Piotr KACORZYK[1*], Agnieszka BARAN[2],
Mirosław KASPERCZYK[1] and Wojciech SZEWCZYK[1]

CONCENTRATION OF CERTAIN TOXIC SUBSTANCES IN SEEPAGE WATER IN RELATION TO DISTANCE FROM SHEEPFOLD

ZAWARTOŚĆ NIEKTÓRYCH SUBSTANCJI TOKSYCZNYCH W WODACH ODCIEKOWYCH W ZALEŻNOŚCI OD ODLEGŁOŚCI KOSZARU OWCZEGO

Abstract: The study was conducted in the mountain terrain on a pasture, where sheep grazing took place. The soil of this area was brown, classified with texture as loamy sand. Prevailing species in the turf were red fescue (*Festuca rubra*) and common bent-grass (*Agrostis capillaris*). The aim of the study was to determine levels of toxic substances in water moving downhill out of a sheepfold along a 6ş slope. In spring 2009 plastic cylinders 50 cm in length and 3 cm in diameter were inserted vertically into soil: in the pasture above the fold (control object), then inside the fold and beneath its surface as three replications along the slope placed 3 m apart in order to collect seepage water. The farthest migration among the whole of analysed elements was distinctive for nitrogen NH_4-N + NO_3-N. As regards the other elements, they had the highest concentration in water from within a sheepfold. Their migration out of folding place was minimal. The highest nitrogen N-NO_3 + N-NH_4 content was found in seepage water from the cylinder fixed into the fold measuring 11.75 mg $\cdot$ dm^{-3} at the first sampling and 9.07 mg $\cdot$ dm^{-3} at the second one. With increasing distance out of the sheepfold this value was decreasing and at 9 m below it was reduced to 6.10 mg $\cdot$ dm^{-3} and 6.76 mg $\cdot$ dm^{-3}, respectively, for the two successive samplings.

Keywords: sheep grazing, sheepfold, seepage water, toxic substances

Introduction

The primary system of sheep maintenance in piedmont and mountain areas is pasturing. Sheep ability to bite plants at minimum height as well as their relatively low demands for green fodder quality are generally known [1, 2]. Such a way of gathering

[1] Department of Grassland Management, University of Agriculture, al. A. Mickiewicza 21, 31–120 Kraków, Poland, phone: +48 12 662 43 60, email: rrkacorz@cyf-kr.edu.pl

[2] Department of Agricultural and Environmental Chemistry, University of Agriculture, al. A. Mickiewicza 21, 31–120 Kraków, Poland.

* Corresponding author: rrkacorz@cyf-kr.edu.pl

herbage crop contributes to sustaining biodiversity between species and results in numerous positive changes within the soil [3]. Furthermore, owing to sheep-folding manure one will obtain higher production of the fodder, which is enriched with macro- and micronutrients required by animals grazed [4–6]. Sheep staying day-and-night in a pasture for the growing season have a beneficial impact on matter circulation in the environment. Another feature of sheep grazing is the fact that animals are hurdled for the time of milking and for night. Concentration of biogenic elements left by sheep in folding sites is high [6, 7]. There is a risk that biogenic elements would escape from a sheepfold with surface runoff or permeate into watercourses, especially in places where sheepfold locations are extremely inclined and/or receive abundant rainfall.

The aim of this study was to determine levels of toxic substances in water moving downhill out of a sheepfold. It was assumed that the concentration of chemicals in water seepage collected along the slope below the sheepfold would change.

Material and methods

The study was conducted in a mountain pasture underneath the Jaworzyna summit near Krynica, where sheep grazing took place (N 49°24′57.38″, E 20°55′32.26″). An investigated area with a 6° slope was situated at an elevation of 613 m a.s.l. The soil prevailing in this pasture was brown, classified with texture as loamy sand. Its chemical properties were as follows: pH_{KCl} – 3.8; total N – 3.5 g · kg^{-1}; organic matter – 50.6 g · kg^{-1}; available P, K and Mg – 10.9, 75.5 and 76.0 mg · kg^{-1}, respectively. Weather conditions in the area of the study are presented in Table 1.

Table 1

Mean daily temperature of air and monthly sum of precipitations during study period

Months	Mean daily air temperature [°C]		Monthly sum of precipitation [mm]	
	2009	2010	2009	2010
January	–4.9	–6.3	23.6	21.6
February	–3.1	–3.3	30.6	25.8
March	0.0	0.4	101.4	40.0
April	8.7	6.2	13.0	83.2
May	10.8	11.1	104.0	194.6
June	13.5	14.5	194.0	203.8
July	17.0	17.5	118.8	156.2
August	15.8	16.3	115.5	118.9
September	12.6	9.9	41.7	198.8
October	5.5	3.5	78.1	17.9
November	2.9	4.9	71.7	30.9
December	–2.5	–6.2	35.8	40.4
April – September	13.1	12.6	587	955.5
January – December	6.4	5.7	928	1132

Predominant species in the turf were red fescue (*Festuca rubra*) and common bent-grass (*Agrostis capillaris*). Sheep left over the fold surface 4790 kg faeces and 3710 kg urine per hectare.

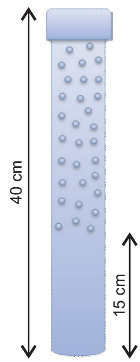

Fig. 1. Diagram of cylinder to collect seepage water

In spring 2009 plastic cylinders 50 cm in length and 3 cm in diameter (Fig. 1) were inserted vertically into soil: in the pasture above the fold (control object), then inside the fold and beneath its surface as three replications along the slope placed 3 m apart (Fig. 2).

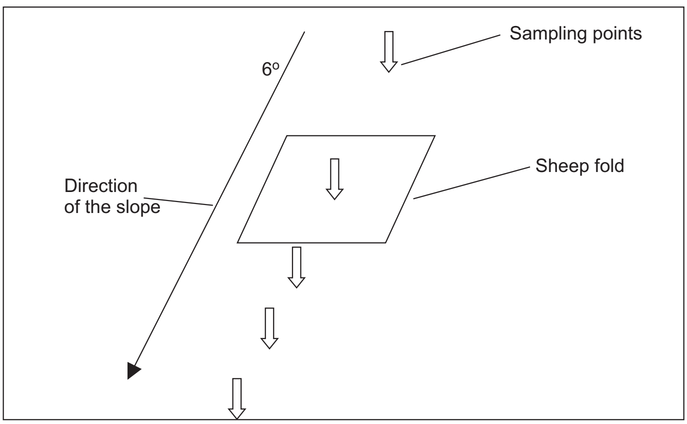

Fig. 2. Scheme of slope direction and location of sampling points

The walls of each cylinder had apertures in a range between 15 and 50 cm of height, where water may enter and accumulate within a cylinder (up to 15 cm of height). Collected water from each cylinder (one month and one year after folding) was used twice to estimate levels of the following elements: NH_4-N + NO_3-N, Cd, Pb, Cr and Ni. Nitrogen content was determined with a microchip photometer LF-205, while the other elements with the aid of the ICP-AES technique. Obtained data underwent statistical appraisal including one-way analysis of variance and LSD test at a significance level of $\alpha < 0.05$ with Statistica 7 software.

Results

The highest level of nitrogen, as NH_4-N + NO_3-N, was found in the first-year sample of drained water from the cylinder fixed in sheep manured surface (Table 2). At the time nitrogen content in water obtained from the sites of 3 and 6 m down from the sheepfold was 25 % lower than in water from the folding object.

Table 2

Levels of NH_4-N + NO_3-N, Pb, Cd, Ni, Cr in seepage water for different sites of sampling

Site of sampling		NH_4-N + NO_3-N	Pb	Cd	Ni	Cr
		[mg · dm^{-3}]	[mg · dm^{-3}]			
Date of sampling 02.06.2009						
Control, at 20 m above sheepfold		6.42 a*	1.83 c	0.90 a	9.14 a	11.03 a
Sheepfold		11.75 c	4.80 b	3.50 b	12.20 b	15.40 b
Below sheepfold	at 3 m	8.59 b	2.90 b	0.80 a	10.50 ab	14.20 b
	at 6 m	8.81 b	3.40 b	0.90 a	9.40 a	12.40 a
	at 9 m	6.10 a	3.60 b	1.00 a	10.20 a	12.80 a
Date of sampling 15.05.2010						
Control, at 20 m above sheepfold		5.87 a	1.72 a	0.64 a	8.82 a	10.42 a
Sheepfold		9.07 c	4.50 b	2.60 b	10.10 b	13.90 b
Below sheepfold	at 3 m	7.45 b	1.30 a	0.60 a	7.80 a	11.30 a
	at 6 m	7.92 b	1.10 a	0.70 a	8.90 a	12.70 a
	at 9 m	6.76 a	1.00 a	0.50 a	7.20 a	10.60 a

* Letters a, b, c indicate homogenous groups according to LSD test, $\alpha < 0.05$.

Water collected at 9 m below the sheepfold contained 6.10 mg · dm^{-3}, which is 49 % less than the value recorded for the fold, although quite similar to the control object. In the next-spring sampling water nitrogen level from the manured object was 9.07 mg · dm^{-3} being 33 % lower than at the prior time. Also at the sites 3 and 6 m from the fold nitrogen content was 10–15 % lower to earlier values for the same objects. At the 9 m distance from the fold a level of NH_4-N + NO_3-N in seepage water was 10 % higher when set beside the previous-year sampling, even though the difference to the control object was not significant statistically.

Lead concentration in the first-year examination of seepage water taken in the sheepfold reached 4.80 mg · dm^{-3} and was 2.5 times as great as the control one, whereas in comparison with the other objects this result was 30–40 % higher. In the successive sampling lead concentration in water drained at each investigated object decreased, especially for the three ones below the fold, in which a range of such reduction fell between 65 and 72 %.

Cadmium level at the first-year sampling of water from the sheep folding area was almost quadrupled when set beside the other object measures ranging from 0.80 to 1.0 mg · dm^{-3}. At the next-year sampling the concentration of cadmium in water taken from each object was 25–50 % lower. The differences in Cd level in water sampled outside the fold were found not significant.

Changes in nickel concentration in water between two yearly samplings as well as differences among objects outside the fold within the same time of sampling were small and ranged from 1.2 to 2.9 mg · dm^{-3}. The relative measure of the differences falls within the range of 12 to 29 %. The highest Ni level was found in water taken in the sheepfold at the first-year sampling; then after a year its concentration in water from the same object was 17 % lower.

The highest chromium level was found at the first-year sampling in water taken from cylinders fixed into the fold and the site 3 m below, and a difference between those objects was not significant. In the other objects Cr level averaged out to 15 % lower measure. After a year chromium concentration was reduced 5 to 20 % except from the object at 6 m below the fold, where a 2% increase was recorded.

Discussion

From the obtained results one must state unequivocally that manuring with the use of sheepfolds is a point source of pollution. At employing them water environment deteriorates due to contamination, in particular with nitrogen NH_4-N + NO_3-N, both inside sheepfolds and in underneath areas. This is evidence for fast migration of nitrogen compounds with seepage water. Their rapid relocation is confirmed by the works of Barszczewski and Sapek [8] and Barszczewski and Paluch [9]. On the basis of their NH_4-N and NO_3-N content the water analysed in the study was classified as falling outside the II class, where no further limits are established by the Regulation of the Minister of Environment dated 20 August 2008 [10]. Great differences in lead and cadmium levels among the sites pointed out their slow migration and high concentration in sheep excreta. Also nickel and chromium moved with seepage water at a rather low speed, however, in contrast to the prior mentioned elements, their concentration in sheep excreta was minor. The study demonstrated for each examined toxic substance that its concentration in seepage water was reduced with growing distance from the manured place and with duration of time. This is clearly evident for lead and cadmium above all and could be explained by the fact that turfs, owing to their function as a biological filter, are able to absorb these elements and to inhibit their spread in environment [11]. To sum up, from the results of previous and current investigation one can conclude that folding would be a good method of fertilisation, although its economical and environmental effect depends on time length spend in fold by sheep, stock density and distance from watercourses.

Conclusions

1. Levels of nitrogen, lead and cadmium in seepage water were excessive, concentration of nickel and chromium were increased as well.

2. Nitrogen and lead were migrating very fast out of sheepfold with seepage water.

3. After one year nitrogen concentration in seepage water outside fold remained high, while lead, cadmium, nickel and chromium levels was similar to control.

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[1] Zakład Łąkarstwa
[2] Katedra Chemii Rolnej i Środowiskowej
Uniwersytet Rolniczy im. Hugona Kołłątaja w Krakowie

Abstrakt: Badania zrealizowano na pastwisku w rejonie górskim, na którym prowadzono kulturowy wypas owiec. Na tym terenie występowała gleba brunatna o składzie granulometrycznym piasku gliniastego. Dominującymi gatunkami w runi były kostrzewa czerwona (*Festuca rubra*) i mietlica pospolita (*Agrostis capillaris*). Celem badań było określenie poziomu substancji toksycznych w wodzie przemieszczającej się z koszaru owczego wzdłuż stoku o nachyleniu 6^{o}.

Wiosną 2009 r. na pastwisku powyżej koszaru (obiekt kontrolny), na powierzchni koszarowanej i w trzech punktach poniżej koszaru, w odległościach co 3 m, umieszczono pionowo w glebie plastikowe cylindry o średnicy 3 cm i długości 50 cm. Na ściankach cylindrów na wysokości od 15 do 50 cm były wykonane otwory, przez które przenikała przesiąkająca woda i gromadziła się w ich dolnej części (od 0 do 15 cm). W zgromadzonej w cylindrach wodzie oznaczono dwukrotnie w 30 dniu po koszarzeniu i w 347 dniu (wiosną

2010 r.) zawartość następujących składników: $N\text{-}NO_3 + N\text{-}NH_4$, Cd, Pb, Cr i Ni. Zawartość azotu oznaczono fotometrem mikroprocesorowym LF-205, a stężenie pozostałych składników metodą ICP-EAS.

Spośród analizowanych składników azot ($N\text{-}NO_3 + N\text{-}NH_4$) w największym stopniu ulegał przemieszczaniu. Natomiast największe stężenie pozostałych składników występowało w wodzie w obrębie koszaru. Ich przemieszczanie poza koszar było znikome. Największą zawartość azotu $N\text{-}NO_3 + N\text{-}NH_4$ charakteryzowała się woda odciekowa zgromadzona w cylindrze umieszczonym wewnątrz koszaru. W pierwszym terminie zawartość ta wynosiła 11,75 $mg \cdot dm^{-3}$, a w drugim 9,07 $mg \cdot dm^{-3}$. W miarę oddalania się od koszaru stężenie tego składnika zmniejszało się i w odległości 9 m od koszaru wynosiło w pierwszym roku 6,10 $mg \cdot dm^{-3}$, a w drugim 6,76 $mg \cdot dm^{-3}$.

Słowa kluczowe: wypasanie owiec, koszar, wody odciekowe, substancje toksyczne