit of i-th parameter

The second index has been specially designed to determine the quality of water in the area of landfills. The first part of this index is calculated like the Nemerow index – namely, it considers the relationship between the values of individual parameters measured at the observation point and the values for points beyond the influence of the object. The LWPI index was calculated using the following formula:

$$S_i = \frac{C_p}{C_b} \tag{2}$$

where:

C_p – is the concentration of the i-th parameter in each of the polluted groundwater samples

C_b – is the concentration of the i-th parameter in the inflow groundwater sample

The general formula is [30]:

$$LWPI = \frac{\sum_{i=1}^{h} S_i \; w_i}{w_i} \tag{3}$$

where:

w_i – is the weight of the i-th pollutant variable

n – is the number of groundwater pollutants.

The index assigns weights to particular parameters. Determining the weights is rather important because it significantly affects the value of the final index. Weights were assigned to individual parameters based on data from (Talalaj, 2014), (see: Table 1). According to the assumptions from the base publication, parameters such as electrical conductivity and pH should have the lowest weight (Talalaj, 2015).

Table 1. Weights of parameters required for the calculation of Landfill Water Pollution Index (LWPI)

Parameter	Weight (w_i)
EC	1
NH_4	3
Fe	3
Cl	4
SO_4	4
Sum of weights	15

Regardless of the number of parameters, the indicator value is interpreted as follows: a LWPI value of ≤ 1 denotes water under no landfill impact; (1 < LWPI ≤ 2) indicates moderately polluted water due to minor landfill impact; (2 < LWPI ≤ 5) is poor water with a highly visible impact of landfill; and LWPI > 5 signifies strongly polluted water (Talalaj, 2014; Baghanam, 2020).

In the case of both indicators, an extremely critical issue that informs the final result is the determination of the hydrochemical background to which the results obtained during the monitoring are compared. Due to the fact that the landfill area is heavily industrially transformed, it is difficult to determine the natural hydrochemical background for this area. As a result, the calculation of the index values may raise reservations as to its representativeness. Accepting the data from the piezometer, which is located at the inflow of groundwater to the area of the landfill, as was done in other studies (Dąbrowska et al., 2018), is impossible in this case due to the fact that the entire area is affected by other landfills, surrounding the municipal waste landfills studied herein. Finally, we have decided to choose three different values of the hydrochemical background for which we proceeded to calculate the values of the indicators. The first were the border values for class III water quality based on the Regulation of the Minister of Maritime Economy and Inland Navigation of October 11, 2019, on the criteria and method of assessing the condition of groundwater bodies (Journal of Laws 2019 item 2148). In the second case, background values obtained on the basis of the data contained in (Rudzińska, 1980; Pacholewski et al., 2016) for the 1980s were used. In the third case, the upper limit of the hydrochemical background specified in the above-mentioned regulation was considered. Background values for individual variants are summarized in Table 2.

Table 2. Hydrochemical background values

Parameter	Class III	1980s	Regulation background
EC	2500	454	700
NH_4	1.5	0.04	1
Fe	5	0.7	5
Cl	250	32.4	60
SO_4	250	38.3	60

Finally, the reliability of both indices was compared with the application of three different hydrochemical background values, and the representativeness of the assessment of water quality in the area of pollution sources was discussed using the existing data.

The total values of the Nemerow indices for the individual piezometers were calculated such that those values where data was missing for any of the components were removed. Hence, the average values for the total index may differ from the data for individual parameters.

RESULTS AND DISCUSSION

The Nemerov and LWPI indices were calculated using the results of measurements from piezometers of the observation network around the Lipówka I and Lipówka II landfills (PZ1, PZ2, PZ3, PZ4, PZ5, T5) from 2016–2020. The EC, ammonium, iron, chloride, and sulphate values were taken into account. Changes in the values of most parameters will affect the value of the electrical conductivity. Hence, the calculations of the indices were preceded by an analysis of the correlation between the values of electrical conductivity for the piezometer data in order to determine whether there are relationships between the data for the observation network. The electrical conductivity data is presented in Figure 3.

The average EC value for most piezometers does not exceed 1000µS/cm. The highest values were observed in the case of the PZ5 piezometer, which read twice as high as the others. After calculating the relationship between the EC values, it turns out that the data from the PZ1 piezometer correlate with the data from the PZ3 and PZ4 piezometers. In turn, the data from the PZ2 piezometer correlate with the data from the PZ3 piezometer. However, there is no relationship between the values of EC obtained from water analyses from the PZ5 and T5 piezometers (see: Table 3) i.e., piezometers located to the west of the landfills. In

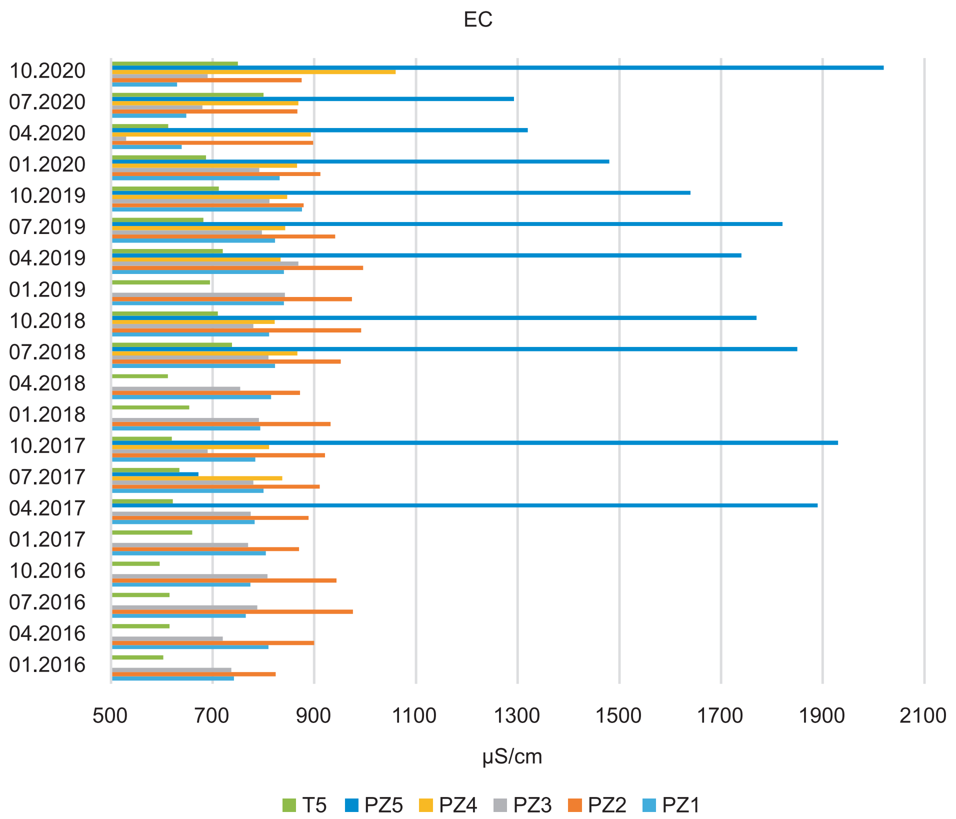

Fig. 3. EC values in piezometers

Table 3. Correlation analysis results

Variable	Correlations of EC values					
	PZ1	PZ2	PZ3	PZ4	PZ5	T5
PZ1	1.00	0.56	0.86	–0.69	0.14	–0.24
PZ2	0.56	1.00	0.60	–0.26	0.22	0.14
PZ3	0.86	0.60	1.00	–0.42	0.25	0.14
PZ4	–0.69	–0.26	–0.42	1.00	0.38	0.43
PZ5	0.14	0.22	0.25	0.38	1.00	0.27
T5	–0.24	0.14	0.14	0.43	0.27	1.00

the case of these piezometers, only the PZ5 piezometer is located at the outflow of water from the Lipówka I landfill.

The first step in calculating both the NPI and the LWPI is to determine the hydrochemical background value (i.e. the reference value). The question is quite simple: can we determine the natural hydrochemical background (Bacjman et al., 1998; Dragon, 2004; Matschullat et al., 2000)? However, when the study concerns an area heavily transformed by industrial activity, this becomes quite challenging. The problem is that, depending on what reference value we take, the obtained indicator value may not be representative. There are a number of methods for calculating the natural hydrochemical background (Pinneker, 2010), but they should not be used for this type of area.

One of the solutions that could apply here is to consider the average value for individual parameters from the piezometer, which is located at the inflow of groundwater to the landfill area and is not affected by any landfill (Karkocha, 2021). Unfortunately, for this landfill it is difficult to identify such a piezometer because municipal waste landfills are adjacent to other groundwater-affecting facilities.

It was decided that one of the solutions would be to use the limit values for class III water quality for individual parameters in accordance with the Regulation of the Minister of Maritime Economy and Inland Navigation of October 11, 2019, on the criteria and method of assessing the condition of groundwater bodies (Journal of Laws 2019 item 2148). The second element was the selection of reference values based on regional data. In this publication (Pacholewski et al., 2016), different background values were given for the 1960s, 70s, 80s, for 1995, and for the years 1995–2004. The values for the 1960s and average data from the last period seem to be the most similar. We therefore decided to select the values specified by Rudzińska based on archival data closest to the commissioning of individual industrial plants in this area (see: Table 2). For the purposes of comparison, the upper limit of the hydrochemical background was also selected from the above-mentioned regulation.

The first of the calculated indicators was the Nemerov index. The average values of the indicators for individual parameters are presented in Table 4.

The highest values were obtained for the parameters with the second option of the reference value. The greatest differences between the values of the indicators were calculated between the first and the second variant. The values of the indicators in the second variant are approximately five times higher than in the first variant in the case of EC, 37 times higher in the case of NH_4, and seven times higher in the other cases. In this context, the values from the third option seem to be the optimal. The values of indicators for individual parameters in variants 1 and 3 differ by no more than five times.

The highest indicators were calculated for the PZ5 piezometer located at the outflow of groundwater from the Lipówka I landfill. High values of the indicators were also calculated for the PZ4 piezometer. When analysing the obtained partial values of the indicators, it can be noticed that extremely high values are re-

Table 4. Partial mean Nemerow index values

Piezometer	Parameter	Nemerow Index		
		class III	1980s	hydrochemical background
PZ1	EC	0.31	1.72	1.12
	NH4	0.28	10.58	0.42
	Cl	0.03	0.26	0.14
	SO4	0.12	0.81	0.51
	Fe	0.01	0.07	0.01
PZ2	EC	0.37	2.02	1.31
	NH4	0.32	11.83	0.47
	Cl	0.30	2.32	1.25
	SO4	0.41	2.68	1.71
	Fe	0.02	0.12	0.02
PZ3	EC	0.30	1.68	1.09
	NH4	0.22	8.20	0.33
	Cl	0.12	0.97	0.52
	SO4	0.35	2.32	1.48
	Fe	0.01	0.05	0.01
PZ4	EC	0.35	1.91	1.24
	NH4	9.36	351.18	14.05
	Cl	0.36	2.82	1.52
	SO4	0.61	4.02	2.56
	Fe	0.01	0.09	0.01
PZ5	EC	0.65	3.57	2.31
	NH4	11.54	432.92	17.32
	Cl	0.95	7.36	3.96
	SO4	0.94	6.16	3.92
	Fe	0.01	0.07	0.01
T5	EC	0.28	1.53	0.99
	NH4	8.64	323.97	12.96
	Cl	0.22	1.71	0.92
	SO4	0.21	1.35	0.86
	Fe	0.09	0.63	0.09

corded for the ammonium ion. The maximum average value of the NPI index for this parameter is approx. 433 for the PZ5 piezometer (second variant). This suggests extremely elevated levels of water pollution. The smallest average values were calculated for the PZ3 piezometer, approx. 0.2 (first variant). If the quality of water in this area was assessed against the limit values for the quality class III, then in the case of the PZ1, PZ2 and PZ3 piezometers, one could speak of water bodies belonging to the quality class I or II. In the case of the other piezometers, the only parameter that causes the average value of this index to exceed 1 is the ammonium ion. Such positive assessment of water quality could not be made by choosing the third option. Here, for all piezometers, there are parameters for which the indicators exceed the value of 1. Thus, none of the waters of any piezometer would meet the standard for quality class III.

Apart from the assumed background value, the representativeness of the LWPI values is influenced by the weights assigned to individual parameters. Assigning the specific electrical conductivity to weight one and to the ammonium ion of weight three causes the final values of the LWPI to be significantly smaller than if both parameters were to be assigned a weight of four. Table 5 presents the summary of the LWPI values and the total NPI values.

The average LWPI values for the first variant for the entire observation network indicate that the PZ1, PZ2 and PZ3 piezometers are characterized by water meeting the requirements for class III. For the same piezometers in variant three, the situation is the same. In the case of the second option, the average LWPI values for these three piezometers do not exceed four. For the PZ4, PZ5 and T5 piezometers, significantly higher LWPI values were calculated, although in the first variant these values do not indicate a significant impact of landfills on groundwater (approx. 2). If the quality of groundwater in the area of landfills was characterized on the basis of this variant of the reference value, then for these three piezometers we could speak of moderately polluted and poor water. If the second option were chosen, for the entire water network they would show either a highly visible impact of the landfill or strong impact thereof. Index values of up to eighty suggest extremely elevated levels of pollution.

The values of individual concentrations should be related to the hydrochemical background. In the case of the research area here described, the background calculated on the basis of archival values before the objects were created is perfectly suitable for this purpose. The use of the second option makes the impact of the site's objects (not only the discussed landfills) on the quality of groundwater more visible. Determin-

Table 5. Minimum, Maximum, and Mean values of the LWPI and Nemerow indices

Piezometer	Background	LWPI (max, min, mean)			Nemerow Index (max, min, mean)		
PZ1	class III	0.36	0.07	0.12	2.07	0.41	0.76
	1980s	11.44	0.96	2.53	58.67	5.12	13.43
	hydrochemical background	0.71	0.21	0.33	4.44	1.32	2.20
PZ2	class III	0.33	0.22	0.28	1.70	1.18	1.41
	1980s	7.18	2.87	3.86	35.80	14.24	18.96
	hydrochemical background	1.23	0.78	0.97	5.76	4.03	4.75
PZ3	class III	0.35	0.09	0.19	1.87	0.56	1.01
	1980s	10.58	1.11	2.64	53.31	6.11	13.21
	hydrochemical background	0.89	0.31	0.67	4.28	1.94	3.42
PZ4	class III	4.09	0.23	2.22	20.34	1.20	11.00
	1980s	155.87	9.41	84.65	721.30	10.36	369.60
	hydrochemical background	6.88	0.88	4.11	33.82	4.47	19.97
PZ5	class III	3.23	1.19	2.30	15.89	5.89	11.34
	1980s	101.17	32.30	70.66	503.06	159.60	351.39
	hydrochemical background	6.57	2.74	4.80	31.45	13.22	23.01
T5	class III	3.53	0.59	1.88	17.77	3.38	9.66
	1980s	130.84	17.53	65.83	654.80	102.62	337.79
	hydrochemical background	5.45	1.29	3.15	27.48	6.77	16.15

ing the water quality with the use of the first option is definitely the most favourable. In this way, it has been shown what changes took place in the chemical composition of soil in the analyzed area over the years. The values obtained in the case of the Nemerow index are definitely less favourable when determining the quality of water in this region.

CONCLUSIONS

The Nemerow and Landfill Water Pollution Index are simple and very useful tools that allow making an assessment of the quality of groundwater based on any given list of parameters. When calculating both indices, a number of different parameters can be taken into account, both for water components and properties, e.g., pH or conductivity.

The representativeness of such measures, however, lies in the appropriate selection of the reference value of the hydrochemical background. The lack of data corresponding to the actual background will mean that the calculated values of indicators will either suggest no impact of a given object on the quality of groundwater or it will suggest a very high impact thereof. An alternative to providing background values is to relate monitoring data to data contained in legal acts, e.g., on the determination of groundwater quality.

The value of pollution indicators strictly depends on the selected parameters. If only those parameters that are imposed for the monitoring of groundwater in the area of landfills were to be selected, the values of the indicators would oscillate around zero. That is why it is so important to choose the kind of parameters that are typical indicators of water pollution in the area of landfills.

Another very important aspect when calculating the LWPI is the appropriate selection of weights for individual parameters. It may turn out that parameters that are not very important for water quality will be highly rated and thus significantly increase the value of the indicator. The weights should be reliably determined for individual parameters in accordance with the recommendations and your own hydrogeological knowledge.

The representativeness of the measures used can be supported by reliable water quality monitoring and regional research.

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SKŁADOWISKA LIPÓWKA: STUDIUM PRZYPADKU W OCENIE JAKOŚCI WÓD PODZIEMNYCH

ABSTRAKT

Cel badania

Jednym z elementów oceny wrażliwości wód podziemnych są badania monitoringowe jakości wód podziemnych w rejonie źródeł zanieczyszczeń. Celem niniejszego artykułu jest wyznaczenie odpowiedniego wskaźnika do oceny jakości wody oraz określenie odpowiedniej wartości tła hydrochemicznego.

Materiał i metody

Jakość wód podziemnych w rejonie składowisk odpadów komunalnych w Dąbrowie Górniczej (południowa Polska) oceniano pod kątem zawartości jonu amonowego, chlorków, siarczanów, żelaza oraz wartości przewodności elektrycznej. Poziom zanieczyszczenia wód podziemnych określono na podstawie danych monitoringowych z lat 2016–2020. W badaniach wykorzystano wskaźnik zanieczyszczenia wody (LWPI) oraz wskaźnik Nemerowa (NI). W celu określenia wiarygodności zastosowanych metod uwzględniono trzy różne wartości tła hydrochemicznego.

Wyniki i wnioski

Wyniki analiz wskazują, że wartości wskaźnika Nemerowa są wyraźnie wyższe niż wskaźnika LWPI. Dodatkowo najwyższe wartości wskaźników uzyskano, porównując otrzymane wyniki z tłem hydrochemicznym z lat 80. XX wieku. Maksymalne wartości wskaźników wynosiły około 156 (LWPI) i około 721 (NI) dla piezometru PZ4 zlokalizowanego na wschód od składowisk. Zróżnicowane wyniki wartości wskaźnika w zależności od doboru wartości tła i przypisania poszczególnych wag sugerują, że dla tego typu przekształconego obszaru problematyczne jest wskazanie wartości tła hydrochemicznego, dla którego wartości wskaźnika byłyby reprezentatywne.

Słowa kluczowe: wskaźnik Nemerowa, wskaźnik LWPI, składowiska, jakość wód podziemnych