APPLICATION OF FIELD LYSIMETERS IN GROUNDWATER POLLUTION ASSESSMENT

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Abstract. In order to implement regulations from The Nitrate Directive in Croatian rural sector, sets of three lysimeters were installed at three agricultural plots in Varaždin County (April 2011). Since main aim is to estimate the impact of agricultural practice on soil and water pollution, each selected plot is characterized by different soil type and different type of production: from typical field crops to predominate vegetable production. The nitrates (NO_3-N) are main agricultural groundwater pollutant and the only parameter which maximum allowed concentration (MAC) of 10 mg/l in aquifers is prescribed by The Nitrate Directive, hence its concentration is the most relevant analysis result. The average value of NO_3-N in samples from Hrastovsko is 7,5 mg/l, from Greda 36 mg/l and from Donja Voća 41 mg/l. According to the presented results, it can be concluded that NO_3-N concentrations on two of three research locations are exceeding MAC. Stated conclusions suggest there is necessity for more precise and less abundant fertilization procedures in this area which can be adjusted according to regular soil and water nutrient content analysis.

Keywords: lysimeter, water pollution, agricultural practice, leachate, nitrates

1. INTRODUCTION

Due to very intense use of different kinds of fertilizers, agriculture is one of the main sources of groundwater pollution. On the other hand, underground aquifers are the most important sources of drinking water and vulnerable to pollution (Solley et al., 1993) at the same time. Traditional agricultural production implies use of significant amount of mineral fertilizers and it is expected that worldwide mineral fertilizer nutrient use will increase from 142 million tonnes in 2002/03 to 199 million tonnes in 2030 (Roy at al., 2006). In intensive agricultural production water can be contaminated with nitrates, nitrites, phosphates, pesticides, heavy metals and aromatic hydrocarbons which can cause eutrophication, severely pollute drinking water and endanger human health (Vukadinović & Lončarić, 1997). There is estimation that on 20% of European Union (EU) area the drinking water contains more residual agrochemicals than it is allowed by the regulations (FAO, 2003).

Main natural resources in Varaždin County are water, agricultural land and mineral deposits (Vincek & Ernoić, 2009). According to Statistical Yearbook of the Republic of Croatia for 2003, there are 38.510 ha of agricultural land; 85% of agricultural production refers to crop production and there is ratio of 1,5 LU[1]/ha. It is obvious that such land use can lead to sever groundwater pollution. The nitrates (NO_3-N) have high tendency to leach to deeper layers, hence there is MAC of NO_3-N in drinking water of 10 mg/l (EC, 1998). Main aim of this research is to monitor nitrates concentrations in collected leachates and to estimate the impact of different agricultural practice on groundwater pollution within selected county.

2. MATERIALS AND METHODS

2.1. Study area – geographic, topographic and climate characteristics

Field lysimeters research is located on three agricultural plots in northern part of the Croatia, Varaždin County. Selected region is characterized by intensive vegetables production with large amount of fertilizers application and a large number of farms (cattle and chicken) on a relatively small area. In addition, the entire area is under significant influence of the large rivers Drava and Mura and due to that entire area is dominated by alluvial soil with shallow active profile mainly on gravel base. Stated facts indicate there is very high risk of groundwater pollution caused by intensive agricultural production. Each research plot was selected based on criteria of diverse agricultural production and different soil types.

[1] livestock unit

Figure 1:. *Geographic position of research plots*

The first selected field lysimeter location (figure 1., A) is in Donja Voća, cca.20 km W from Varaždin (46°17'32"N, 16°06'31"E – according to WGS84 system) in the hilly part of county. Seconde one (figure 1., B) is situated in Hrastovsko (46°14'53"N, 16°35'01"E) nearby Ludbreg and the third one (figure 1., C) is located in Greda (46°16'31"N, 16°12'44"E), cca.15 km W from Varaždin. Each plot has a different type of production, respectively: typical crop production, integrated crop-livestok farm and predominate vegetable production, which implies on use of different fertilizers. Individual plots are, like others in this area, narrow and long – rectangular shaped with an average size of 0,2 ha.

Whole county has a characteristics of moderate continental climate with rather worm summers and wet and cold winters (REPAM, 2012). 30-years average annual temperature is 10,6°C. Maximum temperatures are recorded in July with an average of 20,9°C and the lowest in January with an average of 0°C. Total annual precipitation has a 30-years average of 832 mm. The most significant monthly rainfall amounts are recorded in autumn and winter with maximum of 98 mm in September. Contrary to above stated, there are some significant climate changes in last two years since the research is conducted.

2.2. The field lysimeters installation

At each location three lysimeters per plot were installed. They were installed in open soil profiles at a depth above less permeable horizons or at the solum-gravel contact and room for their placement was additionally excavated so the soil layer above lysimeter remains undisturbed (figure 2). PVC reinforced hose was connected to lysimeter drain and set with sufficient slope to ensure the flow of leachate. Leachated water is, in such way, collected in a plastic container. In the same container vertical stiff PVC pipe was integrated and it has perforations along the wall to allow the pumping of the leachate. Vertical pipe is sealed with a plastic cap to prevent possible contamination of the leachate. In the final stage, opened pedological profiles were filled with excavated soil and additionally compacted to prevent the peripheral flow of groundwater towards the open profile. The unobstructed sowing, planting and other breeding measures are enabled in such way.

Figure 2: *Stages of the field lysimeters installation*

2.3. Methods

Leachate samples are collected by pumping in period May 2011-October 2012 according to determined dynamics: after abundant rainfall or twice a month. They are taken and transported to the laboratory under low temperature condition and kept under that condition until they are analyzed. In collected leachate samples the following parameters are determined: pH on the MettlerToledo pH-meter MPC 227 device and the concentrations of NO_3^-, NH_4^+ and P spectrophotometrically using segmented flow of the Skalar San++ Analyzer.

3. RESULTS AND DISCUSSION

Number of collected samples varies depending on precipitation and soil type (figure 3). In 2011, which was rather dry year compared to 30-years average, fewer samples than in 2012 were collected. This is also a consequence of the fact that research in field conditions must be carried out for a longer period of time to have stabile flow. However, samples were collected from Donja Voća (pseudogley, K=2,1·10^{-3} cm/s) 10 times in research period and there is the largest leachate amount – average of 32% of total precipitation. On other two locations (alluvial soil, K=9,1·10^{-5} cm/s and hypogley, K=4,9·10^{-5} cm/s) samples were collected 3 and 6 times where average leachate was equal to 27% and 29% of total precipitation in significant rainfall period.

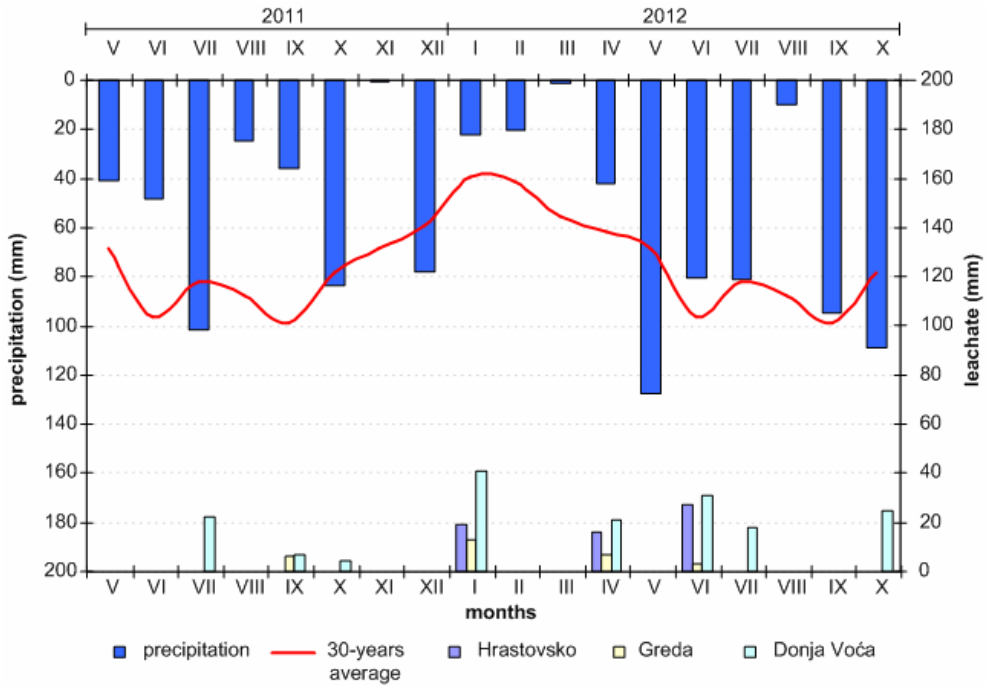

Figure 3: *Dynamics of precipitation (meteorological station Varaždin) and leachate amount (May 2011-October 2012)*

In general, plant's inability of using up all available nitrates in combination with high precipitation results in nitrate leaching (Romić et al., 2003). Average concentrations of NO_3-N and NH_4-N are shown by locations and sampling dates in table 1. The average value of NO_3-N in samples from the Hrastovsko is 7,1 mg/l, which is below MAC. Further, in more volumes samples NO_3-N concentration is lower. Average NH_4-N concentration is 0,96 mg/l, which is rather low and a consequence of fast transformation of ammonia to nitrates. At Greda samples average value of NO_3-N is 31 mg/l, which exceeds MAC almost 4 times. The maximum average concentration of 55 mg NO_3-N/l was determinated in sample collected in September 2011. After this, there is visible decline in average NO_3-N concentration which can be explained by the intense leaching caused by rainfall. Although the NO_3-N concentration is temporally descending, it still exceeds MAC which is related to the intense mineral fertilization which is common for vegetable production such as this. The NO_3-N concentrations at Donja Voća have temporal decline trend, i.e. the maximum average concentration of 56 mg NO_3-N/l was measured in sample collected in October 2011 after

fertilization and due to high precipitation there are lower concentrations afterwards. Nitrate concentrations have the same trend in year 2012. Same as on location Hrastovsko, on other two locations there is no significant difference in NH_4-N concentrations - average values are 1,4 mg/l and 0,79 mg/l.

Table 1: *Results of collected leachate analysis from all locations (May 2011-October 2012)*

	Sampling date	Leachate (mm)	NO_3-N (mg/l)	NH_4-N (mg/l)		Sampling date	Leachate (mm)	NO_3-N (mg/l)	NH_4-N (mg/l)
Hrastovsko	05.01.2012.	19	9.7	1.2	**Donja Voća**	08.07.2011.	22	41	0.48
	27.04.2012.	16	7.2	0.46		02.09.2011.	13	39	0.42
	15.06.2012.	27	4.5	1.3		23.09.2011.	0.95	38	1.2
	average	**21**	**7.1**	**0.96**		10.10.2011.	0.20	56	0.75
Greda	02.09.2011.	8.2	47	0.97		26.10.2011.	8.0	38	1.1
	23.09.2011.	4.0	55	1.7		05.01.2012.	41	36	0.90
	10.10.2011.	0.10	26	0.71		27.04.2012.	21	41	0.63
	05.01.2012.	13	24	3.3		15.06.2012.	31	38	0.76
	27.04.2012.	6.6	12	0.51		20.07.2012.	18	38	1.1
	15.06.2012.	3.3	25	1.0		24.10.2012.	25	54	0.65
	average	**5.9**	**31**	**1.4**		**average**	**18**	**42**	**0.79**

4. CONCLUSIONS

According to the presented results, it can be concluded that all lysimeters are correctly installed and each unit functions properly. However, research in field conditions requires a longer period of time to achieve stabile flow in each unit, which is most obvious from sampling dynamics at Donja Voća. Leachate percentage is mostly related to soil type, more precise its hydraulic permeability, so it is higher in soils which have greater permeability coefficient *K* so the largest number of samples was collected in Donja Voća. NO_3-N concentrations on two out of three research locations are exceeding MAC of 10 mg NO_3-N/l; in Greda 3 and in Donja Voća 4 times. Such high NO_3-N concentrations are correlated to abundant fertilization. In first case it is intense mineral fertilization which is common in vegetable production such as this and in second case it is combination of both manure and mineral fertilization. In Hrastovsko, location with average value of 7,1 mg NO_3-N/l, they also use both types of fertilizer but manure in larger quantities which explains the difference between those two results. Overall, it can be concluded that research area has evident problem with groundwater pollution caused by intensive agricultural production so there is necessity for more precise and less abundant fertilization procedures which can be adjusted according to regular soil and water nutrient content analysis.

5. REFERENCES

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