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Intensity of Nutrient Leaching after Application of Different Organic and Mineral Fertilizers

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Tests have been conducted in an experimental eight lysimeter plot. Lysimeters are dug into the ground. All lysimeters are connected by a tube which leads towards a well with containers for leachate collection installed inside of it. The aim of the research is to determine nutrient leaching intensity after application of various organic and mineral fertilizers. The following fertilizers were chosen for the research: organic - *Biojodis, Biokal, slurry, Horn Shavings Provita, Horn Core Powder;* mineral - *ammonium saltpeter.* After application of fertilizers, nitrate, nitrite, ammonium ions and phosphate concentrations in leachate were periodically measured. Research results show that the lowest concentrations of nitrites and ammonium ions are found after application of *Horn Shavings, Horn Core Powder* and *Provita* fertilizers. Application of ammonium saltpeter fertilizers resulted in nitrates leaching into lysimetric water by the 14th month; application of slurry, *Biokal* and *Biojodis* resulted in nitrates leaching into lysimetric water by the 36th month; application of *Horn Core Powder, Horn Shavings* and *Provita* did not result in nitrates leaching into lysimetric water by the 44th month.

Keywords: *lysimeters, organic fertilizers, nitrite, nitrate leaching.*

1. Introduction

Fertilizers are among the most powerful means of metabolism in agriculture. Without the use of fertilizers it is impossible to regulate the processes of plant nutrition or to alter yield quality. Fertilizers affect soil in a complex way by supplementing soil with nutrients, changing chemical, agrochemical and physical characteristics of the soil, and by assisting nutritional compounds' mobilization within the soil (Минеев 1988). As it was pointed in Recommendation No. 13/9 of February 6, 1992 by the Helsinki Commission, the use of fertilizers in agriculture should be assessed not only in economical but also in environmental dimensions. The simplest method to calculate potential water pollution is the balance of nutrients. This balance shows how much nutrition is needed for the soil to be productive and not to increase environmental pollution (Kutra et al. 2004)

Pollutants are usually by-products of human activity that emerge while solving food and other well-being problems. As it has been emphasized by the US National Academy of Science Committee, the problem is not the by-products themselves, but their distribution throughout the system to which the system is not adapted (Kormandy 1992). Sources of agricultural pollution are scattered throughout a wide territory and are difficult to notice with a naked eye. This is the reason why it might seem that agricultural activity has little impact on environmental quality. Research shows that 60-70% of nitrogen and 10-20% of phosphorus present in Lithuanian rivers are of agricultural origin (Sileika 2007). The main agricultural pollutants are nitrogen, phosphorus, potassium, etc, and pesticides used in fields. Nitrogen and phosphorus are scattered in the fields as fertilizers and then with streams of surface water are washed into rivers, lakes and other water clusters. Although some nitrogen and phosphorus get into water clusters with precipitation and from unfertilized soils mineralizing themselves, fertilizers remain the greatest source of water cluster pollution (Lazauskas et al. 2008). It is known that losses of nitrogen leaching from mineral fertilizers on average account for 0.3-5.5% of total nitrogen leached. Manure is far more dangerous in this respect. Thus, only with large reservations should mineral fertilizers be called potential water pollutants, because their negative effect in either agronomical or environmental sense can only materialize, if scientific recommendations for fertilizing are ignored (Svedas et al. 2001.).

In order to establish which system of fertilization is the best, and how to use fertilizers effectively, how to preserve soil fertility, and how to reduce nutrient leaching, many scientists are researching and perfecting various systems of fertilization, aiming to evaluate their positive and negative effects on the environment (Miseviciene 2005). Some researchers state that the application of mineral and organic fertilizers improves microbiological characteristics of the soil vastly (Svirskiene 1999), while the others claim an increase in the use of mineral fertilizers causes microbiological processes to become intensified, and yet the others point out the decline of microbiological processes (Svirskiene et al., 1986; Grigaliuniene et al. 2003). While assessing the effects on nutrient leaching by fertilization of crop rotations with manure and mineral fertilizers, researchers conclude different things: some have found that more nutrients are leached when manure is applied, while the others claim that this happens when treating soils with mineral fertilizers. According to the research data of the Lithuanian Institute of Agriculture (Tyla 1995; Tripolskaja et al. 1995) drainage water annually washes away 27.3-74.6 kg of nitrate nitrogen, 0.5-0.8 kg of phosphorus and 7.7-43.4 kg of potassium per hectare from the fields treated with mineral fertilizers, and the fields fertilized with manure leach even with greater amounts of nutrients.

It is forbidden to use synthetic nitrogen, phosphorus and potassium fertilizers, and organic fertilizers from industrial agricultural farms in organic farming systems. Since organic cattle-breading is poorly developed in Lithuania, very small amounts of organic fertilizers are produced, not enough to supply organically grown plants with nutrients. Thus, other types of organic fertilizers (composts, organic nitrogen, and other fertilizers), which would succeed in dealing with nutrient shortage in an organic agricultural system are sought after. They need to comply with the EU requirements (Council Regulation (EB) No. 834/2007, 2007; Pekarskas 2008b; Council Regulation (EB) No. 889/2008; Pekarskas et al. 2009). Organic fertilizers are analyzed mostly with regard to the way they affect soil and plant quality; leaching of organic fertilizers (nutrients) into other systems (ground waters) has not been studied. The aim of this research is to determine the intensity of nutrient leaching after application of different organic and mineral fertilizers.

2. Methodology of the research

Tests were conducted in an experimental eight lysimeter plot. Lysimeter installation scheme is presented in Figure 1. Lysimeters are dug into the ground and are connected by a tube which leads towards a well with containers for leachate collection installed inside of it.

They are filled with equally sized soil monoliths. Each lysimeter has waterproof metal walls and a bottom to prevent lysimetric water from mixing with the surrounding soil or deeper layers of ground water. The top part of the lysimeters is 2-3 cm above the ground to prevent water from spilling or flowing in.

The height of a lysimetric soil monolith is 1.1 m (the usual depth of drainage) and its cross-section is 1m^2. Such large cross-section and depth of the monolith ensure good growing conditions for perennial grasses. The lysimetric plot soil is 70% of sandy loam and 30% of light clay loam. Perennial grasses are grown in lysimeters.

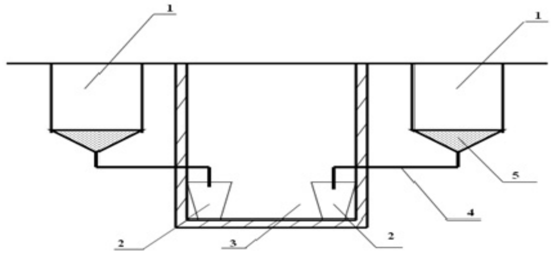

Fig. 1. Lysimeter installation scheme
where: 1- lysimeter; 2- collection container; 3- well; 4- tube that connects the collection container with the lysimeter; 5- layer of the gravel at the bottom of the lysimeter.

Chemical composition of applied fertilizers:

- *Ammonium saltpeter* – in 1 gram of NH_4NO_3 there are 0.225g NH_4^+ and 0.775g NO_3^-.
- *Chemical composition of fertilizer Biojodis (as presented by Jodvila, Ltd)* **-** organic materials 5 – 8 %; pH7,1 – 7.8;Nitrogen (N) 0,85 – 1.5 %; Phosphorus (P) 0.90 – 1.5 %; Potassium (K) 0.82 – 1.5 %; Humates soluble in water 0.15 – 0.7 %; CaO 0.40 – 2.0 %; Mg $_2$O 0.25 – 2.0 %; Fe 0.08 – 0.2 %; Mn 0.002 – 0.05 %; Cu 0.008 – 0.01 %; Zn 0.002 – 0.01 %; Co 0.0005 – 0.002 %; Mo 0.0005 – 0.002 %; B 0.008 – 0.02 %; J 0.10 – 075 mg in a liter; sucrose 0.25 – 10.0 mg in a liter; bacterial micro flora 107 - 1010 colonies are a gram; Pathogenic micro flora - no;
- *Chemical composition of Biokal (as presented by AGLA, Ltd)* **-** 57 % of extractions from medical plants; 38 % of extraction from biohumus; 5 % of essential oils, medicinal water, micro and macro elements; N 230.0 mg/l; P_2O_5 370.0 mg/l; K_2O_5 480.0 mg/l; Ca 110.0 mg/l; Mg 30.0 mg/l; Fe 10.0 mg/l
- *Test results of pelted organic fertilizers (slurry) (Center of Agrochemical Research at LUA)* - dry materials - 0.72%; total nitrogen - 0.13 %; ammonium (NH_4) - 1010 mg/l; nitrites (NO_2) - 0.001 mg/l; nitrates (NO_3) - 2.37 mg/l;
- *Composition of Horn Shaving fertilizers (as presented by IC A. Karkazas)* - organic materials - 97 %**;** total nitrogen – 15.82 %; total phosphorus – 0.047 %; potassium - 0.030 %; calcium - 0.125 %; magnesium – 0.011 %.

- *Composition of fertilizer Provita (as presented by Vyrybalt, Ltd) - n*itrogen - 13 – 14 %; potassium oxide (K_2O) - 0.2 %; phosphorus oxide (P_2O_5) – 1.4 %; magnesium oxide (MgO) - 0.3 %; calcium oxide (CaO) - 1.7 %; zinc, boron, copper - 82.4 %.
- *Composition of Horn Core Powder fertilizers (as presented by IC A. Karkazas) - o*rganic materials - 39.72 %; total nitrogen - 6.43 %; total phosphorus - 9.41 %; potassium - 0.080 %; calcium - 21.8 % ; magnesium - 0.443 %.

Stages of fertilization:

1. On July 30, 2003, lysimeters were fertilized with different amounts of ammonium saltpeter fertilizers (NH_4NO_3) as follows: lysimeter No. 1 - 50 g $(m^2)^{-1}$, No. 2 - 100 $g(m^2)^{-1}$, No. 3 - 150 $g(m^2)^{-1}$, No. 4 - 200 g $(m^2)^{-1}$, No. 5 - 300 $g(m^2)^{-1}$, No. 6 - 442 $g(m^2)^{-1}$, lysimeters No. 7 and No. 8 were left as control and no fertilizer was applied. During the first month of the research, due to the lack of humidity, lysimeters were covered and watered artificially. Starting with September 1 the weather became more humid, and lysimeters were left to irrigate naturally. Leachate samples were taken each week from August 2003 to May 2004 (Data by S.Cernuliene 2003-2004).
2. On May 13, 2005, different amounts of organic fertilizers were applied to the plants growing in lysimeters:
   No. 1 – 0.5 l Biokal liquid organic fertilizer,
   No. 2 – 0.5 l. Biojodis liquid organic fertilizer,
   No. 3 - 2 l. slurry (260 N total mg l^{-1}),
   No. 4 - 3 l. slurry (390 N total mg l^{-1}),
   No. 5 - 4 l. slurry (520 N total mg l^{-1}),
   No. 6 - 5 l. slurry (650 N total mg l^{-1}),
   No. 7 - 6 l. slurry (780 N total mg l^{-1}),
   No. 8 - left as control, no fertilizers applied. Lysimeters were left to irrigate naturally. From July 19, 2007 to May 6, 2008 water samples were taken whenever the amount of water accumulated was sufficient for analysis. Obtained data were compared to the data collected by A.Zaranka (2005) and D.Steponavicius (2006).
3. In June 2008, plants growing in lysimeters had different organic fertilizers applied to them:
   – Lysimeter No. 1 - Horn Core Powder at a rate of N180 of active nitrogen substance.
   – No. 2 - Horn Core Powder at a rate of N90 of active nitrogen substance.
   – No. 3 - Horn Core Powder at a rate of N270 of active nitrogen substance.
   – No. 4 - Horn Shavings at a rate of N90 of active nitrogen substance.
   – No. 5 - Horn Shavings at a rate of N180 of active nitrogen substance.
   – No. 6 - Provita at a rate of N180 of active nitrogen substance.
   – No. 7 - Provita at a rate of N90 of active nitrogen substance.
   – No. 8 - control (no fertilizers applied).

   Lysimeters were left to irrigate naturally, and it was observed how much time it took for nutrients to be leached into the ground water. Water samples were taken from July 2008 to March 2012.

The following indicators of water quality were determined: nitrates (NO^-_3) - mg l^{-1}(NO_3^-) (LST EN ISO 7890 – 3:1998; Nitrites (NO^-_2) - mg l^{-1} (LST EN 26777:1999). Ammonium ion concentration, (NH^+_4) - mg l^{-1}. (LAND 38 – 2000). Phosphates Concentration (PO_4^{-3}) - mg l^{-1}. (LAND 58: 2003). Tests of chemical analysis were performed in the Laboratory of Environmental Research, the Institute of Environment and Ecology, Aleksandras Stulginskis University.

To express substantiality of interdependence between water quality indices and the amount of water leached, coefficients r were calculated and statistical significance of this relationship was assessed according to p coefficient (when $p > 0.05$ correlation was regarded as statistically significant) (statistical program *STATISTICA*).

3. Results and discussion

3.1. Dynamics of ammonium ion concentrations in leachate from lysimeters

Ammonium ion concentrations in leachate from lysimeters are shown in Figures 1.1 a-c. As can be seen from the data in Figure 1.1 a, the application of ammonium saltpeter fertilizers results in leaching of ammonium ions starting after three months. The more ammonium saltpeter is used for fertilization, the greater is ammonium ion concentration in leachate from lysimeters. The test has shown that application of ammonium saltpeter does not result in ammonium ion concentration leaching by the 15th month (differences were found statistically significant, $p<0.05$).

As can be seen from the data presented in Figure 1.1 b, ammonium ion concentration is altered depending on the amount of fertilizers applied. The greater the amounts of slurry applied, the greater the amount of ammonium ions leached (correlation coefficients r=0.9839, p=0.000). Application of organic fertilizers (slurry) resulted in a significant decrease ($t<0.05$) in the maximum ammonium ion concentration in June and July of 2005 and 2006 (at the same time concentrations of $NO_3{}^+$ and NO_2^+ were increasing due to the process of nitrification) and in its increase at the beginning of August. After application of organic fertilizers in the second year (2006), the amount of ammonium ions in leachate from lysimeters was found to be significantly higher than in the first (2005) and in the third (2007) years of the research (t = 0.0006; t = 0.0032, respectively), the ammonium ion concentration in leachate from lysimeters was higher than it was in the control lysimeter ($t<0.005$). In the third year the ammonium ion concentration decreased, however, it still remained higher than it had been during the first year of the research (differences were found statistically significant, t<0.05). In the fourth year of the research an ammonium ion concentration decreased significantly (r=-0.8752 p= 0.004) compared to the data obtained in the first year of the research. Ammonium ion concentrations were higher in all lysimeters compared to the concentration in the control lysimeter (t<0.005).

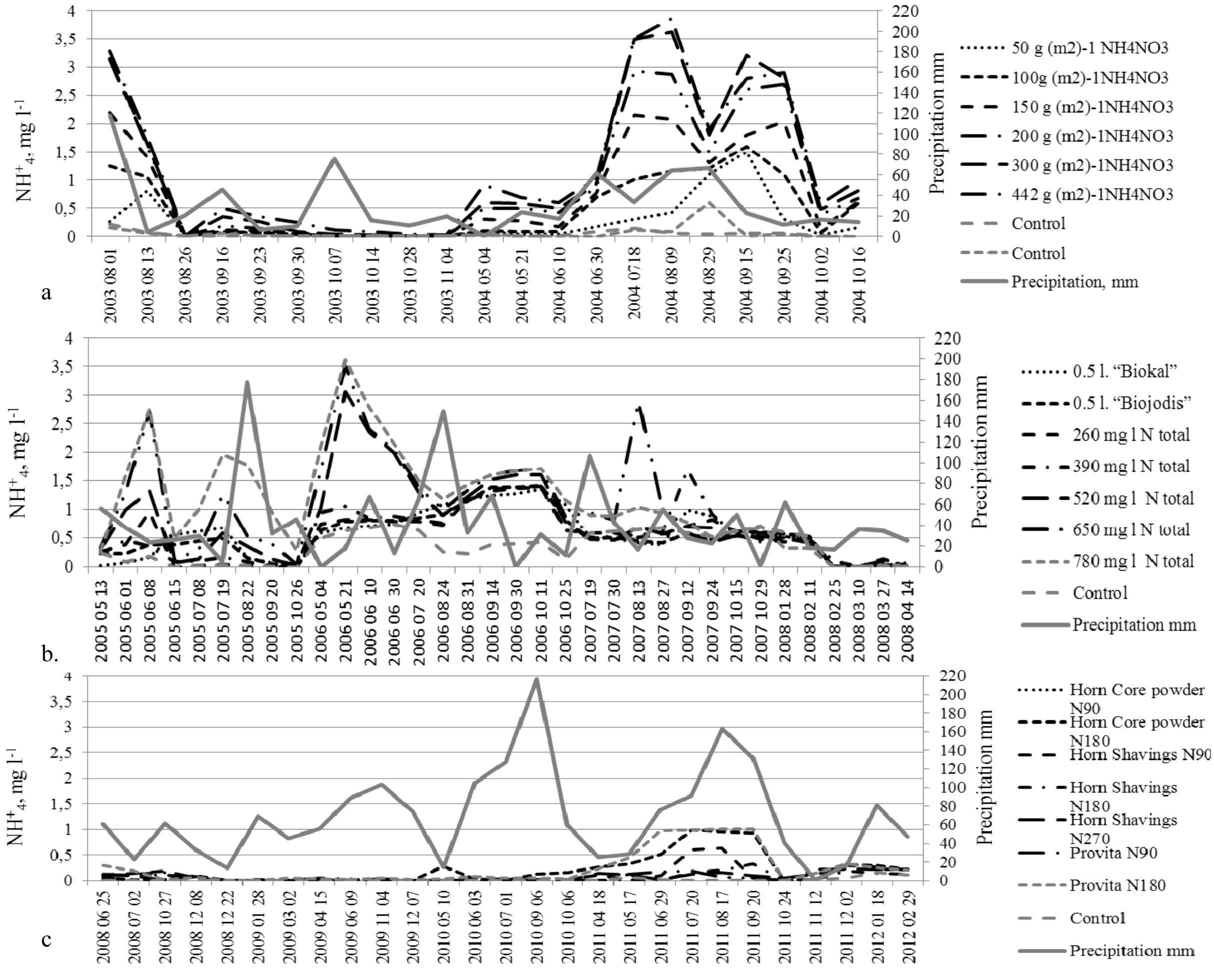

Fig. 1.1. Ammonium ion concentrations in leachate from lysimeters after application of mineral fertilizers - ammonium saltpeter (a), slurry, Biojodis and Biokal fertilizers (b) and after Horn Core powder, Horn Shavings and Provita (c)

Application of different amounts of *Horn Core Powder, Horn Shavings* and *Provita* fertilizers resulted in lowest ammonium ion concentrations during the first and the second year of the research. In the third year of the research the increase in an ammonium ion concentration in leachate from lysimeters was observed. In the fourth year of the research ammonium ion concentrations were the highest in all lysimeters (differences were found statistically significant p<0.05). Correlation between the amount of precipitation (mm/days between tests) and the ammonium ion concentration in leachate from lysimeters was found statistically insignificant (p>0.05).

It can be concluded from the data that ammonium ion concentrations were the lowest in spring (April-May) and winter (October-December), and the highest in summer (June-July) and autumn (September-October).

3.2. Dynamics of nitrite concentrations in leachate from lysimeters

Nitrite concentrations in leachate from lysimeters are shown in Figures 1.2 a-c.

As can be seen in Figure 1.2 a, application of different amounts of mineral fertilizers resulted in similar nitrite concentrations in all leachates from lysimeters. The highest concentrations were found in the first month after the application of fertilizers and one year later. Concentrations were the lowest in May and June, yet they still were higher than the ones in control lysimeters (differences were found statistically significant p<0.05). In the 15th month since the beginning of the test, nitrite ion concentration decreased in lysimeters with lesser amounts of mineral fertilizers applied to them, yet the concentration remained higher than in control lysimeters. Application of 300 mg $(m^2)^{-1}$ and 442 mg $(m^2)^{-1}$ of ammonium saltpeter fertilizers to the lysimeters resulted in a decrease in nitrite ion concentration compared to the results obtained in the beginning of the research, yet no statistically significant differences were found (p>0.05).

Application of organic fertilizers (slurry) is shown in Figure 1.2 b. The highest nitrite concentrations were found in July, 2005 and 2006, (NH_4^+ concentration was decreasing during that time), and it decreased in September. There was a significant decrease in a nitrate ion concentration ($t<0.05$) as the process of nitrification became slower. After application of slurry in 2005, the amounts of nitrites were similar to those in 2006 and 2007, (differences were found statistically insignificant $t>0.05$). After application of *Biojodis* and *Biokal* fertilizer, nitrite concentrations in leachate from lysimeters were very low in the first year, no statistically significant differences were found between lysimeters with *Biojodis* and *Biokal* applied and control lysimeters (no statistically significant differences were found, $t<0.005$). Application of *Horn Core Powder, Horn Shavings* and *Provita* resulted in different nitrite concentrations throughout all five years of the research, as shown in Figure 1.2 c. It changed from 0.001 mg l^{-1} to 0.225 mg l^{-1}; however, it never exceeded the highest allowed concentration of 0.50 mg l-1.

The most evident alteration in nitrite concentration in leachate from lysimeters was observed in the third year of research (2010) after the use of *Horn Core Powder N90* (from 0.105 mg l^{-1} to 0.225 mg l^{-1}). After the application of fertilizers *Horn Shavings N90,* the amount of nitrite leached to the ground water was similar to that of nitrite leached after application of three times higher amount of the same fertilizer *Horn Shavings N270* ($t>0.05$), and was higher than in a control lysimeter (difference was found statistically reliable $t=0.041$).

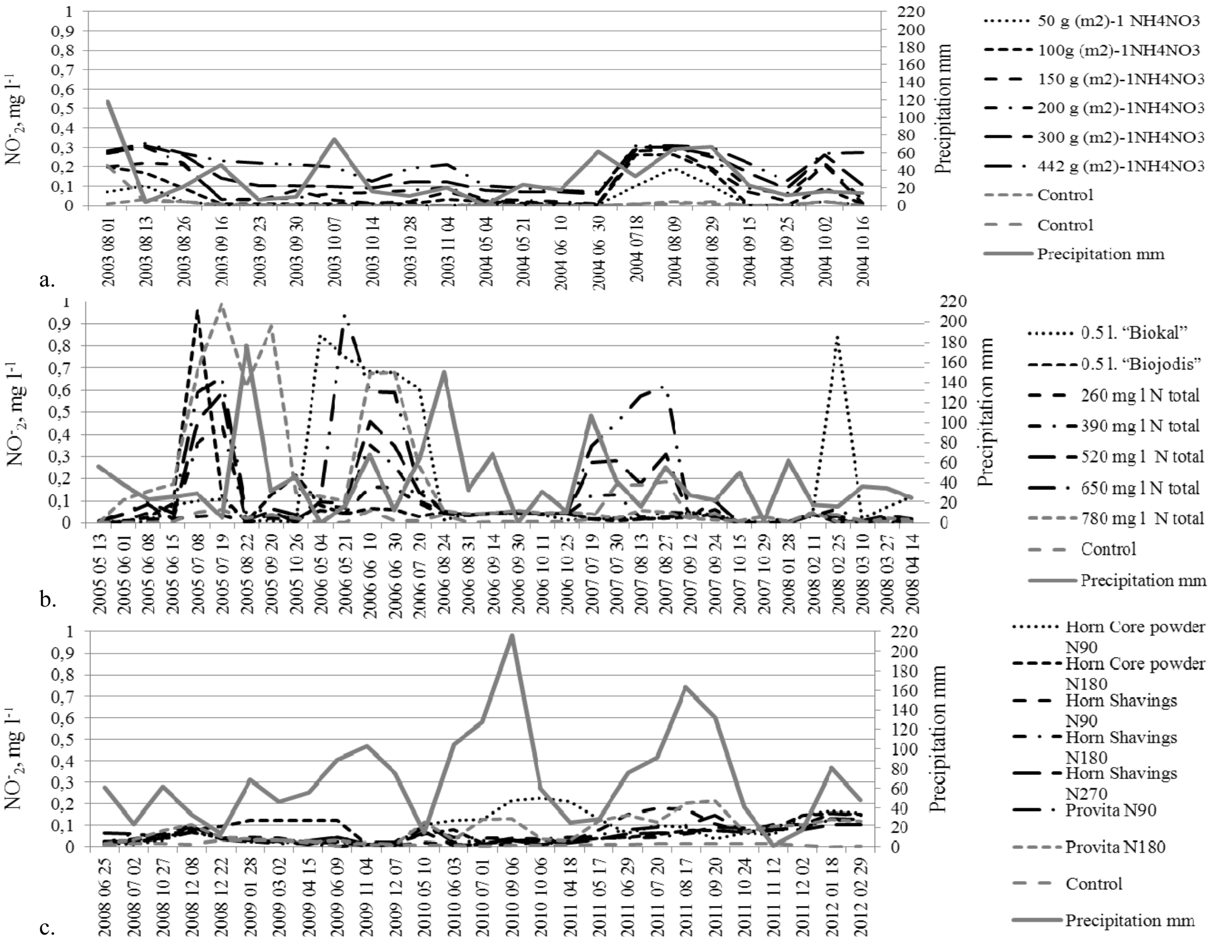

Fig 1.2. Nitrite concentrations in leachate from lysimeters after application of mineral fertilizers - ammonium saltpeter (a), slurry, Biojodis and Biokal fertilizers (b) and after Horn Core powder, Horn Shavings and Provita (c)

The highest nitrite concentrations were observed in the fourth and fifth year of research (2011-2012), after application of *Horn Shavings N90* - the concentrations varied from 0.069 mg l^{-1} to 0.177 mg l^{-1}. At the same time nitrite concentrations after application of a three times higher amount of the same fertilizer *(Horn Shavings N270)* fluctuated from 0.058 mg l^{-1} to 0.105 mg l^{-1}.

Application of fertilizers *Provita N180* resulted in higher nitrite concentrations in the ground water compared to fertilizers *Provita N90* (differences were found statistically insignificant ($t>0,05$) throughout all years with the exception of year 2009 (concentrations varied from 0.009 mg l^{-1} to 0.030), yet it was still higher than the control ($t<0.05$).

Comparing these data to the control lysimeter data, it can be seen that highest nitrite concentration occurred in 2010, after application of *Horn Core Powder N90 (*0.225 mg l^{-1}), and the lowest occurred in 2009, after application of *Horn Shavings N180* (0.003 mg l^{-1}), yet it never exceeded the allowed limit. The highest concentration was observed during summer and autumn, the lowest - during winter and spring. After application of saltpeter (100g $(m^2)^{-1}$) and Provita N180 fertilizers, correlation between the amount of precipitation (mm/days between tests) and the nitrite concentration in leachate from lysimeters was found positive and statistically significant ($p<0.05$).

3.3. Dynamics of nitrate concentrations in leachate from lysimeters

Nitrate concentrations in leachate from lysimeters are shown in Figures 1.3 a-c. As seen in Figure 1.3 a, the greater the amount of mineral fertilizers applied, the greater the nitrate concentrations found in the ground water. Application of ammonium saltpeter resulted in the values fluctuating from 1 mg l-1 to 900 mg l-1. Nitrate concentrations in ground water started to decrease after the 14th month of the research and achieved minimal concentrations (change in the interval from 1 mg l-1 to 15 mg l-1), yet they remained higher than in the control lysimeter, with the exception of lysimeter with the lowest amount of fertilizers (50 mg (m2)-1) applied. After application of ammonium saltpeter (50 g $(m^2)^{-1}$, 100g $(m^2)^{-1}$, 150 g $(m^2)^{-1}$, 200 g $(m^2)^{-1}$), correlation between the amount of precipitation (mm/days between tests) and the nitrate concentration in leachate from lysimeters was found positive and statistically significant ($p<0.05$).

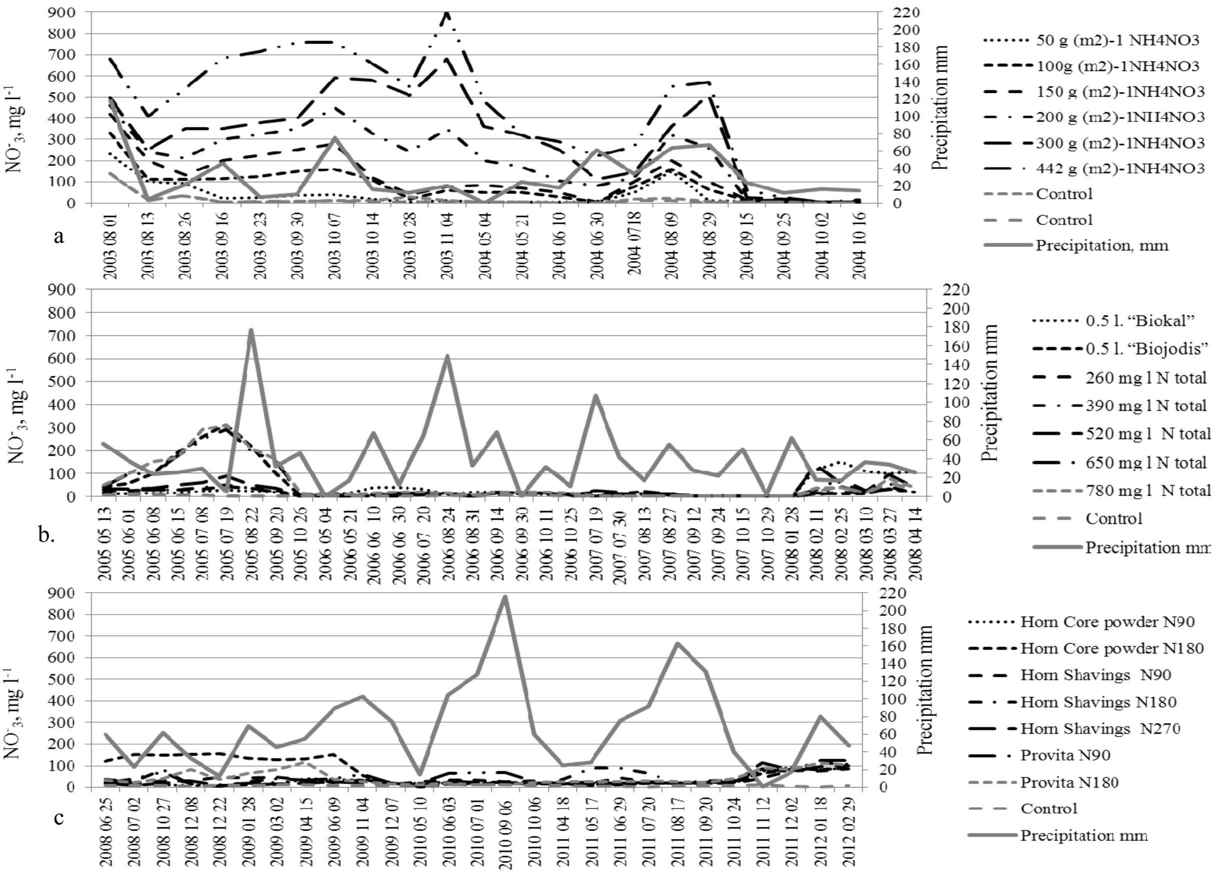

Fig. 1.3. Nitrate concentrations in leachate from lysimeters after application of mineral fertilizers - ammonium saltpeter (a), slurry, Biojodis and Biokal fertilizers (b) and after Horn Core powder, Horn Shavings and Provita (c)

Application of organic fertilizers (slurry) is shown in Figure 1.3 b, the highest nitrate concentrations were found in July 2005, 2006, and 2007, ($NH4^+$ concentration was decreasing at the time), and it started to decrease in September. Application of slurry in 2005 resulted in the highest nitrate concentrations found in leachate from lysimeters, they were higher than in 2006, (difference was found statistically significant t=0.033), and in 2007, (differences were found statistically significant t=0.003). The amounts were the smallest in 2007, (differences were found significant, $t\leq0.05$). In the third year of the research similar nitrate concentrations were found in all lysimeters, including the control one (differences were found statistically insignificant, $t>0.05$). Application of 6 l of slurry resulted in a similar nitrate concentration in leachate from lysimeters to the concentration found after application 0.5 l of *Biokal* (the difference was found statistically insignificant, $t>0.05$). A nitrate concentration resulting from application of *Biojodis* was higher than in the control lysimeter (difference was found statistically significant, t=0.045), yet lower than in the lysimeter with 6 liters of slurry applied to it (difference was found statistically significant, t=0.008). Similar nitrate concentrations were found after application of *Biojodis* and application of 1-5 liters of slurry (differences were statistically insignificant, $t>0.05$). In the third year of research, application of *Biojodis* and *Biokal* did not result in any statistically significant differences in the nitrate concentrations compared to those in a control lysimeter and lysimeters with 1-6 liters of slurry applied.

The highest nitrate concentrations in leachate from lysimeters were found in the first year after application of fertilizers, and decreased in the second year, though they remained higher than in the control lysimeter. In the third year of the research nitrate concentrations in leachate from lysimeters were found similar to that in a control lysimeter (differences were statistically insignificant, t>0.05).

Application of *Horn Core Powder, Horn Shavings* and *Provita* fertilizers (shown in Figure 1.3 c) resulted in varying nitrate concentrations during different periods of the research. The greatest changes in nitrate concentrations occurred in 2008-2009 in the lysimeter with *Horn Core Powder N180* applied. In the first and the second year of the research (2008 and 2009) nitrate concentration in the lysimeter with *Horn Core Powder N180* applied was significantly higher than in the lysimeter with *Horn Core Powder N90* applied (the difference was statistically significant, t=0.000). At the same time, nitrate concentrations in the lysimeter fertilized with half the amount of the same fertilizer *Horn Core Powder N90* did not exceed the rate allowed (50 mg l^{-1}) and fluctuated from 8 mg l^{-1} to 20 mg l^{-1}. Only in the last months of 2011 (November-December) and in the beginning of 2012 (January-March), nitrate concentration varied from 75 mg l^{-1} to 92 mg l^{-1}, but remained higher than in the control lysimeter (t<0.05).

Application of organic fertilizers *Horn Shavings N90, Horn Shavings N180* and *Horn Shavings N270* resulted in similar nitrate concentrations in leachate from lysimeters during the period of the research (differences were statistically insignificant, t>0.05).

Application of *Horn Shavings N90, Horn Shavings N180* and *Horn Shavings N270* resulted in higher nitrate concentrations than those in the control lysimeter (differences were found statistically significant, t=0.03; t=0.024; t=0.032).

Application of *Provita N90* and *Provita N180* resulted in similar nitrate concentrations throughout all five years of the research (differences were not statistically significant, t>0.005).

Application of *Provita N180* resulted in a nitrate concentration being significantly higher than that in the control lysimeter (difference was found statistically reliable, t=0.047).

The highest nitrate concentrations were observed during the first and the second (2008-2009) year of the research after application of *Horn Core N180* and *Provita N180* fertilizers (difference was found statistically significant t=0.010). Seasonal changes in nitrate concentrations in ground water were observed: the highest concentrations were found in spring and winter, the lowest - in summer and autumn. If precipitation exceeds evapo-transpiration, nitrate can leach to a groundwater. But, where the amounts of rainfall are low and potential evapo-transpiration exceeds annual precipitation, the concentration of nitrate tends to be high because a diluting effect is reduced (Leskošek 1994).

3.4. Dynamics of phosphate concentrations in leachate from lysimeters

Phosphate concentrations leached in leachate from lysimeters are shown in Figures 1.4 a-b.

As shown in Figure 1.4 a; application of slurry resulted in the highest phosphate concentrations in leachate from lysimeters in June-July of 2005, 2006 and 2007, which started to decrease at the end of July. Application of organic fertilizers (slurry) resulted in similar phosphate concentrations in leachate from lysimeters in 2005 and 2006 (difference was found statistically insignificant, t>0.05) and greater than in 2007 (differences were found statistically significant, t<0.05). In the first year of the research a phosphate concentration in the control lysimeter was similar to phosphate concentrations in lysimeters with 1-2 l of slurry applied to them (differences were found statistically insignificant, t>0.05).

Application of greater amounts of slurry (3-6 l) resulted in higher phosphate concentrations in the control lysimeter (t<0.005). In the second year of the research phosphate concentrations in all lysimeters were higher than in the control lysimeter (t<0.005). In the third year of the research similar amounts of phosphate were leached from all lysimeters and the control lysimeter (differences were found statistically insignificant, t> 0.05).

After application of *Biokal,* phosphate concentrations in leachate from lysimeters in the first and second year of research were significantly higher than after application of *Biojodis* (differences were found statistically significant, t<0.05) and higher than in the control lysimeter (differences were found statistically significant t<0.05). In the first year after application of *Biokal* fertilizers the phosphate concentration was similar to the one in the lysimeter with a great amount of slurry (6 liters) applied (difference was statistically insignificant, t>0.05). After application of *Biojodis,* the phosphate concentration in the first year of the research was found similar to that in the control lysimeter (difference was found statistically insignificant, t>0.05), though it was lower than after application of 1-6 l of slurry (differences were found statistically significant, t<0.05).

In the second year the tendencies were reverse: the phosphate concentration in the lysimeters with *Biokal* applied was lower than in the lysimeter with a great amount of slurry (6 liters) applied (difference was found statistically significant, t=0.016). Application of *Biokal* resulted in phosphates leaching in two years time.

Application of *Biojodis* did not cause any statistically significant differences in the phosphate concentrations compared to the control lysimeter and lysimeter with 1-3 liters of slurry applied (differences were found statistically insignificant, t>0.05). However, smaller amounts of phosphates leached than after application of 5-6 liters of slurry (differences were found statistically significant, t<0.05).

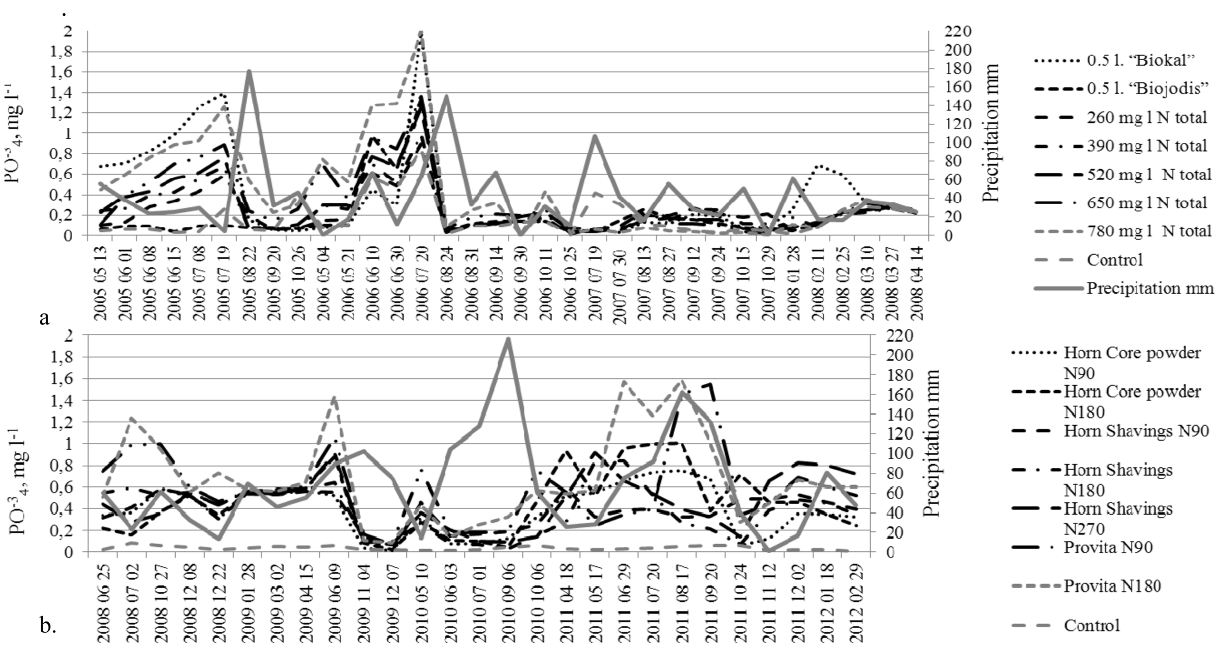

Fig. 1.4. Phosphate concentrations in leachate from lysimeters after application of organic fertilizers: slurry, Biojodis and Biokal fertilizers (a) and after Horn Core Powder, Horn Shavings and Provita (b)

Application of *Biokal* and *Biojodis* fertilizers resulted in phosphate leaching in the period of two years. Application of different organic fertilizers *Horn Shavings*, *Horn Core Powder* and *Provita* (shown in Figure 1.4 b resulted in different phosphate concentrations in leachate from lysimeters, varying in the interval between 0.01 and 1.59 mg l^{-1}.

The lowest phosphate concentrations were observed in November and December of the second year of the research and in October of the fourth year of the research, however, they were still higher than in the control lysimeter (differences were found statistically significant $p<0.05$). The highest concentrations in ground water resulted from application of *Provita N90* and *Provita N180* ($t>0.05$). Application of *Provita N90* resulted in outstanding variations in the phosphate concentration in four years of the research (2008-2011). In the final year of the research (2012) phosphate concentrations in leachate from lysimeters after application of all different fertilizers (*Horn Core Powder N90, Horn Core Powder N180,* Horn *Shavings N90, Horn Shavings N180, Provita N90 and Provita N180)* were within the permissible limits, with the exception of *Horn Shavings N270* (phosphate concentration exceeded the highest permissible concentration -0, 7 mg l^{-1}). Correlation between the amount of precipitation (mm/days between tests) and the phosphate concentration in leachate from lysimeters was found statistically insignificant ($p>0.05$).

In conclusion, it was observed that phosphate concentrations were the highest during summer and spring and the lowest during autumn and winter.

4. Conclusions

The lowest ammonium ion concentrations were observed after application of *Horn Core Powder, Horn Shavings* and *Provita* fertilizers (ammonium ion concentrations did not exceed 1.0 mg l^{-1}). Application of ammonium saltpeter fertilizers resulted in the highest ammonium ion concentration 12 months after their application (3.87 mg l^{-1}). Application of slurry resulted in the highest ammonium ion concentration of 3.6 mg l^{-1} (after application of the greatest amount of slurry 780 mg l Nb), application of *Biojodis* and *Biokal* resulted in less noticeable ammonium ion concentrations fluctuations (concentrations varied in the interval from 0.001 mg l^{-1} to 1.6 mg l^{-1}), concentrations were similar to those after the use of slurry (260 mg l Nb and 390 mg l Nb).

The lowest nitrite ion concentrations were observed after application of *Horn Core Powder, Horn Shavings* and *Provita* fertilizers (the highest concentration was 0.225 mg l^{-1}), however, they did not leach from soil into lysimetric water in all four years of the research. Applying different amounts of slurry and *Biokal, Biojodis* fertilizers, nitrite concentrations were the highest in 1-3 years of the research and leached from soil into lysimetric water by the fourth year of the research. Application of ammonium saltpeter resulted in a high ammonium ion concentration during the whole period of the research, but leached from the soil by the fifteenth month, with an exception of lysimeters treated with the biggest amounts of ammonium saltpeter.

The obtained data showed that application of ammonium saltpeter resulted in nitrites leaching into lysimetric water by the 14th month of the research, then application of slurry, *Biokal* and *Biojodis* resulted in nitrites leaching by the 36th month, and application of *Horn Shavings, Horn Core Powder* and *Provita* fertilizers did not result in nitrites leaching into lysimetric water by the 44th month.

Application of *Horn Shavings, Horn Core Powder* and *Provita* fertilizers resulted in varying phosphate concentrations during the research period.

The lowest concentrations were observed in November and December in the second year of the research, and in October in the fourth year of the research, however they were still higher than in the control lysimeter (differences were found statistically significant, $p<0.05$). Application of slurry, *Biokal* and *Biojodis* resulted in the highest phosphate concentrations in the first and the second year of the research. In the third and the fourth year of the research phosphate concentrations decreased and were similar to those in the control lysimeter (differences were found statistically insignificant, $p>0.05$).

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Maistingųjų medžiagų išplovimo intensyvumas panaudojus skirtingas ekologiškas ir mineralines trąšas

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Tyrimai atlikti Aleksandro Stulginskio universiteto mokomajame ūkyje įrengtoje aštuonių lizimetrų aikštelėje. Lizimetrai yra įkasti į žemę. Kiekvienas lizimetras sujungtas vamzdžiu ir nuvestas į šulinį, kuriame įrengtos išsiplovusio vandens surinkimo talpos. Tyrimų tikslas – nustatyti maistingųjų medžiagų išplovimo intensyvumą panaudojus skirtingas ekologiškas ir mineralines trąšas. Tyrimams buvo pasirinktos ekologiškos trąšos: *Biojodis*, *Biokal, srutos, ragų drožlės Provita*, *ragų geluonių miltai*, ir mineralinė trąša – *amonio salietra.* Paskui periodiškai matuojamos nitratų, nitritų, amonio jonų ir fosfatų koncentracijos ištekančiame iš jų vandenyje. Tyrimų rezultatai rodo kad mažiausios amonio jonų ir nitritų koncentracijos išsiplovusiame vandenyje nustatytos panaudojus *ragų geluonių mitų, ragų drožlių* ir *Provita* trąšas. Panaudojus amonio salietros trąšas, nitratai per 14 tyrimų mėnesių išsiplauna į lizimetrinį vandenį. Panaudojus srutas, *Biokal* ir *Biojodis* trąšas, nitratai per 36 mėnesius iš dirvožemio į lizimetrinį vandenį neišsiplauna. Panaudojus *ragų geluonių miltus, Ragų drožles* ir *Provita* trąšas, jie neišsiplauna per 44 mėnesius.