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ORIGINAL PAPER

Factors affecting changes in water table level and water quality in a rural farmstead well*

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Abstract

An inseparable element of rural areas and farms are built-up areas organized in the form of a farmstead. The presence of such facilities is almost invariably linked to the appearance of sources, usually point ones, of water contamination. The aim of this study was to analyse the factors that affect changes in the water level and quality in a dug well at a farmstead situated in the catchment area of Lake Wydmińskie. The research was conducted in the years 2016-2018, on the farm in the village of Sucholaski (warmińsko-mazurskie voivodeship, Poland). Changes in the water level and quality were examined in a 3.75 m deep dug wall. In the past, it was used as a drinking water intake; now it is only an extra water source, used for the farm’s needs (watering plants and cattle). The study showed that changes in the well water level and physicochemical parameters were affected to the greatest extent by the weather conditions at the time of sampling (precipitation and air temperature). The quality of water in the well was affected by the amount and distribution of rainfall as well as by the farm buildings, especially by the cow shed and its surroundings. The amount and distribution of rainfall did not always have a direct impact on the water level in the well and the intensity of impurity migration within the soil profile, which was associated with a temporal shifting of groundwater resource replenishment relative to the time of rainfall. High concentrations, mainly of nitrate nitrogen (NO_3-N) and potassium ions in the well water, indicate that it is poorly protected against the influx of pollutants from the immediate surroundings, with the cow shed being their main source.

Keywords: well water, water testing, water quality, weather conditions, rural areas

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INTRODUCTION

The threats posed to groundwater resources in rural areas are a consequence of the interplay of many natural and anthropogenic factors. The most important anthropogenic factors, which in principle can be controlled and modified, include the management strategy applied in the catchment area, including the share and distribution of arable land, permanent grassland, forest areas, swamps and wetlands, ponds, trees and shrubs, and the presence of farm buildings (Szymczyk 2010, Rengasamy, Marchuk 2011, Rao et al. 2012, Smoroń 2016). Although a considerable portion of the population consumes drinking water from collective water supply systems, rural populations often use private water intake points, drinking water of unknown physicochemical and microbiological parameters. Little research is performed on such intake points; therefore, the health risk to people who consume water of such origin is also unknown. Test data published in the literature indicate that drinking water from uncontrolled private intake points often poses a serious health risk and can be harmful to watered animals and irrigated plants. Dug or drilled wells are common types of private intake points; they draw water from shallow aquifers, up to about a dozen meters deep (Wójcik-Jackowski, Bielak 2015, Kubicz et al. 2018). Due to their small depth, such well waters are contaminated, mainly with impurities carried by infiltrating rainwater, from non-point and point sources on rural land, and with household and farmstead wastewater leaking out of septic tanks. In the area of a farmstead, groundwaters contaminated the most with NO_3-N occur in the vicinity of dung pits and barns, whilst those contaminated with NH_4-N are in the vicinity of dung pits. Those contaminants may migrate both with the surface flow and with ground outflow. Unfortunately, once carried by groundwaters they reach dug wells located in farmsteads, where they are often the only source of drinking water and water for animals. This creates a severe threat to human and animal health (Dragon, Górski 2015, Nowak, Imperowicz-Pawlaczyk 2018). The intensity of water filtration and migration of chemical substances to water from agricultural sources depends on a number of natural and anthropogenic factors. Such natural factors include weather, relief and inclination of the land surface, flora and soil properties. Anthropogenic factors mainly include the land development, intensity of land use, influx of impurities from agricultural land, and the presence of a farmstead. The presence of farm buildings and facilities is almost invariably linked to the appearance of sources, usually point ones, of contamination of ground and surface waters. Impurities on a farmstead often come from a septic tank, dunghills, tanks for liquid manure and from the effluent from farmstead yards and farm animal pens. Consequently, chemical substances (mainly nutrients and other substances dissolved in effluent water soaking up soil) become dispersed in the soil and water environment. They originate mainly from unused nutrients supplied with mineral and organic fertilisers and from decaying harvest remains, as well as from microbial impurities originating at farmsteads (Rao et al. 2012, Yang et al. 2012, Smoroń 2016, Ridpath et al. 2016). The intensity and extent of nutrient migration from non-point sources is mainly affected by weather conditions, particularly the amount, intensity and distribution of precipitation (Krasowska, Banaszuk 2007).

The process of replenishing groundwater is very complex and complicated; it is affected by a number of factors (such as weather), which are variable both temporally and spatially. Groundwater can be supplied with water from the infiltration of atmospheric precipitations or surface waters. Infiltrating water is the main source of supplying, replenishing and maintaining the balance of groundwater resources. It contributes to fluctuation of the water resources, both in the annual and multi-year cycles. They manifest as the variability of the groundwater table level (Nowak 2007).

MATERIALS AND METHODS

The chemical indices analysis of water from a farmstead well, in the catchment area of Lake Wydmińskie, was conducted between June 2016 and May 2018 in the village of Sucholaski (warmińsko-mazurskie voivodship, Poland). It is a 3.75 m deep dug well situated at the highest point on the premises occupied by the farm buildings. In the past, it was used as a drinking water intake; now it is only an extra water source, used for the farm's needs, i.e. for watering plants in the garden and watering cattle. The catchment area of the well consists of Quaternary formations, mainly glacial tills of ground moraine, in addition to sands of postglacial accumulation and gravel. Mainly brown soils developed on their surface. The study object is situated in the north-east of Poland, in the western part of the mesoregion of the Ełk Lake District (Figure 1), within the macroregion of the Mazury Lake District, in the sub-province of East-Baltic Lake Districts in the Province of East-Baltic Lowlands (Kondracki 2011).

In terms of the administrative division of Poland, the area is situated in warmińsko-mazurskie voivodship, in the municipality of Wydminy.

The Ełk Lake District is a mesoregion with adverse climate conditions. It is one of the coldest areas in the Mazury Lake District, characterized by the lowest average daily temperatures, minimal and maximal ones, among all the regions in the Mazury Lake District, a relatively short growing season and a short time period with no ground frost. It is also a consequence of high annual amplitudes of air temperature relative to the average and extreme values. Winds of the highest velocities are from the western direction.

A YSI 6600 multiparametric probe was used to determine the specific

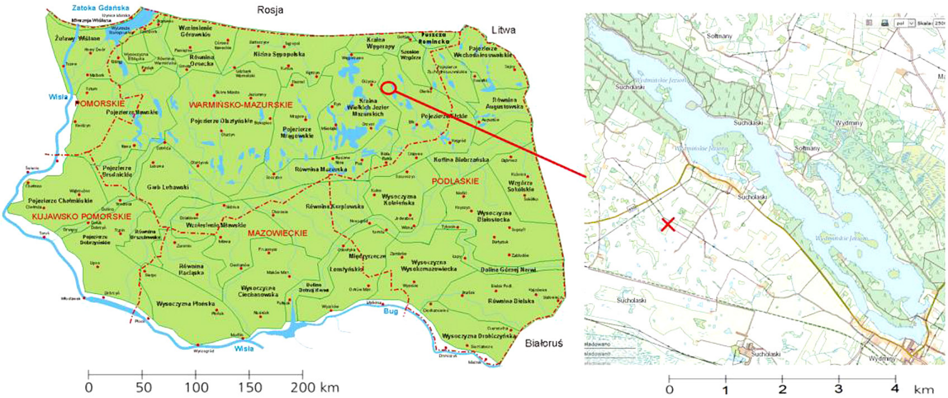

Fig. 1. Location of the rural farmstead and the well in the catchment area of Lake Wydmińskie in the physico-geographical mesoregions according to J. Kondracki and in warmińsko-mazurskie voivodship

electrolytic conductivity (EC), total dissolved substances (TDS), salinity (SAL) and pH. Water samples were collected into 3 dm^3 polyethylene bottles, fixed and transported to the laboratory, where chemical composition analyses were performed by commonly applied methods (APHA 1999): nitrate nitrogen (V) – NO_3-N, nitrate nitrogen (III) – NO_2-N, ammonia nitrogen – NH_4-N, Kjldahl nitrogen – N_{Kj} (ammonia nitrogen + organic nitrogen – ON), total phosphorus -TP, phosphorus phosphate – PO_4-P, sulphates – SO_4^{2-} and chlorides – Cl^-. The following concentration were calculated for the analyzed water samples: mineral nitrogen (NM) from the formula (MN = NH_4-N + NO_3-N +NO_2-N) and total nitrogen (TN) – (TN = NH_4-N + NO_3-N +NO_2-N + ON). Concentrations of calcium – Ca^{2+}, magnesium – Mg^{2+} sodium – Na^+ and potassium – K^+ ions were determined by ion-exchange chromatography. The water table level in the well was determined with a hydrogeological whistle.

The meteorological data quoted in the paper come from the hydrological and meteorological station of the Institute of Meteorology and Water Management (IMGW) in Kętrzyn, located at a distance of about 30 km from the research object.

The results were analysed statistically with Statistica ver. 13 PL software. The distribution normality was determined by the Shapiro-Wilk test at $p \leq 0.05$; the basic statistical analyses included the minimum, maximum, average, standard deviation, coefficient of variation and a cluster analysis was also performed (data visualisation on a dendrogram and a heat map). Moreover, a Spearman rank (r) correlation analysis was performed for weather conditions and the water table levels in the well. Statistically significant differences in physical and chemical properties of groundwater were tested using the nonparametric analysis of variance, i.e. the Kruskal-Wallis test.

RESULTS AND DISCUSSION

The distribution of monthly total precipitation and monthly average air temperature during the study period is shown in the graph below (Figure 2).

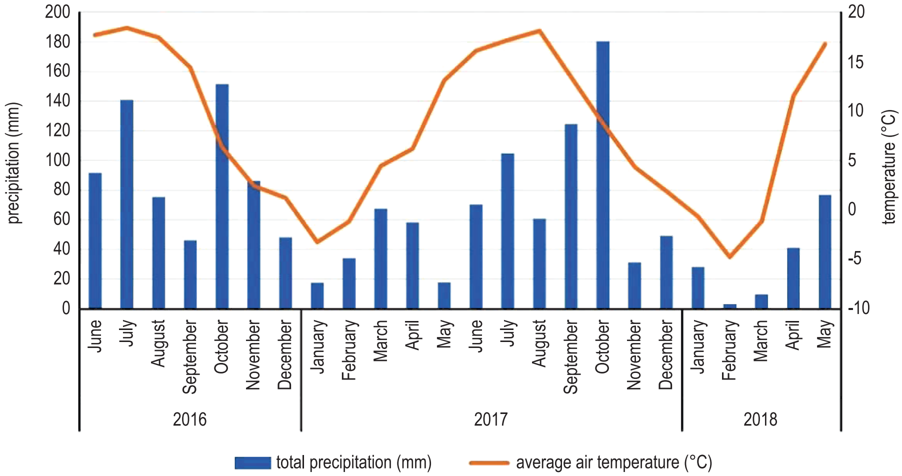

Fig. 2. The distribution of monthly total precipitation and the monthly average air temperature during the study period (data from the Institute of Meteorology and Water Management Institute – National Research Institute)

For the interpretation purposes, the study period was divided into two sub-periods (June – May 2016/2017 and June – May 2017/2018). The total precipitation in the Mazury Lake District for the multi-year period was determined to be 599 mm (Szwejkowski et al. 2017). The precipitation during the analysed periods was submitted to the classification system by Kaczorowska (Gąsiorek, Musiał 2011).

Since the total precipitation during the first period was 834 mm, which accounted for 139% of the normal level in the multi-year period, it can be classified as very humid. The total precipitation recorded during the second year of the study was 782 mm. It is equivalent to 131% of the norm, i.e. it was also a humid period. However, an analysis of precipitation in different months revealed great variance between them. The highest monthly precipitation in the first study year was recorded in July (141 mm) and in October (151 mm), which accounted for 35% of the annual total precipitation. The lowest total precipitation (17 mm) during this period was recorded in January and in May (18 mm). The total precipitation in these months accounted only for 4% of the whole precipitation. October (180 mm), September (124 mm) and July (105 mm) were the most humid months during the second study year. The total precipitation in these months accounted for 52% of the annual precipitation. February (6 mm) and March (10 mm) were the driest months during the period, with only 2% of the total annual precipitation.

January was the coldest month during the first study year, with an average temp. of -3.2°C, and July was the warmest (average 18.4°C). The average monthly temp. amplitude was 21.6°C. The lowest average temperature during the second study period was recorded in February (-4.8°C), and the highest was in August (18.1°C). The amplitude of the average monthly temp. was 22.9°C.

The changeability of the water table level during the study period (divided into two sub-periods) in the well under study is shown in Figure 3.

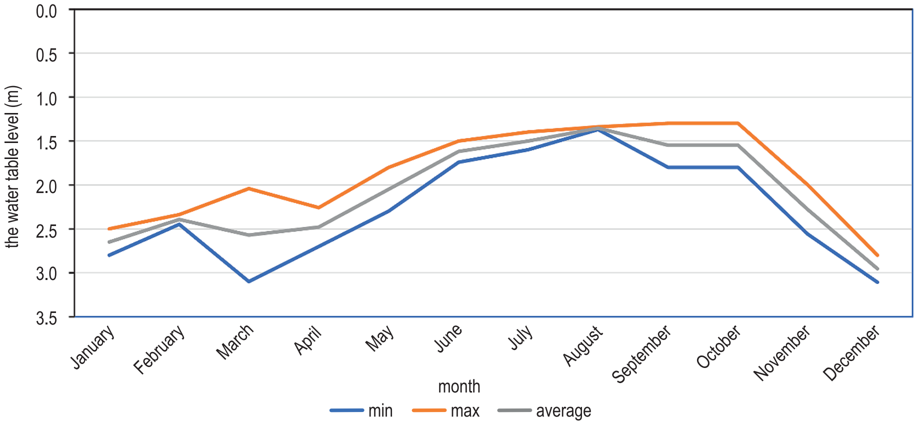

Fig. 3. Changes in the water table level (m below the ground level) in the well during the study period

Relatively high water table levels were observed during the period, for example the water table level ranged from 1.30 m to 1.50 m below the ground level during the summer-autumn season (from June to October 2016).

The lowest water table levels were observed in the winter-spring period, with the highest levels observed in December (3.11 m under the ground level) and in March (3.10 m under the ground level).

An analysis of the correlation of the weather parameters with the water table level in the well showed a significant correlation between the water table level and the air temperature (r = 0.73) and a significant correlation (r = 0.56) of precipitation with the water table level (Table 1).

Table 1

Correlation of meteorological conditions with water levels in the analysed well

Water table level	Air temperature	Total precipitation
Current water table level	0.73*	0.56*
Water table level (1-month shift)	0.57*	0.67*
Water table level (2-month shift)	0.26	0.61*
Water table level (3-month shift)	-0.24	0.10

* Correlation coefficient significance at α=0.05.

It is noteworthy that the impact of environmental factors on the water table level in the well is complex, with other factors affecting the outcome, apart from the two mentioned above. The well is relatively shallow and unprotected against the external factors, which is why the water in it is exposed to the environmental factors. The total precipitation during the summer-autumn season (June – October 2016 = 504.9 mm and June – October 2017 = 540.3 mm) was much higher than in winter-spring (November-May 2016/2017 = 329.2 mm and November-May 2017/2018 = 241.1 mm), whereas the water table level was much lower. This was associated with relatively high air temperature and intensive evapotranspiration. Due to the low evaporation rate in winter-spring, with relatively low air temperatures and precipitation, surface water infiltration to the ground took place, the groundwater resources were replenished with a consequent increase in the water table level in the well.

The statistical analysis revealed an increased correlation of the groundwater table level with the monthly total precipitation, with a 1-month shift (r = 0.67, p<0.05) and a 2-month shift (r = 0.61, p<0.05). However, the correlation decreased considerably with the 3-month shift (r = 0.10, p<0.05) and it was statistically non-significant.

Jędruszkiewicz et. al. (2016) showed in their studies that the average monthly water table level is slightly, yet significantly, correlated with the monthly precipitation, but the correlation strength increases when compared with 1-month shift strings of data. The correlation coefficients were significant even at the 5- and 7-month shifts. This is a consequence of water infiltration through the aeration zone and inertness of the whole groundwater reservoir. A 1-month shift in the process of water replenishing or depleting was observed by Nowak (2007). According to the author, the first aquifer level change rate varied during individual months and depended on the season of the year, volume and type of precipitation and air temperature, which affects the evaporation rate, among other things. Precipitation is solid in winter months, and the air temperature falls below zero, which may result in precipitation water retention and its release during the thawing period. Furthermore, high temperatures in summer result in an evaporation increase and, for this reason, the groundwater table level can remain unchanged despite the precipitation (Nowak 2007).

In order to demonstrate the extent of the well water contamination, it seems reasonable to start the analysis of the results from the specific electrolytic conductivity, which represents the total amount of ions dissolved in water (Table 2).

This parameter was relatively high (984-1584 μS cm^{-1}), which indicates that the water under analysis contained large amounts of dissolved substances. Similarly, high values (640-1030 mg dm^{-3}) were obtained for the total dissolved substances (TDS).

A high (788-1096 mg dm^{-3}) content of suspended and dissolved compo-

Table 2

Concentration of chemical substances and indicator values in the water of the analysed well ($mg\ dm^{-3}$)

Substance/ index	Min.	Max.	Average	LOQ	SD	V (%)
EC ($dS\ m^{-1}$)	984	1588	1431	1	148	10.3
SAL (ppt)	0.49	0.80	0.72	0,01	0.08	10.7
TDS	640	1032	930	1	96	10.3
Dry residue	788	1096	975	1	95	9.8
Ash	632	900	809	1	78	9.6
COD	6.3	51.8	26.7	0,1	9.5	35.6
NO_3-N	7.77	22.75	15.60	0,01	3.70	23.7
NO_2-N	0.0054	0.0225	0.0104	0,0001	0.0042	40.0
NH_4-N	0.064	0.581	0.175	0,001	0.120	68.4
ON	0.32	1.33	0.98	0,01	0.24	24.7
TN	9.11	24.10	16.76	0,01	3.75	22.4
PO_4-P	0.109	4.408	1.363	0,001	1.069	78.5
TP	0.606	4.856	2.144	0,001	1.217	56.8
K^+	142.5	340.2	275.4	0,1	47.85	17.4
SO_4^{2-}	20.0	274.4	90.3	0,1	69.9	77.4
C^l-	11.0	35.0	29.0	0,1	5.8	20.4
Na^+	12.0	33.3	23.1	0,1	5.52	23.9
Mg^{2+}	11.7	27.4	19.6	0,1	4.33	22.1
Ca^{2+}	41.2	144.8	85.8	0,1	31.92	37.2
HCO_3^-	348	625	524	1	63.97	12.2
pH	6.4	9.8	-	0,1	-	-

* min. – minimum value max. – maximum value, SD – standard deviation, LOQ - limit of quantification, V – coefficient of variation

nents in the water under analysis is confirmed by the amount of dry residue. Ash dominated (83%) in the dry residue – it is shows that mineral substances dominate over organic substances in the water.

Furthermore, chemical oxygen demand (COD), which represents the organic and mineral substance load in water, was variable and ranged from 6.3 $mgO_2\ dm^{-3}$ to 51.8 $mgO_2\ dm^{-3}$. Moreover, high concentration of some pollutants in the water in the shallow well situated in the farmstead, mainly nitrate-nitrogen (NO_3-N) and potassium ions, indicate that the well is not sufficiently protected, which makes it susceptible to the impact of the farm buildings and their immediate surroundings. Such a large variability of the indices depends largely on the type and method of soil use, as well as on the weather conditions which modify soil processes, and the intensity of substance bioaccumulation and their elution from soil to groundwater lying close to the ground surface.

The pH value of the water under study ranged from slightly acidic (6.4) to alkaline (9.8). The seasonal variability of the water pH is affected by the weather conditions, which in turn determines the availability of the major ions in water.

The research showed a significant seasonal variation in the concentration of the analysed indicators (Figures 4-7), but the differences were not

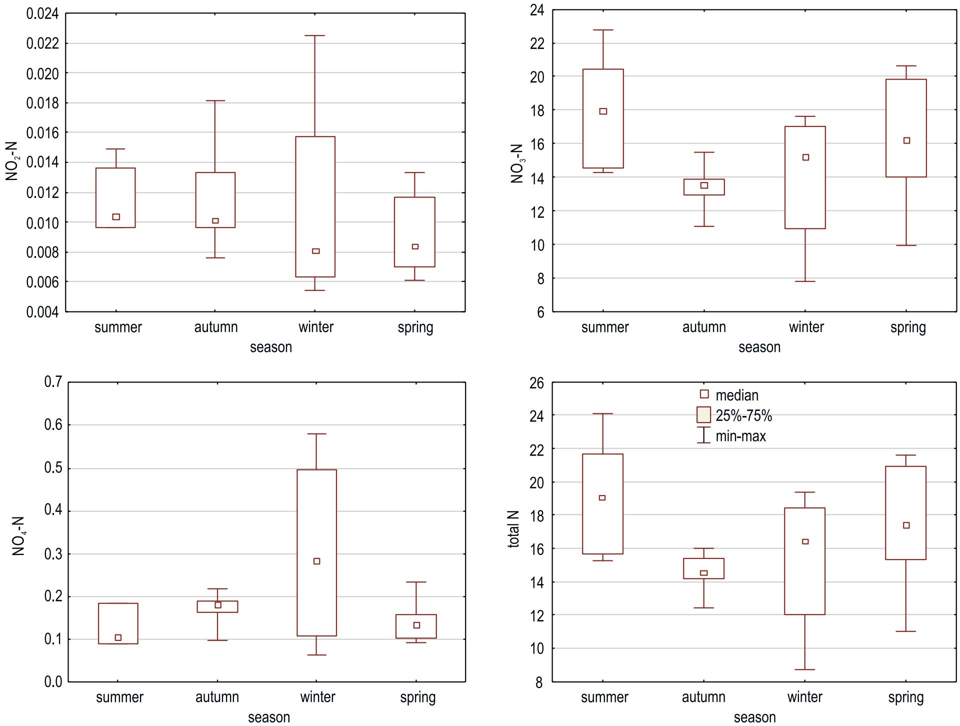

Fig. 4. Seasonal variability of the concentration of nitrogen compounds in the tested water (mg dm^{-3})

statistically significant. This was mainly due to the significant variability of meteorological conditions determining the chemical composition of the analysed groundwater.

The concentration of nitrogen compounds, including nitrate (V) nitrogen, is an important index of water contamination; its high concentration (15.60 mg dm^{-3} NO_3-N) is a sign of permanent water contamination. Due to exceeding the limit value (50 mg NO_3^- dm^{-3}) stipulated in the regulation of the Minister of Health (The Directive of the Polish Ministry of Health,

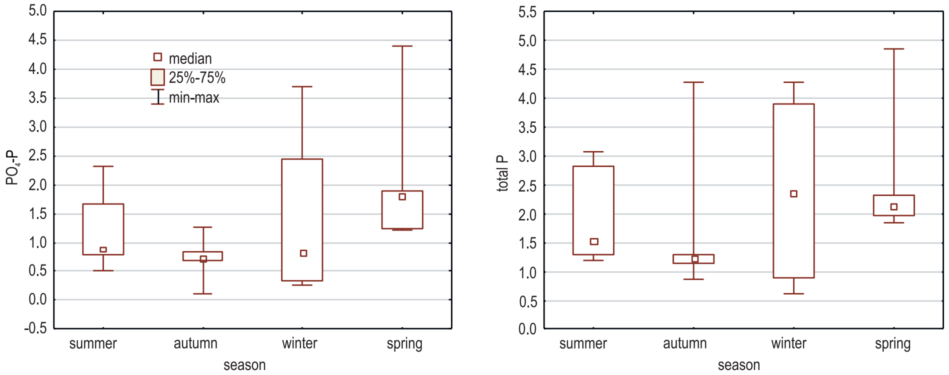

Fig. 5. Seasonal variability of the concentration of phosphorus compounds in the tested water (mg dm^{-3})

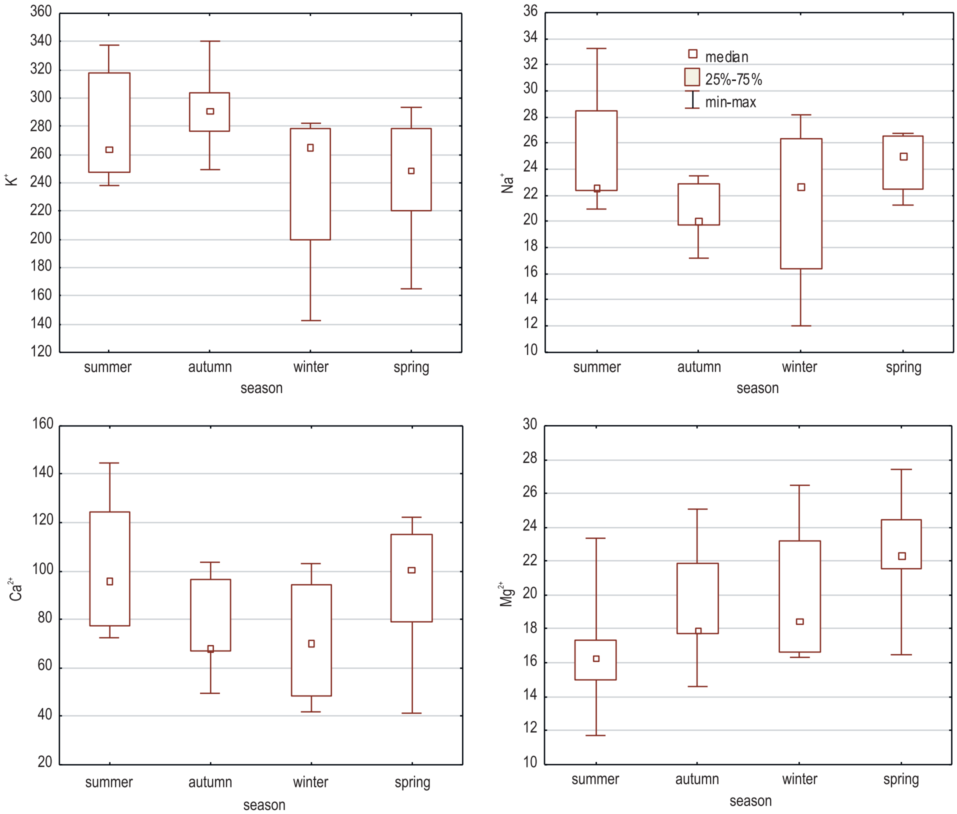

Fig. 6. Seasonal variability of the concentrations of potassium, sodium, calcium and magnesium ions in the tested waters (mg dm^{-3})

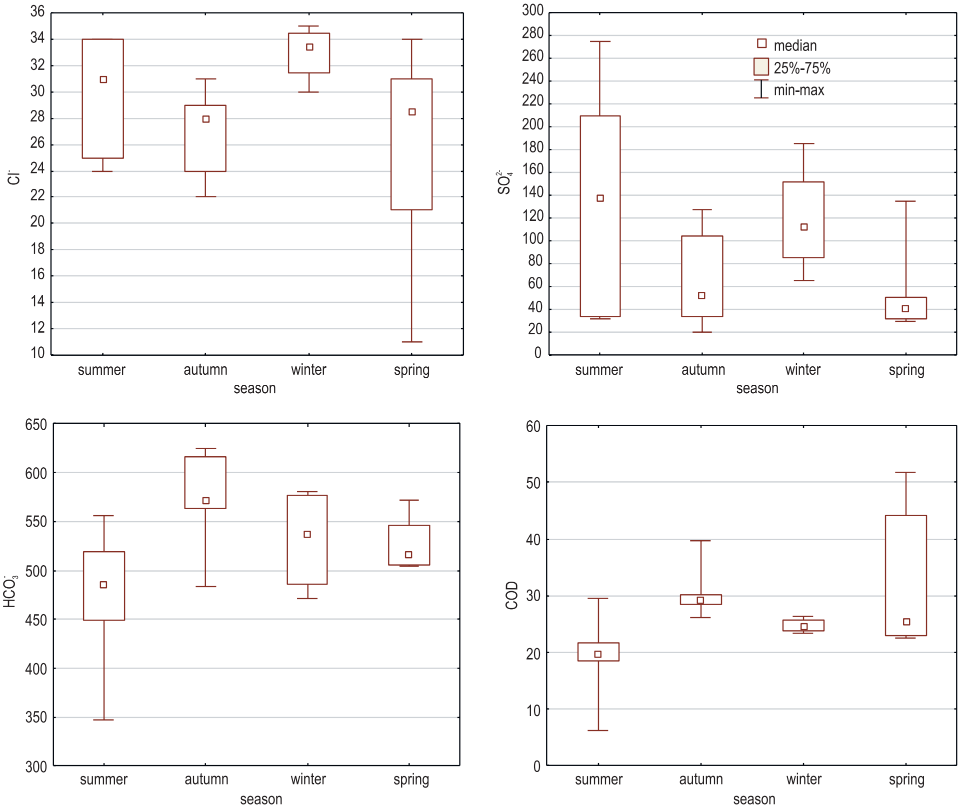

Fig. 7. Seasonal variability of the concentrations of chlorides, sulphates, bicarbonates (mg dm^{-3}) and COD (mgO$_2$ dm^{-3}) in the studied water

2017), it did not meet the standards of drinking water, and therefore it is also unsuitable for watering animals. A high concentration of nitrates in the water is a problem faced in many regions around the world. This is largely a consequence of excessive use of organic and mineral fertilisers. Nitrates may cause health problems, such as methemoglobinaemia, cancers, thyroid gland issues, miscarriages and birth defects. An adverse effect of nitrate (NO_3^-) is associated mainly with their susceptibility to reduction by bacteria to hazardous nitrite (NO_2^-), which are a precursor of carcinogenic N-nitrosamines (Ward et al. 2018). The concentration of nitrite nitrogen in the well under study was variable (coefficient of variance of 40.0%). Nitrite (NO_2^-) should be considered together with nitrate (NO_3^-) because they are transformed into one another in the environment. Moreover, nitrates (III) are formed by incomplete oxidation of ammonia or organic nitrogen, or by reduction of nitrate (NO_3^-). Toxicological studies have shown that neither of these two types of nitrates has directly carcinogenic properties, but that they can increase the risk of cancer development in people by endogenous and exogenous formation of N-nitroso compounds. Natural groundwater resources, free from anthropogenic contaminants, usually contain nitrates (NO_3^-) at less than 3 mg dm^{-3} (Koc et al. 2014).

The concentration of nitrate-nitrogen (NO_3-N) in the water from the well under study ranged from 7.77 to 22.75 mg NO_3-N dm^{-3}, which indicates a considerable anthropogenic impact on the well. It provides grounds for the conclusions that the water in the well under study is considerably polluted because it is supplied with nitrogen from agricultural sources. The well in question is situated at the highest point compared to the position of the farm buildings, but it lies 10 m from a cow shed. Due to its small depth (3.75 m), it is fed by water from the first aquifer which, in these conditions, is exposed to contaminants infiltrating the soil with precipitation. For this reason, the cow shed is probably the source of contaminants for the well water.

According to the current construction law, a well has to be situated at a distance of at least 15 m from buildings in which livestock is kept and places where organic fertilisers are stored. However, there are wells in many farmsteads which were dug before the current regulations came into force. Therefore, because of a shorter distance from individual farm buildings, they do not meet the applicable standards, which has an adverse effect on the water in such wells (Dec 2014).

This was also confirmed by a very high concentration of phosphorus compounds, which play a crucial role in water over-fertilisation (Szymczyk et al. 2010). Szymczyk and Świtajska (2013) showed that farmsteads in agricultural areas are often considerable sources of pollution for soils and groundwater, which leads to the deterioration of water quality in aquifers situated close to the ground level. A similar problem exists in the studied farm.

Concentrations of other ions (Cl^-, Na^+, Mg^{2+}, Ca^{2+}, HCO_3^-) in the well water under study also changed considerably during the study period, but they did not deviate significantly from their natural levels in waters.

A persistently high concentration of potassium (142.5-340.2 mg K dm^{-3}) was observed in the well. Potassium is rarely included in monitoring studies. Literature data suggest that a high potassium concentration has an adverse effect on the soil structure and causes problems linked to water infiltration (Rengasamy, Marchuk 2011). Potassium can be used as an anthropogenic pollution indicator, including the pollution caused by agricultural land use (Griffioen 2009). A high potassium concentration can be observed in agricultural land, in infiltration areas, where nutrient leaching takes place (Frey et al. 2009). The so-called "critical source areas" (CSA), i.e. spots of high nutrient concentration in soil with favourable conditions for leaching, are of special importance (Nödler et al. 2011). Potassium loss caused by effluence and leaching is affected by climate conditions (Kayser et al. 2012), agrotechnology, including the fertiliser type and doses, and the type and properties of the soil (Skowron et al. 2018). Nitrogen formed from mineral or organic fertilisers can stimulate migration of potassium cations from soils to water. NH_4^+ cations push out K^+ of the binding sites to the soil solution and induce the acidification effect, which additionally mobilises potassium ions. Furthermore, NO_3^- ions also accelerate K^+ ions loss from the soil (D'Alessandro 2012, Świtajska et al. 2013). These authors showed in their studies relatively high concentrations of mineral nitrogen in the well water, which may confirm this relationship.

The sulphate ion was another element with a high concentration in the well water. Along with chlorides, sulphates are the major components of natural waters, and they are usually good indicators of sources responsible for increased salinity. Household, industrial and agricultural wastewater is the main anthropogenic sources of sulphates (Jakubowski et al. 2013). However, one must stress a very high variance (from 20.0 to 274.4 mg SO_4^{2-} dm^{-3}) of the sulphate concentration in the well water during the study period, which testifies to the variable impact of external factors.

Gopal et al. (2018) pointed out that the sulphate ion can be easily leached into the soil profile depending on the soil type, weather conditions and the pH value. Sulphates do not affect the process of water over-fertilisation, but they can increase their salinity, thereby causing their quality to deteriorate. The pH value affects the solubility of many substances. An influx of contaminants can result in a pH decrease. A low pH stimulates the transformation of many substances, including heavy metals, sulphur compounds and nutrients, into their active species (Sienkiewicz, Gąsiorowski 2017).

When analysing the heat map and the dendrogram (Figure 8), which show the variability of the well water chemical properties, one should note that individual months of the study were assigned to two main groups and four subgroups. Individual ranks on the heat map represent the concentration of individual chemical substances. The first group reveals the variance between the study months. The first subgroup consists of all the analysed months of 2016 as well as January 2017 and April 2018. Despite the large differences between the ranks, the concentrations of contaminants in this subgroup are lower than in the others. Another subgroup comprises mainly months representing the spring-summer season of 2017 (April, May, June and July) but it also includes March 2018. These are the months with relatively high chemical substance concentrations in the water of well.

Concentrations of most of the analysed substances were above the average during these months. The other months are in the second group, in which a different trend is observed, namely individual months do not differ from one another; however, concentrations of some substances are relatively high and others are relatively low. The concentrations of nitrogen and phosphorus compounds in the first subgroup, represented by February and March 2017, are relatively high and those of the other substances are relatively low. The opposite trend was generally observed in the next group,

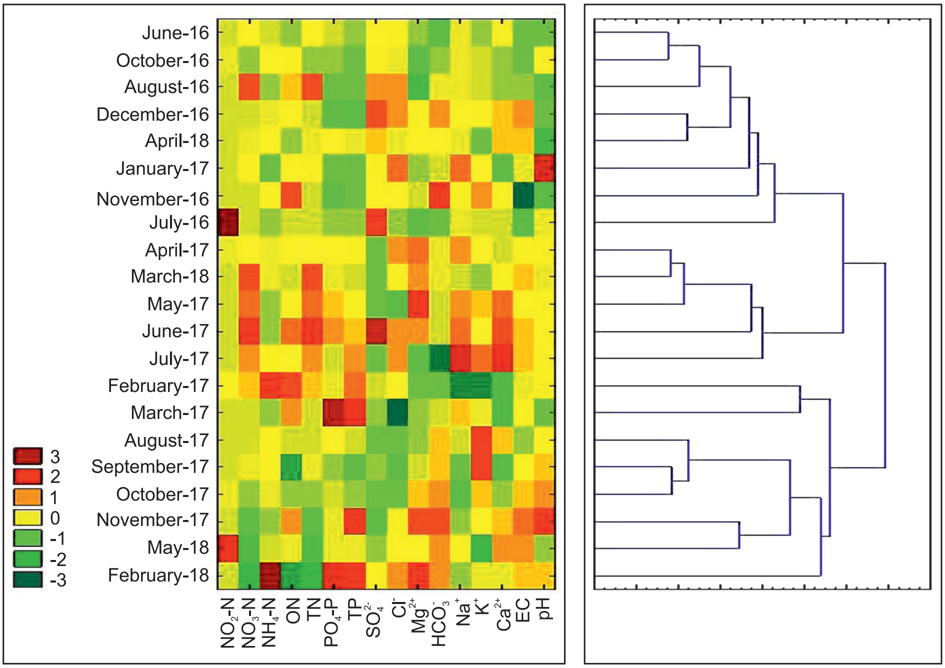

Fig. 8. The heat map and dendrogram showing the monthly changes in the concentrations of chemical substances in the well water

which comprises the months of the summer-autumn season of 2017 (August, September, October, November) as well as February and May 2018; however, large differences were observed.

The results show that the highest concentrations of contaminants in the well water occur between April and July 2017, whereas the lowest ones were determined in all the months of 2016 as well as in January 2017 and April 2018. For this reason, it is rational to assert that the concentrations of pollutants in groundwater are affected not only by the weather in individual seasons of the year but also by the typical processes affecting the intensity of bioaccumulation or leaching of chemical substances from the soil to groundwater lying close to the ground surface. High concentrations, mainly of nitrate nitrogen (NO_3-N) and potassium ions, in the well water indicate that it is poorly protected against the influx of impurities from the immediate surroundings, with the cow shed being the main source.

CONCLUSIONS

The changeability of the status and physicochemical properties of water in the shallow dug well situated in the farmstead was mostly affected by the weather conditions (precipitation and air temperature), which determine the water and chemical substance circulation in the soil profile and their transport to the aquifer.

A positive correlation was shown between the air temperature (*r* = 0.73) and precipitation (*r* = 0,56) and the well water table level.

The quality of water in the well was found to be affected by the amount and distribution of rainfall, but also by the farm buildings, especially by the cow shed and its surroundings, which was mainly due to its location at a short distance (only 10 m) from the well.

Precipitation was shown to not always be adequately reflected in the intensity of supplying and replenishing groundwater and the intensity of contaminant migration within the soil profile.

It was also found that the high concentration of nitrates (average 69.09 mg $NO_3^-\cdot dm^{-3}$) in the tested water does not meet the standards of drinking water, which makes it unsuitable for consumption by farm animals either.

Author contributions

All elements related to the development of results and the preparation of the manuscript, such as: conceptualization, methodology, data storage, formal analysis, obtaining financing, project administration, software; supervision are the individual contribution of the author. The work has been read and approved by the author for publication.

Conflicts of interest

There are no conflicts of interest.

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