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EFFECT OF THE WAY OF UTILIZATION AND THE LEVEL OF FERTILIZATION ON THE QUALITY OF LEACHATE WATER PART II. THE LOADS OF COMPONENTS CARRIED WITH LEACHATE WATER*

WPŁYW SPOSOBU UŻYTKOWANIA I POZIOMU NAWOŻENIA NA JAKOŚĆ WÓD ODCIEKOWYCH CZ. II. ŁADUNKI SKŁADNIKÓW WYNIESIONYCH Z WODAMI ODCIEKOWYMI

Abstract: The location of the experiment, kind of soil as well as variants and the way of their utilization were reported in the part I entitled: "Concentration of mineral components in leachate water". The amount of mineral components in leachate water was calculated by multiplying the amount of water outlet from 1 ha by the concentration in [dm^3] of these components. Among all examined components calcium was washed out in the highest degree. Significantly higher washing out of nitrate nitrogen, potassium, calcium and magnesium from the arable land and forest in comparison with the other variants resulted from the following reasons: arable land was cultivated for a short period of time, which determined a limited uptake of the above-mentioned components by the plants, on the other hand the roots of forest trees were not able to penetrate deep and assimilate nutrients from the lysimeters which constituted a closed area. The surface of the lysimeters was not covered with living plants but with the duff layer. Additionally, a high amount of organic matter in the forest (11 %) and fast mineralization of the arable land caused by aeration, plough cultivation of the soil, resulted in an increased supply of these components.

Keywords: fertilization, plant coverage of the soil, macroelements, load provided

The protection of water reservoirs is a significant factor of multifunctional and balanced development of the mountain areas. The proper management of the mineral components provided to the soil with fertilizers is also of great importance. The balanced management of these components is important from a productive, ecological and economic point of view and is a basic criterion for the operation of a farm [1].

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Circulation of the components in the environment should proceed by balanced rules, which are fulfilled when natural fertilizers supplemented with mineral fertilizers are applied rationally and under conscious utilization of self-control mechanisms proceeding in an ecosystem. In the mountain area the landscape, high amount of rainfalls, shorter vegetation period, longitude of snow-cover, low level of soil thickness, which is additionally strongly acidified, makes the rural management very difficult and non-profitable for many cultivations. Therefore, the production of forages under such conditions should be done mainly on grasslands, which provides cheap and good quality forage and has a positive influence on the natural environment [2].

The aim of the study was to compare the losses of nutrients from the soil as affected by the kind of plant cultivation.

Materials and methods

The location of the experiment, kind of soil as well as variants of the study and the manner of their utilization were presented in [3]. The amount of mineral components in leachate water was calculated by multiplying the amount of water outlet from 1 ha by the concentration of these components in dm^3.

The results of investigations

Table 1 presents the amount of macroelements in kg derived with the leachate water in the years 2007 and 2008. The lowest losses (0.37 kg · ha^{-1} per year) of ammonium nitrogen ($N\text{-}NH_4$) were observed on the meadow which was not utilized, whereas on the utilized meadows they were 20 % higher. On the arable land the losses reached the value of 0.53 kg · ha^{-1} and were 0.04 kg lower then those measured for the forest. During the winter and spring periods the levels of ammonium nitrogen losses were the lowest. In 2007 the losses of $N\text{-}NH_4$ were greater than during the following year.

In the analyses of the amount of nitrate nitrogen ($N\text{-}NO_3$) in leachate water, great differences between the results were observed. The lowest concentration of this component was found for the leachates of the non-fertilized meadow, 4.05 kg · ha^{-1}, in contrast the concentration for the leachate water of the fertilized meadow was higher, 6.00 kg · ha^{-1}. The losses of this nitrogen form from the arable land and forest amounted to 34.63 and 52.40 kg · ha^{-1}, respectively. During the spring period the losses of this component for both meadows were several times lower, and for the rest of objects even up to a dozen times lower, when compared with the respective values determined during the summer, autumn and winter.

The phosphorus losses with leachate water on the non-utilized meadow amounted to 0.4 kg · ha^{-1} and were 25 % higher than the respective losses stated for the other objects. The amounts of potassium washed out from both meadows were usually equal and amounted to 3 kg · ha^{-1}, twice higher losses were found for the arable land and 6 times higher for the forest object. During spring and autumn the losses of this element reached levels ranging between 0.03 kg · ha^{-1} for the non-fertilized meadow and 3.65 kg · ha^{-1} for the forest.

Table 1

The amounts of components derived from the leachate water [kg · ha^{-1}]

Variant	Lear/season	[kg · ha^{-1}]													
		N-NH_4		N-NO_3		P		K		Ca		Mg		Na	
	Year	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
Non-utilized meadow	Spring	0.08	0.01	0.26	0.05	0.09	0.00	0.52	0.03	4.84	4.60	0.63	0.17	0.24	0.08
	Summer	0.29	0.22	2.34	2.30	0.19	0.06	1.55	1.15	27.87	127.48	2.85	4.54	1.34	1.95
	Autumn	0.09	0.04	0.69	0.08	0.31	0.01	1.22	0.15	69.17	42.3	3.40	0.96	1.28	0.45
	Winter	0.00	0.00	1.85	0.52	0.08	0.06	1.37	0.55	34.97	124.12	6.24	4.76	3.12	2.06
	Total	0.46	0.27	5.14	2.96	0.67	0.13	4.67	1.89	136.85	298.43	13.12	10.43	5.98	4.53
	Mean for 2007–2008	0.37^a		4.05^a		0.40^b		3.28^a		217.64^c		11.78^b		5.26^a	
Fertilized meadow	Spring	0.02	0.01	0.07	0.05	0.08	0.00	0.43	0.01	1.74	0.54	0.19	0.06	0.12	0.04
	Summer	0.23	0.16	1.98	2.10	0.09	0.05	1.10	0.37	16.46	14.70	1.86	2.01	1.65	1.03
	Autumn	0.16	0.12	0.79	1.27	0.12	0.01	0.56	0.11	11.18	5.76	1.21	0.96	0.95	0.54
	Winter	0.00	0.23	4.50	1.25	0.16	0.06	2.27	1.54	32.01	24.13	4.22	3.16	2.92	1.65
	Total	0.41	0.51	7.33	4.66	0.45	0.12	4.37	2.04	61.39	45.13	7.48	6.20	5.65	3.26
	Mean for 2007–2008	0.46^a		6.00^a		0.29^a		3.20^a		53.26^a		6.84^a		4.45^a	
Arable land	Spring	0.07	0.02	0.53	0.06	0.04	0.00	0.24	0.04	5.81	1.15	0.55	0.14	0.19	0.07
	Summer	0.34	0.28	14.96	11.54	0.14	0.11	2.91	1.49	91.92	36.77	9.43	6.43	4.20	4.69
	Autumn	0.18	0.17	8.73	12.96	0.09	0.02	1.56	1.06	69.46	16.72	6.99	5.34	3.00	5.50
	Winter	0.00	0.00	18.52	1.97	0.12	0.06	3.75	1.22	130.83	30.16	11.47	6.79	7.42	2.96
	Total	0.58	0.48	42.73	26.52	0.39	0.20	8.45	3.81	298.01	84.79	28.43	18.70	14.81	13.21
	Mean for 2007–2008	0.53^b		34.63^b		0.29^a		6.13^b		191.40^b		23.57^c		14.01^c	

Table 1 contd.

Variant	Lear/season	[kg · ha^{-1}]													
		$N\text{-}NH_4$		$N\text{-}NO_3$		P		K		Ca		Mg		Na	
	Year	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
Forest	Spring	0.12	0.02	7.09	1.44	0.06	0.00	2.58	0.54	25.19	5.12	2.41	0.48	1.30	0.21
	Summer	0.16	0.25	17.83	15.73	0.07	0.06	5.39	5.75	51.05	54.74	4.48	3.88	2.21	2.13
	Autumn	0.40	0.11	18.65	11.60	0.09	0.01	3.65	1.48	84.99	17.11	7.60	1.16	3.37	0.59
	Winter	0.00	0.09	14.11	18.35	0.23	0.09	10.73	7.77	160.02	79.34	11.83	9.51	7.73	4.52
	Total	0.67	0.47	57.68	47.12	0.46	0.16	22.35	15.54	321.26	156.31	26.32	15.03	14.61	7.46
	Mean for 2007–2008	0.57^{b}		52.40^{c}		0.31^{a}		18.94^{c}		238.79^{cd}		20.67^{c}		11.03^{b}	

** Homogeneous groups according to LSD test, $\alpha < 0.05$, s.i. – statistically insignificant.

The load of calcium derived with the leachates from the fertilized meadow was the lowest and equal to 53 kg · ha^{-1}, the arable land was characterized with a 138 kg higher level for this parameter. The losses observed for the non-utilized meadow amounted to 218 kg · ha^{-1}, in the forest object the amount of Ca washed out was 4.5 times higher than in the fertilized meadow. The lowest level of Ca in leachates was observed in the spring.

The losses of magnesium for the fertilized meadow amounted to 6.8 kg · ha^{-1} and were the lowest among all the objects. The non-fertilized meadow was characterized with a 72 % higher level for this parameter. The amount of magnesium washed out from the forest was equal to 20.7 kg · ha^{-1}, whereas for the arable land the measured magnesium losses were the highest with a value of 23.6 kg · ha^{-1}. The highest Mg level was found in leachates during the winter period.

The amounts of sodium washed out from both meadows were similar and amounted to 4.5 kg · ha^{-1} for the fertilized and 5.3 kg · ha^{-1} for the non-utilized meadow, whereas the forest object was characterized with an almost 2 times higher value. The highest amount of sodium (14 kg · ha^{-1}) was washed out from the arable land. When the effect of the season of the year is taken into consideration, it can be stated that the highest amount of this element were found in leachates during the winter and the lowest in the spring.

Discussion

The plant coverage of the soil has no significant effect on the level of ammonium nitrogen and phosphorus retained in the soil, because both components were washed out from all objects only in small quantities. These results are in agreement with the findings of Sapek [4]. On the fertilized meadow the losses of nitrate nitrogen were 28.6 kg · ha^{-1} lower than the respective losses found for the arable land. Kasperczyk et al [5] reported that on the mountain meadow which was fertilized in a similar way, 1 kg · ha^{-1} of nitrogen gives a 30.4 kg (d.m.) increase in yield. The calculations indicate that the yield losses from the arable land amounted to 876 kg · ha^{-1} d.m., which constitutes 10 % of a large yield under such conditions. The losses of potassium were affected to a higher degree by the season of the year than by the kind of plant coverage and reached the highest level during the winter, due to the fact that this element is released from the crystal network as a result of the freeze-thaw processes proceeding in the soil [6]. The amounts of losses of the other elements: calcium, magnesium and sodium were affected by the plant coverage of the soil and its ability to retain water as well as by the amount of rainfall. The large losses of nutrients derived from the forest resulted from the fact that the roots of the trees were not able to penetrate deep into the soil profile and assimilate nutrients from the lysimeters which constituted a closed area. The surface of the lysimeters was not covered with trees (due to technical circumstances) or with other living plants but with a layer of duff. Additionally, the soil contained a high level of organic matter (11 %) which was mineralized.

Conclusions

1. The fertilized and mown meadow limits the losses of the biogenic components to the highest degree.

2. The lowest losses of the nutrients were observed in the spring, ie, the most intensive period for plant development.

3. On the arable land the short-term plant coverage as well as fast mineralization caused by aeration, plough cultivation of the soil affected the increased washout of the nutrients from the soil.

4. The plant coverage of the soil has no significant effect on the losses of ammonium nitrogen and phosphorus.

References

[1] Głąb T. and Kacorzyk P.: *Root distribution and herbage production under different management regimes of mountain grassland.* Soil Tillage Res. 2011, **113**, 99–104.

[2] Kasperczyk M.: Wpływ okrywy roślinnej gleby na jakość wód. Wyd. Polit. Krakowskiej, Kraków 2001, pp. 169–177.

[3] Kacorzyk P.: *Effect of the way of utilization and the level of fertilization on the quality of leachate water. Part I. The concentration of mineral components in leachate water.* Ecol. Chem. Eng. A 2011, **18**(8), 1033–1039.

[4] Sapek A.: Procesy związane z wymywaniem azotu z gleb użytkowanych rolniczo. IMUZ, Falenty 1990, pp. 17–29.

[5] Kasperczyk M., Szewczyk W. and Kacorzyk P.: *Produktywność azotu na łące górskiej*. Łąkarst. w Polsce 2007, **10**, 111–118.

[6] Kopeć M.: *Dynamika plonowania i jakość łąki górskiej w okresie trzydziestu lat trwania doświadczenia nawozowego*. Zesz. Nauk. AR Kraków, 2000, **267**, Rozprawy, pp. 84.

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Abstrakt: Wapń był wymywany spośród wszystkich badanych składników w największych ilościach. Zdecydowanie większe wymywanie azotu azotanowego, potasu, wapnia i magnezu z gruntu ornego oraz lasu w porównaniu do innych wariantów wynikało z następujących przyczyn: na gruncie ornym roślinność była uprawiana przez krótki okres, w związku z tym pobieranie wyżej wymienionych składników przez rośliny zostało ograniczone, a na obiekcie las korzenie drzew nie mogły wnikać i pobierać składników pokarmowych z lizymetrów, ponieważ te stanowiły zamkniętą przestrzeń. Na powierzchni lizymetrów również brakowało żywych roślin, zalegała natomiast ściółka leśna. Dodatkowo duża ilość materii organicznej w lesie (11 %), a na gruncie ornym szybka mineralizacja spowodowana napowietrzaniem, uprawą płużną gleby, powodowały zwiększoną podaż tych składników.

Słowa kluczowe: nawożenie, okrywa roślinna gleby, woda, makro składniki, ładunek wyniesiony