ELIMINATION OF NITRATE POLLUTION OF SOIL GROUND WATER BY ENERGY FOREST PLANTATION

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Introduction

Nitrate ions can reach through their infiltration into deeper soil layers the ground water without any barrier, where they may cause serious contaminations. Regarding the leaching process it is totally unimportant, whether nitrate ions reached the soil through chemical fertilizers, manure, communal or agricultural wastewaters or such sewage sludge. The possibility of the microbial transformation of the nitrogen-containing material is even less parallel to the deeper soil layers.

Materials and methods

The effect of different nitrogen fertilizer dosages on maize (*Zea mays L.*) production was investigated within the confines of a 20-years long-term experiment on a Ramann-type ferruginous soil, in Gödöllő Szárítópuszta, Hungary.

The physical properties of the experimental soil are the following: the upper 60 cm layer is sandy, underneath that there is a sandy loam layer and the 200-300 cm layer under surface is clay-loam. The width of the layer that contains humus is 35 cm. $CaCO_3$ occurs in a depth of 60 cm. The humus content of the ploughed layer is 1.3 %, underneath that this value is less than 1 %. The groundwater level lays under 4 m. In some parts of the soil profile there is a limestone layer in a depth of about 2 m.

Since the autumn of 1969 increasing nitrogen fertilizer dosages were applied at a range from 0 to 90, 180, 270 and 360 kg N ha^{-1} resp. Parallel to the increasing nitrogen dosages the amounts of the applied phosphorous and potassium fertilizer were also enhanced (Füleky-Kovács, 1994). During the autumn of 1989 fertilization was finished and alfalfa (*Medicago sativa L.*) has been planted. We measured the hay yield and the nitrogen content of these plants each year.

In 1994 and 2003 we took soil samples each 20 cm in a total depth of 3 m, so that we could reveal the changes in the soils of 4 treatments with high N-fertilizer dosages from the total 12 treatments. The studied samples were taken from the plots treated each year with the fertilizer dosages in Table 1.

After the mechanical preparation (sieving, chopping) and the drying of the samples we made soil extracts using 1.0 % KCl solution and 1 hour shaking time. The soil suspensions were filtered and their NH_4^+-N and NO_3^--N contents were measured by a Parnas-Wagner water steam distillation equipment.

The changes in the previous period and the effect of the former treatments on the depth distribution of nitrogen have been evaluated with a 3-way ANOVA (Sváb, 1981). For the calculations we used our own computer program – written in Excel Macro – just as we did in our former studies (Tolner, 2008; Vágó, 2008).

Treatment code	1	9	10	11	12
N dosage	0 kg ha^{-1}	90 kg ha^{-1}	180 kg ha^{-1}	270 kg ha^{-1}	360 kg ha^{-1}

Table 1. Codes of the investigated treatments and the per year applied N-dosages (kg ha^{-1})

Results and discussion

The fertilization experiment is a single factor (12 fertilizer stages) experiment with 4 replications and a random block design. We took soil samples from the total depth only in 5 selected treatments and on each 2 plots. The evaluation was executed for the total mineral nitrogen (NH_4^+-N + NO_3^--N mg kg^{-1} soil) content according to the 3 factor-random block design. The factors were the followings:

- **Factor A:** soil depth (15 soil layers: each 20 cm, until the depth of 3 m),
- **Factor B:** the former fertilizer treatment (5 dosages: 0, 90, 180, 270, 360 kg N ha^{-1}),
- **Factor C**: time (2 levels: 1994, 2003).

Upon the results of the evaluation and the table of variance, following important statements can be concluded and statistically confirmed:

1. The interaction between soil depth and time (A x C) was significant (F-rate: 1.8*). That means that the distribution of soil nitrogen content in the soil profile changed between the first and second sampling period (9 years). It can be followed on Figure 1., that in the depth of 240-300 cm the in 1994 detected N accumulation could not be traced any more in 2003. This confirms that it is possible to eliminate the nitrate accumulation, leached until 3 m soil depth, by planting forests. A significant N accumulation was measured in the upper 20 cm layer in both sampling periods. The extent of this accumulation was significantly more expressed in 2003, than in 1994. This effect can be attributed to the N-binding effect of the – with acacia, as a legume host plant – symbiotic Rhizobium bacteria.

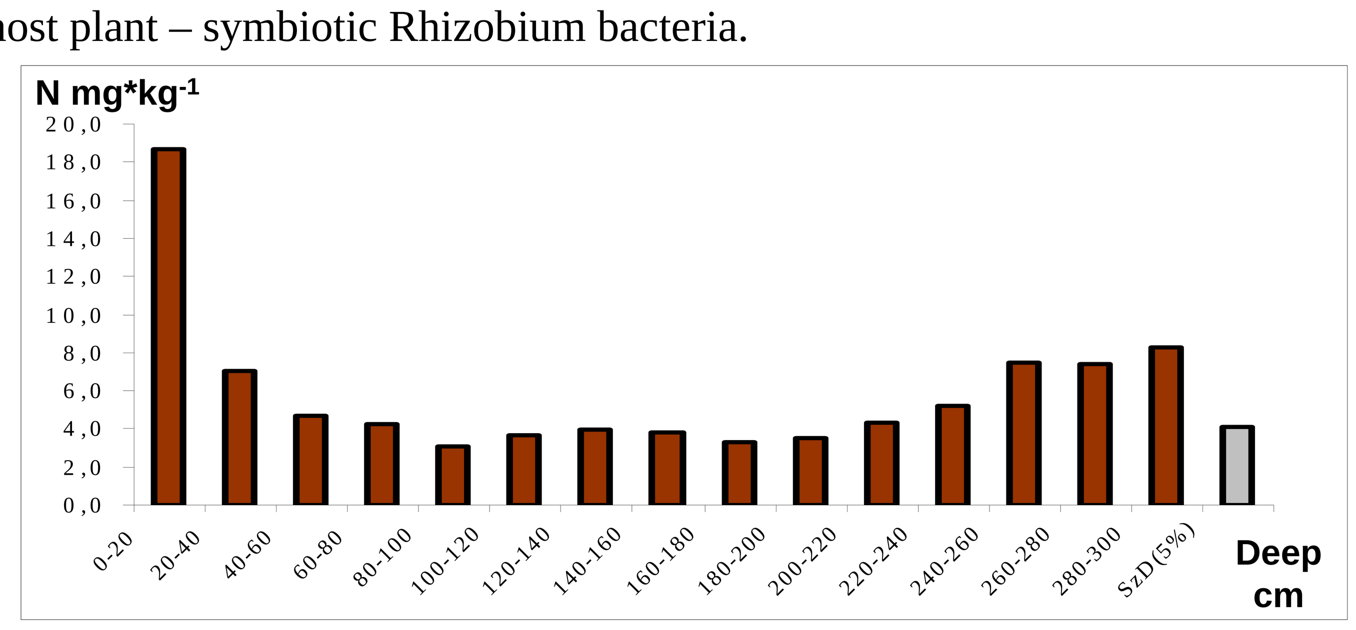

Figure 1. Depth distribution of soil N in the years 1994 and 2003 in the average of the fertilizer treatments

2. The interaction between fertilizer treatments and time (B x C) was also significant (F-rate: 2.5*). This means that differences in soil N-content – originating from the previous differences in the applied fertilizer dosages – changed during the 9 years between the two sampling periods. It is evident from Figure 2., that in 1994 the soil nitrogen content was increased by the increasing fertilizer dosages, although this effect cannot be revealed between the sequential steps. In 2003 a significant difference can be detected only between the control and the 270 kg ha^{-1} N treatments. It can be stated that the effect of the former fertilization decreased during the surveyed 9 years.

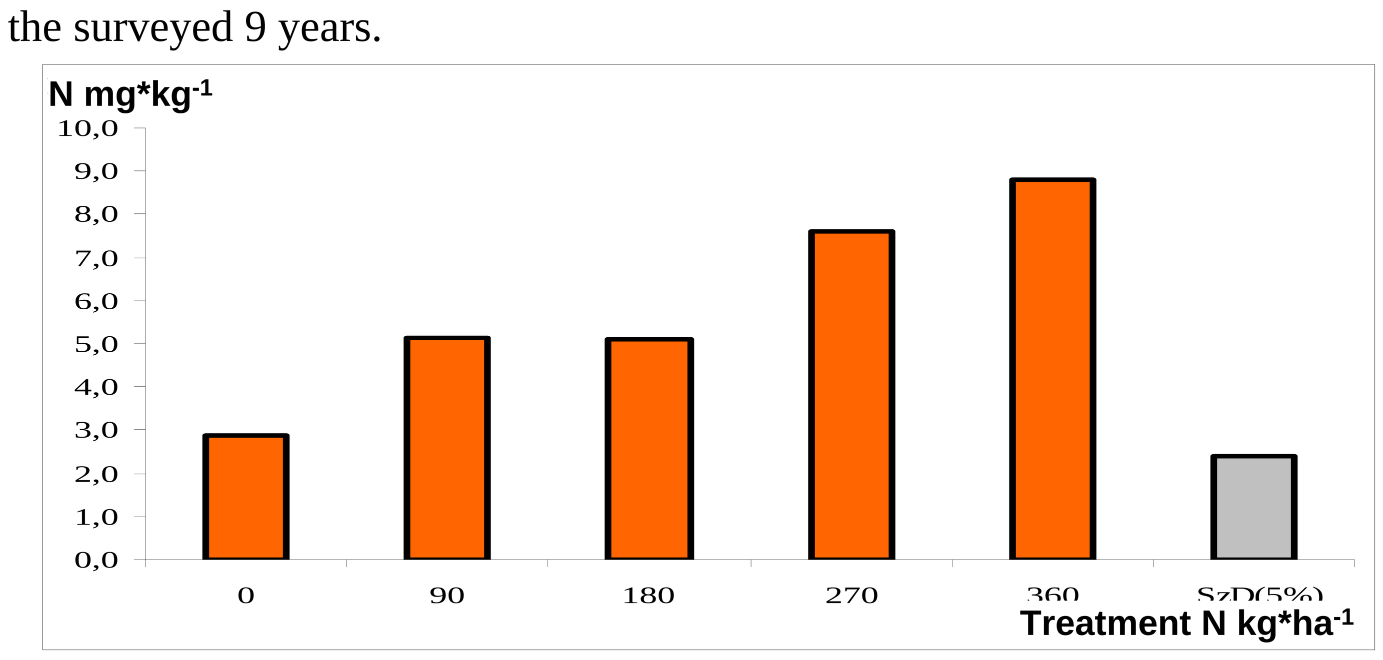

Figure 2. Differences in soil N-content as affected by N fertilization in the years 1994 and 2003, in the average of the factor soil depth

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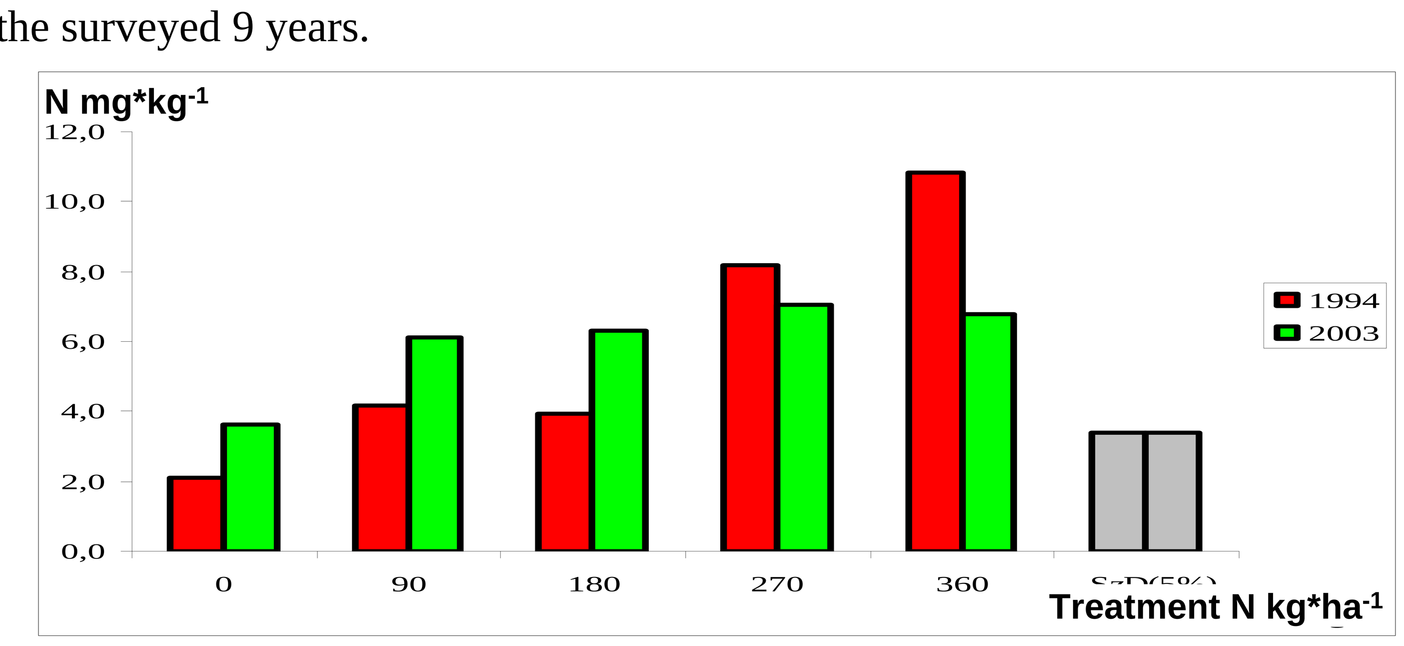

Figure 3. Differences in soil N-content as affected by N fertilization in the years 1994 and 2003, in the average of the factor soil depth

As an effect of forest planting the former heterogeneity of the experimental plots decreased significantly. It can be stated also from the satellite picture from the 30th June 2009 that the steady forest does not show any effect of the former soil heterogeneity.

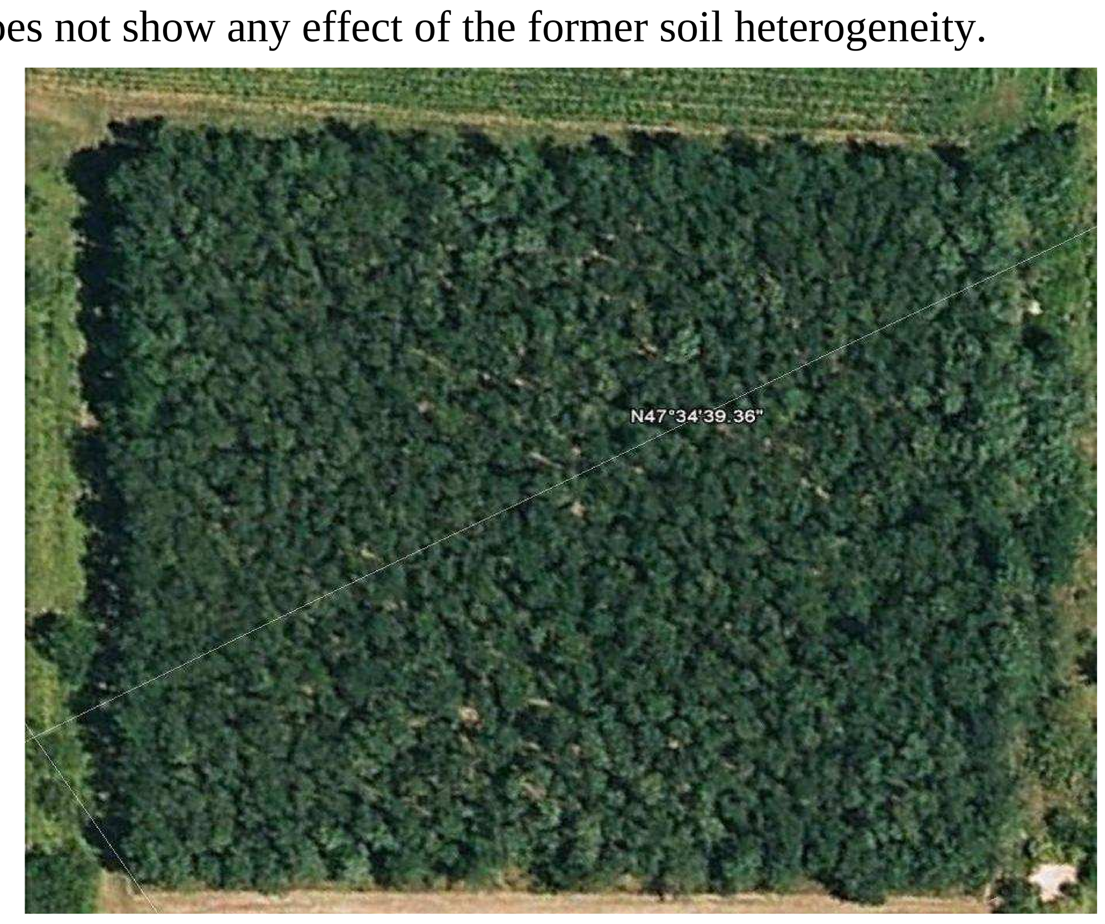

Figure 3. the steady forest does not show any effect of the former soil heterogeneity