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Quality of shallow groundwater and manure effluents in a livestock farm

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Abstract

The aim of the study was to assess the quality of shallow groundwater on the site pens and runoff from livestock manure heaps, in three selected farms involved in animal production and vegetable crops in the area of Plateau Proszowice. The analysis mainly included water from farm wells and effluents from manure. Additionally, water from drainage ditch running nearby farms was collected, before inflow of effluent (i.e. ditch water without manure effluent) and below inflow of effluent from heap of manure (i.e. ditch water containing manure effluent). Samples of the research material were collected from April 2012 to March 2014 at monthly intervals and analysed for the content of NO_3-N, NH_4-N, PO_4-P, K, Na and Cl. Based on the obtained results it was found that water from the farm wells near the livestock buildings and from manure storage sites, was heavily polluted by the majority of these contaminants. The highest concentration of these pollutants, except for the NO_3-N, was found in manure effluent – it exceeded a few dozen to a few hundred to any standards for water quality. There was also a significant deterioration in the quality of drainage ditch water because of the penetration of contaminants into ditch water from heaps of improperly stored manure. The water of the farm wells was characterized by excessive concentrations of NO_3-N which disqualified it for drinking purposes.

Key words: *fertilizer components, ground water, natural fertilizers, surface water*

INTRODUCTION

It is understood that human impact on the environment, called anthropopressure, began more than 12,000 years ago. In a short time, man became the dominant species and even determining life on earth [JANIKOWSKI 2004]. In agricultural areas the largest anthropopressure occurs with intensive livestock production. The concentration of animals in a small space inside a pen is a point source of contamination of soil, groundwater and surface water mainly by mineral nutrients, especially compounds of nitrogen, phosphorus and potassium [DURKOWSKI *et al*. 2006; MAGETTE 2001; SAPEK, SAPEK 2006a, b; SMOROŃ, SAPEK 1988]. The source of these substances is inappropriately stored liquid and solid fertilizers including those located in livestock buildings as well as animal droppings in outdoor range. Also daily activities related to handling of animals in the area of farms pose a threat to disperse contaminants into the soil and indirectly into groundwater [BARSZCZEWSKI *et al*. 2001; ROSSA, SIKORSKI 2006; SAPEK *et al.* 1998].

Long-term research conducted by SAPEK [2006] showed that the concentration of contaminants in groundwater and watercourses within farm areas with dairy cattle were many times higher than in water containing pollutants from agricultural areas, and the concentrations of nitrogen and phosphorus exceeded the limits laid down in the Nitrates Directive. This is confirmed by studies conducted by other authors [WORONIECKI, RUMASZ-RUDNICKA 2008].

The aim of this study was to evaluate water quality in wells fed by shallow groundwater in selected farms of Proszowice Plateau in terms of impact on the state of water of contaminants within farm area, especially within improper storage of liquid and solid livestock manure. The analysis also included effluent from manure heaps as well as its impact on water quality in drainage ditches running nearby farms.

MATERIAL AND METHODS

Research was conducted in Szreniawa river basin in three agricultural farms located in Proszowicki district. It has been carried out since 2012 by Institute of Technology and Life Sciences within framework of the Multiannual Programme – action no. 1.3 (Fig. 1). Two of the three examined farms (no. 1 and 2) are located in the western part of the country community Koniusza (village Niegardów), and one (no. 3) in the country community Pałecznica (village Pieczonogi). Niegardów is characterized by compact housing, while Pieczonogi is characterized by dispersed housing and both are not channelled. This is a source of contamination of water in environment of living. In the farm no. 1 and 2 wells are used for the needs of residents and feeding of livestock, and in the farm no. 3 they are used only for animals. Geographically the research area lies in the southern part of Malopolska Upland, on Proszowicki Plateau [DRUŻKOWSKI 2004; GILEWSKA 1999].

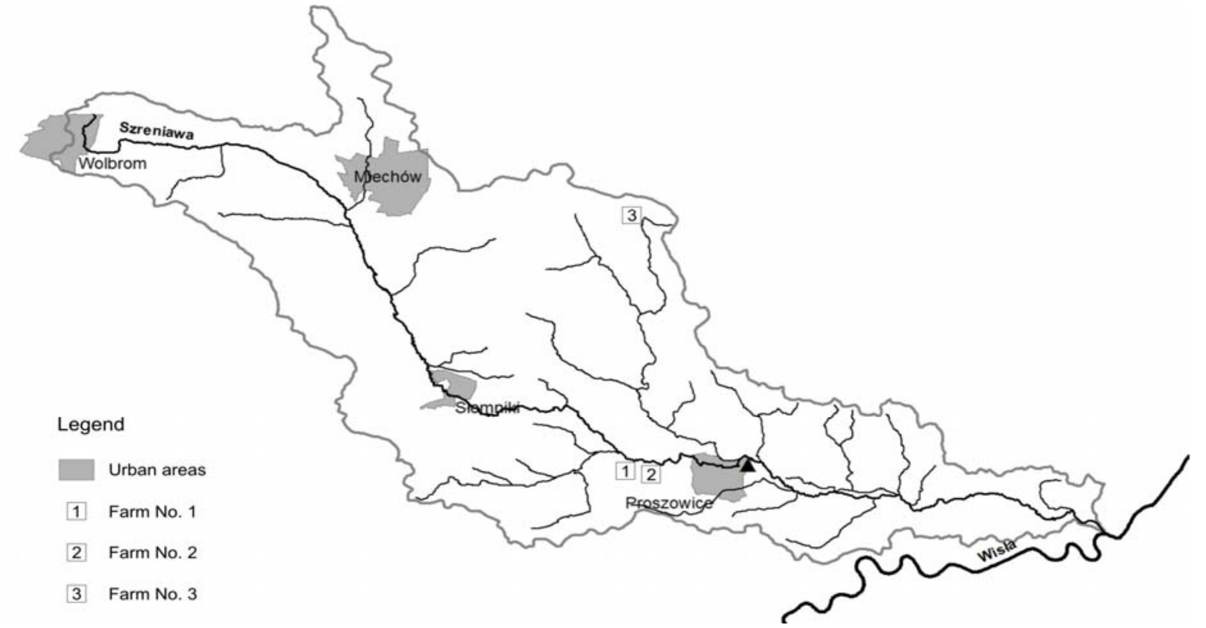

Fig. 1. Location of farms from which water samples were analysed; source: own elaboration

Geologically, the western part of the community Koniusza is created by sedimentary rocks of Upper Cretaceous, i.e. marls and limestone with good permeability (0.36–3.6 $m \cdot h^{-1}$) [KONDRACKI 2000; PAZDRO, KOZERSKI 1990; TŁUSZCZ 2007]. These rocks with a thickness of more than 20 m and levels of water-bearing of slot type are covered with semi-plastic loess of a type of loess silt dating from the last glacial period. Thickness of the loess layer is characterized with lower permeability (0.036–0.36 $m \cdot h^{-1}$) in comparison with deeper limestone layers and varies from 2 to 5 m. Soils originating from loessial forms are categorized as silty brown and, as in the majority of the Szreniawa water catchment area, they are very fertile. The soils are of high viability and are most often placed in I–II quality class.

In the area of farm no. 3, the upper layer of the ground consists of loessial forms with layer thickness of 5–15 m. Similarly to the previous farms, its soils are silty brown of high viability (II quality class). Layers below the loess are made of loam and shale (i.e. impermeable forms) [PAZDRO, KOZERSKI 1990].

The annual temperature of multi-year average for the area of Proszowice Plateau is 8.0°C, and annual precipitation is 600 mm [NIEDŹWIEDŹ, OBRĘBSKA-STARKLOWA 1991]. This makes the conditions of the area favourable for intensive agricultural production. The value of the overall index of quality of the agricultural production is very high and stands at 95.8 [WITEK *et al*. 1993].

The characteristics of the described farms are summarized in Table 1. Farms no. 1 and 3 are set to livestock production, and the farm no. 2 was in the middle of changing the production profile of the animal into vegetable cultivation. In addition to the mineral fertilization, manure from livestock was used in the field cultivation as fertilizer. The analysed farms applied high doses of mineral fertilizers and, depending on the type of field crops, which were on average: 40–130 kg of N; 30–60 kg of P_2O_5 and 40–90 kg of $K_2O \cdot ha^{-1}$.

The animals were maintained in system of shallow bedding. Livestock buildings were built in the 70s of the twentieth century. Farms 1 and 2 were not

Table 1. Basic characteristics of the farms (located in rural communities), taking into account the medium-scale annual agricultural area (ha), livestock population in pcs, mineral fertilization and the method of storage of natural fertilizers for the period 2012–2014

Specification	Farm no. 1, community Koniusza	Farm no. 2, community Koniusza	Farm no. 3, community Pałecznica
Arable area	30	14	18
The number of animals	cattle 34 pcs including 17 dairy cows	pigs including: 2 sows, 45 cutters	pigs including 19 sows; 425 cutters cattle 2 pcs including 1 cow and 1 heifer
Mineral fertilizers, $kg \cdot ha^{-1}$ of arable area			
– N	40–100	60–130	60–80
– P_2O_5	30–50	40–60	30–60
– K_2O	70–90	60–90	40–70
Storage of manure	without manure plate, directly on the ground	without manure plate, directly on the ground	concrete manure platform or pit
Storage of liquid manures	manure container with leakage	manure container with leakage	container for liquid manures without signs of leakage

Source: own elaboration.

equipped with manure plates (pits) and containers with liquid manures were in poor condition with numerous leaks. Only in the farm no. 3 the manure is stored on concrete manure slab and slurry is stored in airtight container. However, the floor in the livestock building requires major repairs, as cracks appear through which liquid manure leaks into the ground. Natural fertilizers were stored on average in the two six-month cycles and they are applied in fields early in spring as well as in the autumn.

Samples of material for the research for chemical analysis were taken from farm wells, effluent from manure storage, and, in one case, from drainage ditch before and below inflow of effluent from manure heap (Fig. 2).

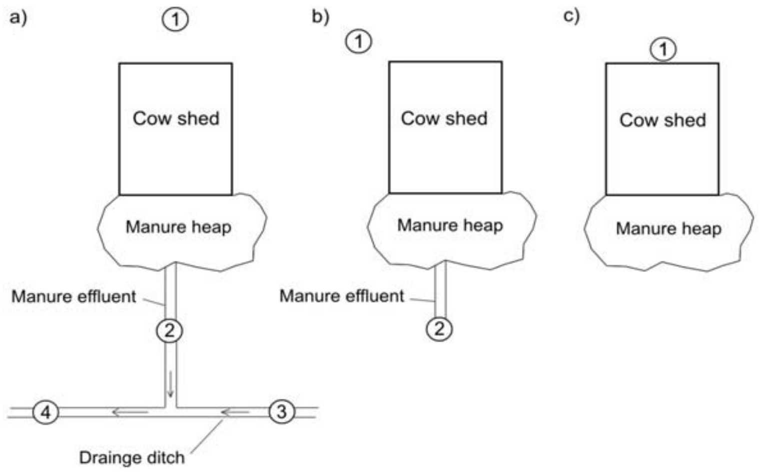

Fig. 2. Scheme of the location of sampling points for chemical analyses in the farms: a) no. 1; b) no. 2; c) no. 3; *1* = farm wells, *2* = manure effluent, *3* = drainage ditch in the point before inflow of the effluent from the manure, *4* = below the inflow; source: own elaboration

In farm no. 1 samples were taken from four points: 1 – homestead well with a depth of 8 m (water level 3–5 m); 2 – leakage from heap of manure located directly on the ground at a distance of 10 m from the heap; 3 – drainage ditch at a distance of 15 m from the inflow of the leakage from the heap of manure; 4 – the same ditch, but at a distance of 15 m below the inflow of the leak from the heap of manure (Fig. 2a). Effluent from the heap of manure and slurry from the leaky container were getting along the surface of the ground to the drainage ditch located 30 m away.

In the second farm samples of water were taken from farm well with a depth of 10 m (water table of 4–6 m, point 1) and leakage from manure heap located on the ground (point 2), at a distance of 25 m from the mentioned farm well (Fig. 2b). Effluents from manure and slurry from leaky container were soaking into the ground in the vicinity of the storage of these organic fertilizers.

In the farm no. 3 water samples were taken from only one point, i.e. from well with a depth of 18 m (ground water of 9–15 m), located 20 meters from manure heap (Fig. 2c). The material for chemical analysis was taken each month from the start of monitoring (April 2012) to March 2014. Analysis of the research material was conducted in the Research Laboratory of Environmental Chemistry of Institute of Technology and Life Sciences. The material was determined for the concentration of NO_3-N, NH_4-N, PO_4-P, K, Na and Cl. The concentration of NO_3-N, NH_4-N, PO_4-P was determined by the colorimetric method using automated flow analyser. The concentration of Mg and Ca was determined by atomic absorption – flame spectrometry, Na and K – by emission method with the use of atomic absorption spectrometer SOLAAR S, while Cl was determined by titration. The results of the study are presented as mean concentrations of the components for each sampling month for the period of the research and for each sampling point. Dispersion of concentrations around the average was calculated for the whole research period (standard deviation *SD*).

RESULTS

Concentrations of the analysed components of the four points of material sampling in farm no. 1 differed (Tab. 2). As regards nitrogen, the average concentration of NO_3-N in water of farm wells for the years 2012–2014 was large – 21.34 mg·dm^{-3} (point 1).

Other contaminants were characterized by a significant lower concentration and in case of NH_4-N and PO_4-P amounted respectively 0.30 and 0.06 mg·dm^{-3}.

Table 2. Descriptive statistics on concentration of contaminations in well water and effluent from heap of manure in different sampling points in the farm 1

Parameter	Indicator					
	NO_3-N	NH_4-N	PO_4-P	K	Na	Cl
	Sample 1 – farm well					
n	23	23	23	23	23	23
$\bar{x}$, mg·dm^{-3}	21.34	0.30	0.08	4.33	8.73	45.40
SD, mg·dm^{-3}	3.99	0.29	0.06	0.56	7.55	5.83
	Sample 2 – effluent from manure heaps					
n	21	21	21	21	21	21
$\bar{x}$, mg·dm^{-3}	0.97	337.02	38.49	1560.34	160.63	717.73
SD, mg·dm^{-3}	1.21	432.42	27.15	940.79	75.43	323.79
	Sample 3 – drainage ditch before inflow from manure heap					
n	23	23	23	23	23	23
$\bar{x}$, mg·dm^{-3}	10.94	0.86	0.14	11.45	13.55	38.96
SD, mg·dm^{-3}	4.22	2.50	0.10	12.26	9.86	12.83
	Sample 4 – drainage ditch below inflow from manure heaps					
n	23	23	23	23	23	23
$\bar{x}$, mg·dm^{-3}	19.61	1.98	0.39	21.92	14.05	48.10
SD, mg·dm^{-3}	4.24	2.25	0.27	13.72	3.23	7.48

Explanations: *n* = number of samples, $\bar{x}$ = arithmetic mean, *SD* = standard deviation.

Source: own study.

The biggest concentration in well water concerned chlorides with average of 45.40 mg·dm^{-3}. In case of the other two components, the concentrations were much lower and amounted to 8.73 mg of Na and 4.33 mg of K·dm^{-3}. High standard deviation values of NH_4-N and PO_4-P show a large variation of the concentrations of the components between different monthly periods of water sampling for chemical analysis.

The highest concentration of the studied pollutants was found in the leakage from the manure heaps located within the homestead (point 2). Potassium was the component of the highest concentration and its value exceeded 1500 mg·dm^{-3}. The average concentration of chlorine was approximately half of the above value: 717.73 mg·dm^{-3}.

The manure leakage was also highly polluted by NH_4-N which was 337.02 mg·dm^{-3} on average. The concentration of this pollutants was changeable in each sampling period. It is evidenced by the *SD* value which is even greater than the average concentration of this contaminant in manure leakage for the study period. The average concentration of sodium remained at a lower level – 160.63 mg·dm^{-3}, while the average concentration of PO_4-P in manure effluent was high – 38.49 mg of NH_4-N·dm^{-3}. The lowest concentration was found in case of NO_3-N and was on average 0.97 mg·dm^{-3}.

As regards samples of water from the drainage ditch before inflow of manure leakage, chlorine was in the highest concentration of the analysed pollutants – 38.96 mg·dm^{-3} (point 3). Another contaminant which was present in high concentration, was sodium – 13.55 mg·dm^{-3}. Concentration of potassium was at a similar level – 11.45 mg·dm^{-3}. The concentration of potassium was changeable in each sampling period which is evidenced by the *SD* value – 12.26 mg·dm^{-3}. Among the macro-contaminants, NO_3-N was in the largest concentration on average – 10.94 mg·dm^{-3}, whereas NH_4-N and PO_4-P were at much lower concentration, respectively 0.86 and 0.14 mg·dm^{-3}. In case of NH_4-N, SD value was nearly three times greater than average concentration of NH_4-N in ditch water.

Water samples taken from the downstream flow of the ditch below the inflow of effluent from manure heap exhibited increased concentrations of the analysed contaminants. The concentration of potassium was nearly two times greater than before the inflow of effluent with average value of 21.92 mg·dm^{-3} (point 4). The concentration of sodium in the ditch after the inflow was slightly bigger reaching 14.05 mg·dm^{-3}. NO_3-N content in the measuring point in relation to the measurement before the inflow of effluent was increased by 8.67 mg·dm^{-3}, while the content of other contaminants, such as: NH_4-N and PO_4-P, was respectively 1.12 and 0.15 mg·dm^{-3}.

The concentrations of contaminants in farm well water as well as effluent from manure heap within the farm no. 2 were mostly greater than in the farm no. 1 (Tab. 3).

Especially it is seen in farm well water (point 1) in which the average concentration of potassium was 64.91 mg·dm^{-3}, sodium 67.73 mg·dm^{-3}, chlorine

Table 3. Descriptive statistics on concentration of pollutions in water and effluent from the heap of manure from different sampling points within the farm no. 2

Parameter	Indicator					
	NO_3-N	NH_4-N	PO_4-P	K	Na	Cl
Sample 1 – homestead well						
n	23.00	23	23	23	23	23
$\bar{x}$, mg·dm^{-3}	25.30	0.26	0.16	64.91	32.68	54.81
SD, mg·dm^{-3}	5.93	0.26	0.16	10.99	8.40	83.49
Sample 2 – effluent from manure heap						
n	14	14	14	14	14	14
$\bar{x}$, mg·dm^{-3}	1.93	165.32	83.28	1919.11	327.81	1269.91
SD, mg·dm^{-3}	83.28	162.03	48.96	1470.63	223.00	941.51

Explanations: *n* = number of samples, $\bar{x}$ = arithmetic mean, *SD* = standard deviation.

Source: own elaboration.

54.81, NO_3-N 25.30, PO_4-P 0.16 mg·dm^{-3} and NH_4-N 0.26 mg·dm^{-3}.

The biggest concentration in the effluent from manure heap located in this farm concerned potassium, reaching 1919.11 mg·dm^{-3} (point 2). Average concentration of chlorine was significantly high and amounted to 1269.91 mg·dm^{-3}, whereas the concentration of sodium was much lower (327.81 mg·dm^{-3}), yet twice as in the farm 1. Similar tendency was also seen in case of PO_4-P where the average concentration was about two times higher – 83.28 mg·dm^{-3}. Also the value of concentration of NO_3-N in relation to the identical point in the farm no. 1 was higher and reached 1.93 mg·dm^{-3}. In this case the high value of *SD* was 2.17 mg of NO_3-N·dm^{-3}, which is remarkable.

The only contaminant, of which the average concentration was lower than in the analogous point in the farm no. 1, was NH_4-N – 165.32 mg·dm^{-3}.

The last point of water sampling for chemical analysis was farm well located in the farm 3 (Tab. 4).

Table 4. Descriptive statistics on concentration of pollutants in well water in the farm no. 3

Parameter	Indicator					
	NO_3-N	NH_4-N	PO_4-P	K	Na	Cl
n	23	23	23	23	23	23
$\bar{x}$, mg·dm^{-3}	60.46	0.42	0.15	54.41	25.88	67.73
SD, mg·dm^{-3}	28.07	0.41	0.15	22.63	2.25	38.83

Explanations: *n* = number of samples, $\bar{x}$ = arithmetic mean, *SD* = standard deviation.

Source: own study.

A characteristic feature of well water from this farm is very high concentration of NO_3-N in relation to the previously described, which was on average 60.46 mg·dm^{-3}. It was about 2.8 times larger than in case of the farm no. 1, and 2.4 times larger than in the farm 2.

Another contaminant showing the highest concentration in relation to well water compared to previous farms were chlorides – 67.73 mg of Cl·dm^{-3}. The value of potassium remained at a lower level (54.41 mg·dm^{-3}), while sodium was approximately two times lower – 25.88 mg·dm^{-3}. Like in case of the previous farm wells the concentration of NH_4-N and PO_4-P was the lowest – respectively 0.42 and 0.15 mg·dm^{-3}.

DISCUSSION OF RESULTS

The research results illustrate the scale of the problem which is a threat to the aquatic environment due to pollutants generated in farms, inter alia from points where natural fertilizers are stored. This is confirmed inter alia by COOKE [1976], CHADWIK and CHEN [2002], FOY and O'CONNOR [2002], SAPEK and SAPEK [2006a]. Effluents from manure heaps are the main source of groundwater contamination. Within the following research the concentration of NH_4-N and PO_4-P was extremely high (Tab. 1, 2) and exceeded all quality standards established by law [Rozporządzenie ... 2014]. Very high concentrations of NH_4-N in manure effluent that seeps through the heap, especially in the farm 2, reaching over 160 mg·dm^{-3}, was the evidence that the effluent also contained liquid manure from defective containers and leaking manure pits in livestock buildings.

Nitrogen in livestock manure is in fact mainly in the form of ammonium cation produced during the hydrolysis of urea which is the primary source of nitrogen in the urine of livestock [ILNICKI 2004; KOBUS 1996; SAPEK *et al.* 1998], whereas the concentration of ammonium nitrate in livestock manure is very low. This is confirmed by relatively low concentrations of NO_3-N in manure effluence ranging on average 0.97–1.93 mg·dm^{-3}. Very high concentration of potassium was also found in manure effluent which even reached about 2000 mg of K·dm^{-3}. This is confirmed inter alia by DEWES [1997] and SCHULZ and HRADETZKY [1999] – the authors indicate that potassium is one of the contaminants which in the largest quantities seeps through manure storage into aquatic environment.

Such contaminants, as sodium and, especially, chlorine, as well as nitrogen, phosphorus and potassium were also found in high concentrations in manure effluents. The presence of N, P, K was confirmed by DEWES [1997].

The results of the report developed in the UK on pollution from solid organic fertilizers which are stored temporarily on the ground surface also show that concentration of ammoniacal nitrogen in manure effluent is very high and often exceeds 1000 mg·dm^{-3}, and nitrate nitrogen exceeds 100 mg·dm^{-3} [NICHOLSON *et al*. 2011].

According to SAPEK and SAPEK [2006b] the impact of manure storage within the farm on contamination of aquatic environment can be a problem that concerns only Poland, however, as world literature in this area is extremely modest and mostly limited to outdoor range of livestock.

The consequence of penetration of pollutants into the soil under manure heap as well as contaminants from manure effluent flowing over the surface of farm area farms was contamination of shallow groundwater supplying farm wells [BARSZCZEWSKI *et al*. 2001; SAPEK, SAPEK 2006c; SMOROŃ 2009]. Average concentration of NO_3-N in water sampled from wells located within manure heap in the farm no. 1 and 2 exceeded 20, while in the farm no. 3 was even 60 mg·dm^{-3}. This means that the concentration of this contaminant was greater than it is permitted by drinking water standards – 11.3 mg of NO_3-N and makes such contaminated water unfit for human consumption [Rozporządzenie... 2007]. The highest concentration of most of the contaminants in well water in the farm no. 3 was most likely related to the high intensity of animal production here. In the farm about 500 cutters are produced annually which translates into a large load of chemical components that partially penetrate into water with leakage from defective floor of livestock building.

Noteworthy is also high concentration of potassium exceeding 50 mg·dm^{-3} K in well water in the farm 2 and 3, which clearly indicated the penetration of contaminations from storage of natural fertilizers. Similar concentration of contaminations in farm wells were also found in other studies [OSTROWSKA *et al.* 1997; SAPEK, SAPEK 2006a; SAPEK *et al.* 1998; SĄDEJ, PRZEKWAS 2006; SMOROŃ, SAPEK 1988].

Pollutions from manure effluent increased concentration of all discussed contaminants in water flowing in drainage ditch running near the farm no. 1. The concentration of PO_4-P increased the most – it was about 2.8 times bigger (up to 0.36, Tab. 2), while NH_4-N and potassium were slightly increased – respectively by 2.3 and 1.9 times. Average concentration of NO_3-N in ditch water was increased by manure effluent from 10.94 to 19.61 mg·dm^{-3}. Under the Nitrates Directive, this means that drainage ditch water containing manure effluent changed the classification of water at risk of contamination into water contaminated by nitrogen compounds from agricultural sources [Rozporządzenie... 2002]. In terms of the content of NO_3-N the drainage ditch water did not meet the requirements of class II of surface water quality, which means a status below good, and which creates conditions for development of eutrophication [Rozporządzenie... 2014]. Water in ditches and other minor watercourses carrying this kind of contaminations feed rivers causing a significant deterioration in their quality, limiting possibilities of their use [DURKOWSKI *et al.* 2006; ROSSA, SIKORSKI 2006; SMOROŃ, KOWALCZYK 2012; 2014].

The conducted research shows that despite trainings and demonstrations on how to store natural fertilizers properly etc. that were carried out, farmers' awareness about ecology as well as legal knowledge of protection of the aquatic environment in rural areas are not yet sufficient. Codes of good agricultural practice [DUER *et al.* 2004], which are a collection of environmentally friendly practical actions, such, as e.g. how to reduce the risk of water contamination both within farmstead and agricultural land, are not always respected.

CONCLUSIONS

1. Water quality in the wells within farms involved in the production or keeping of cattle and pigs located near storage of natural fertilizers, livestock buildings, was polluted and did not fulfil the criteria for drinking water.

2. In the light of the Nitrates Directive manure effluents caused deterioration of quality of water in drainage ditch and changed the classification of water at risk of pollution into water contaminated by nitrogen compounds from agricultural sources.

3. Manure effluent containing liquid manure from leaking containers, as well as leaking floors in livestock buildings were characterized by the greatest contaminations of mineral components.

4. Conducted research shows that training of farmers in the rural development programmes on codes of good agricultural practice regarding management of natural fertilizers, were not fully translated into greater awareness on ecology aspects.

5. Various steps should be taken to promote effective ways to reduce these contaminants within farmstead

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Jakość płytkich wód gruntowych i wycieków obornikowych na terenie zagrody w gospodarstwach z chowem zwierząt

STRESZCZENIE

Słowa kluczowe: *nawozy naturalne, składniki nawozowe, wody gruntowe, wody powierzchniowe*

Celem pracy była ocena jakości płytkich wód gruntowych na terenie zagrody i odpływów ze stert obornika w trzech wybranych gospodarstwach zajmujących się produkcją zwierzęcą i uprawą warzyw na obszarze Płaskowyżu Proszowickiego. Analizowano zwłaszcza wodę ze studni zagrodowych i odcieków obornikowych. Dodatkowo w jednym przypadku pobierano wodę z rowu melioracyjnego biegnącego w pobliżu zagrody, przed i poniżej dopływu wycieku ze sterty obornika. Próbki materiału badawczego pobierano co miesiąc od kwietnia 2012 do marca 2014 r. i analizowano je pod kątem zawartości $N\text{-}NO_3$, $N\text{-}NH_4$, $P\text{-}PO_4$, K, Na, Cl. Na podstawie uzyskanych wyników badań stwierdzono, że woda ze studni zagrodowych w pobliżu budynków inwentarskich i miejsc składowania obornika była bardzo zanieczyszczona większością wymienianych substancji chemicznych. Największe stężenie składników z wyjątkiem $N\text{-}NO_3$, stwierdzono w odcieku obornikowym – przekraczały one nawet od kilkudziesięciu do kilkuset razy wszelkie normy jakości dotyczące środowiska wodnego. Zaobserwowano również znaczne pogorszenie jakości wody w okresie badań z rowu melioracyjnego, do którego przenikały zanieczyszczenia ze sterty niewłaściwie składowanego obornika. Woda studni zagrodowych cechowała się nadmiernym stężeniem $N\text{-}NO_3$, co dyskwalifikowało ją do celów pitnych.