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The Impact of Environmental Factors on the Amount of Nitrates and Nitrites in Different Types of Soils and Ways of Their Utilization

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Abstract*: Despite the last decade considerable advances in the study of nitrate and nitrite pollution of soil, there are still some gaps in research related to neglecting or ignoring the role of soil in the food chain and its effects on upper trophic units. The article presents the results of a study on the impact of air and soil humidity and temperature, as well as soil type and utilization on the amount of nitrates and nitrites in the soil solution at the end of vegetation period. It was proved that statistically significant impact on the amounts of residual nitrate and nitrite ions was caused by the temperature and moisture of soil, its type, and the specific properties of the crops grown.*

Keywords*: nitrates, nitrites, pollution of soils, soil types*

Introduction

Studies conducted over the last 20-25 years have confirmed the need for a thorough research of the composition and properties of soil solution, since this dynamic component of the soil is particularly sensitive to the changes caused by different factors, and can therefore be used as a criterion for measuring the risk of overloading each of agroecosystems' components - soil, vegetation and waters [1, 2].

The fact that plants absorb substances from the surrounding environment leads to the accumulation of these substances, which depends on the abiotic characteristics of the environment [3]. Finding a solution to the problem of soil pollution with nitrates and nitrites as a result of its use for growing crops, and ensuring the quality of soils, subterranean waters and food produce is of vital importance and has economic and social significance.

Materials and methods

Region of research: The study was conducted in the area of Shumen region, in the grounds of the villages Dibich and Ivanski, Shumen municipality, in the North-East of Bulgaria. The area has temperate continental climate [4] and is mainly arable land, which in 2016 was used for growing grains - corn and sunflower.

The material was collected at the end of plant vegetation in the period from July to October 2016 from 9 sampling plots. Six of these plots (SP 1, 2, 3, 4, 5 и 6) were located on the grounds of Dibich, while SP7 and SP8 were in the territory of Ivanski on arable land planted with corn and sunflower. Sampling plot 9 is located between two villages and is fallow land (Fig.1). The first 6 sampling plots and plot 9 are located on typical chernozem loamy soils (with a humus soil horizon of up to 40 cm) [5], and sampling plots 7 and 8 - on ordinary grey forest soils (Haplic luvisols) [6].

Collection of material:

The soil samples were collected once a month in July, August and September, and the last sample was taken on the 9 th October after the harvest and clearing of the terrain. Simultaneously with the sample collection were measured the temperature and humidity of the air and the moisture and temperature of the soil with a combined digital device (a soil thermometer, hygrometer) (TFA, Germany), and the pH of the soil - with a digital pH-meter of HI 83141 type (HANNA instruments, USA).

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The sample collection was done in the following way: form 5 locations at each of the sampling plots were taken equal amounts of soil which were mixed in a collective sample [7]. The soil mixture was carefully stirred and the necessary amount of this combined sample was taken for study.

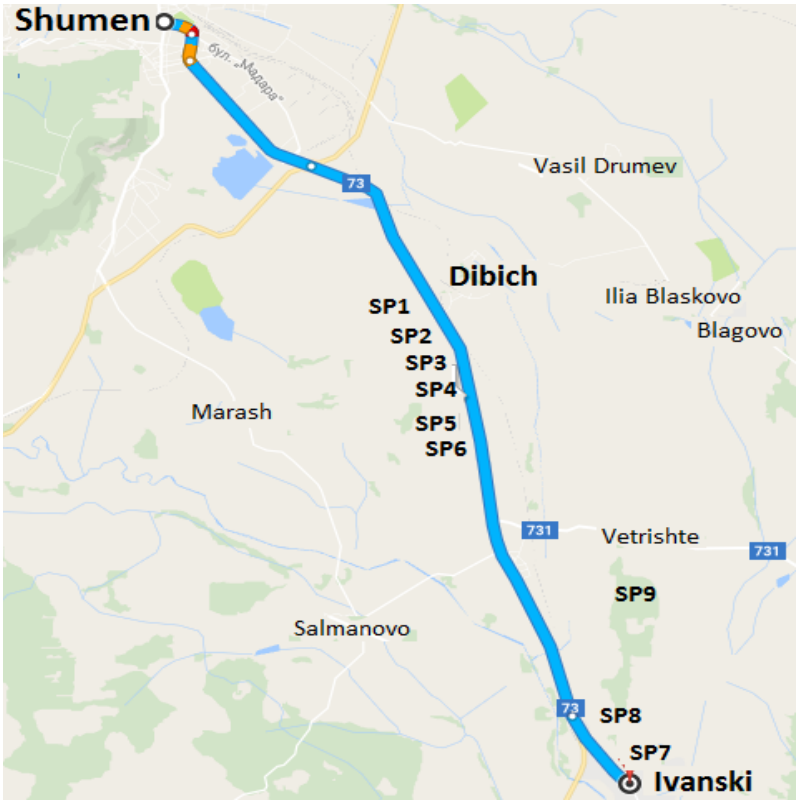

Fig.1. The area of study with the location of sampling plots

The soil extraction was done on the day of sample collection and was mixed with distilled water in a ratio 1:10 for the period of 24 hours. The mixture was later filtered spectrophotometrically with a blue band filter [8] in order to measure the amount of nitrates and nitrites by means of Multiparameter Bench Photometer for Laboratories, HI 83200, HANNA instruments, USA. The results were then processed statistically with a t-test, analysis of the main components and cluster analysis with the programme Multibase 2015 (Numerical Dynamics, Japan).

Sampling plots:

Sampling plots 1 to 3 were planted with hybrid sorts of sunflower as follows: on SP 1 there were 5 sorts belonging to LG company; on SP 2 - 6 sorts belonging to Euralis company, and on SP 3 - 9 sorts belonging to Syngenta company. Sampling plots 4 to 6 were planted with hybrid sorts of corn belonging to two companies - on SP 4 there were 5 sorts of LG, SP 5 had 3 early hybrids of Syngenta and SP 6 - 3 early-middle hybrids of the same company. SP 7 was planted with a hybrid sort of sunflower 56.63 of LG company, and SP 8 - with a hybrid sort of corn 34.75 of the same company. Sampling plot 9 was a fallow land with nothing planted on it.

Throughout the study year the corn and sunflower were treated with the products of Timac AGRO Bulgaria company. The crops were treated with a combined fertilizer at the time of their planting. The corn and the sunflower were treated after their planting and before germination with the soil herbicide Dual Gold, Gardoprim Plus Gold or Lumax.

Results and discussion

The experimental data from the sampling plots together with the measured parameters, the crops and the type of soils are presented in table 1.

The results were processed with the in-built statistical functions and the module for data processing in Microsoft Office Excel 2016. The main statistical parameters of the measured experimental values such as mean values and dispersion were calculated. The data for nitrate and nitrite nitrogen presence in the samples from all sampling plots were compared through a t-test with the control sampling plot (fallow land). The

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results show statistically significant differences (with a level of significance < 0.0001) at all planted plots in comparison with the fallow land plot.

Table1. Average values of the measured parameters of the soil and environment

Crops	Sun-flower	Sun-flower	Sun-flower	Corn	Corn	Corn	Sun-flower	Corn	Fallow
Soil	cherno-zem	cherno-zem	cherno-zem	cherno-zem	cherno-zem	cherno-zem	luvisols	luvisols	cherno-zem
Sampling plots→ ↓variables	**SP1**	**SP2**	**SP3**	**SP4**	**SP5**	**SP6**	**SP7**	**SP8**	**SP9**
Nitrate N	22.98	23.37	23.77	10.02	8.07	9.51	26.83	20.39	29.10
Nitrite N	6.48	5.75	5.97	0.98	0.00	0.45	8.52	5.35	11.33
pH	7.50	7.52	7.45	7.21	7.23	7.14	6.34	6.17	8.08
Humidity of soil	48.25	48.25	48.25	48.25	48.25	48.25	39.50	35.75	56.38
t (°C) of soil	24.25	24.25	24.25	24.25	24.25	24.25	24.00	24.00	24.00
Humidity of air	60.88	60.88	60.88	60.88	60.88	60.88	56.50	56.50	56.50
t (°C) of air	30.38	30.38	30.38	30.38	30.38	30.38	32.50	32.50	32.50

The table with t-test results for the presence of nitrate nitrogen is shown below:

It can be seen that the values of the calculated t-numbers are much bigger than the critical values, and the level of significance in all cases is lower than 1×10^{-4}.

Table 2. Amount of Nitrate N in sampling plots depending on soil utilisation

t-Test: Two-Sample Assuming Equal Variances:

	№1	*№2*	*№3*	*№4*	*№5*	*№6*	*№7*	*№8*	*№9*
Mean	22.9775	23.3675	23.77	10.0225	8.065	9.505	26.825	20.39	29.1
Variance	1.03016	0.19449	0.12127	0.50082	0.6417	0.65343	0.15583	0.0284	0.03333
Observations	4	4	4	4	4	4	4	4	4
Pooled Variance	0.53175	0.11391	0.0773	0.26708	0.33752	0.34338	0.09458	0.03087	
Hypothesized Mean Difference	0	0	0	0	0	0	0	0	
df	6	6	6	6	6	6	6	6	
t Stat	11.8739	24.02	27.1114	52.2055	51.2047	47.2901	10.4614	70.1113	
P(T<=t) two-tail	2.2E-05	3.4E-07	1.7E-07	3.3E-09	3.7E-09	6E-09	4.5E-05	5.7E-10	
t Critical two-tail	2.44691	2.44691	2.44691	2.44691	2.44691	2.44691	2.44691	2.44691	

Two other statistical procedures - analysis of the main components (PCA) and cluster analysis - were conducted with an additional module of Excel Multibase 2015 (Numerical Dynamics, Japan). In the dialog box of the module Multibase 2015 the measured factors of the environment were selected (defined) as *variables*; the *samples* were the sampling plots, and for categories were chosen the three options: (1) crops, (2) types of soils, and (3) crops and soils. The results of the analyses are presented below:

The graphs below show the distances of the variables (Fig.2) and the samples (Fig.3) for PCA depending on the crops in the studies sampling plots. The role of the measured parameters can be seen clearly - the temperatures of the air and the soil, as well as the air humidity are at a longer distance from the pH and the soil moisture on the one hand, and the presence of nitrate and nitrite nitrogen, on the other.

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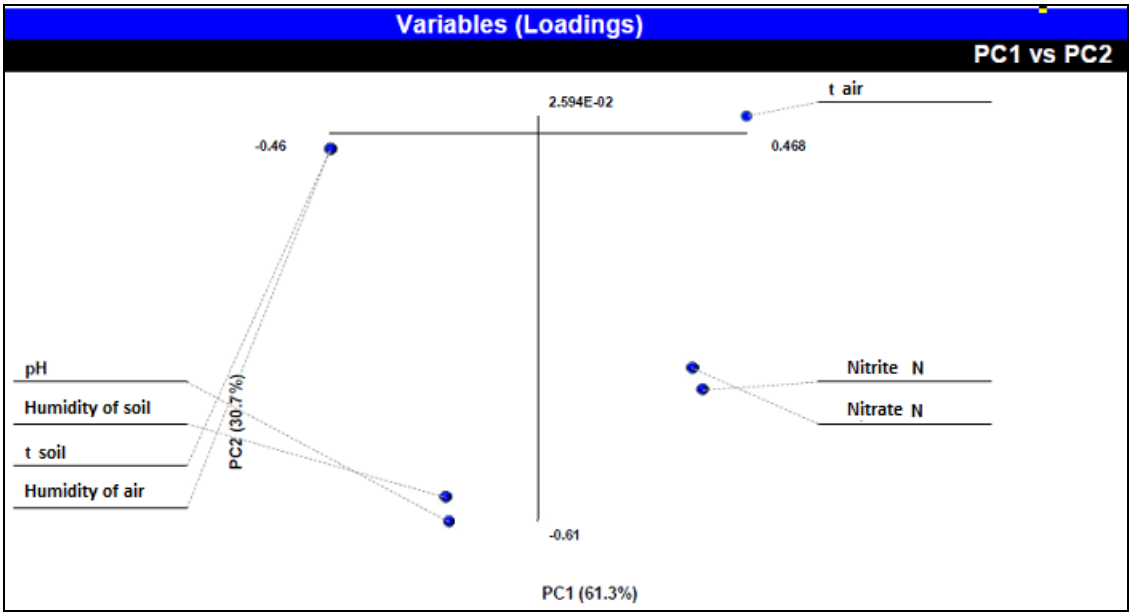

Fig. 2. Distances of the variables (pH and temperature and humidity of air and soil)

The analysis divides the studied sampling plots into three clearly distinctive groups - soil samples planted with sunflower; plots planted with corn and, at a distance from both groups - the values for the fallow sampling plot.

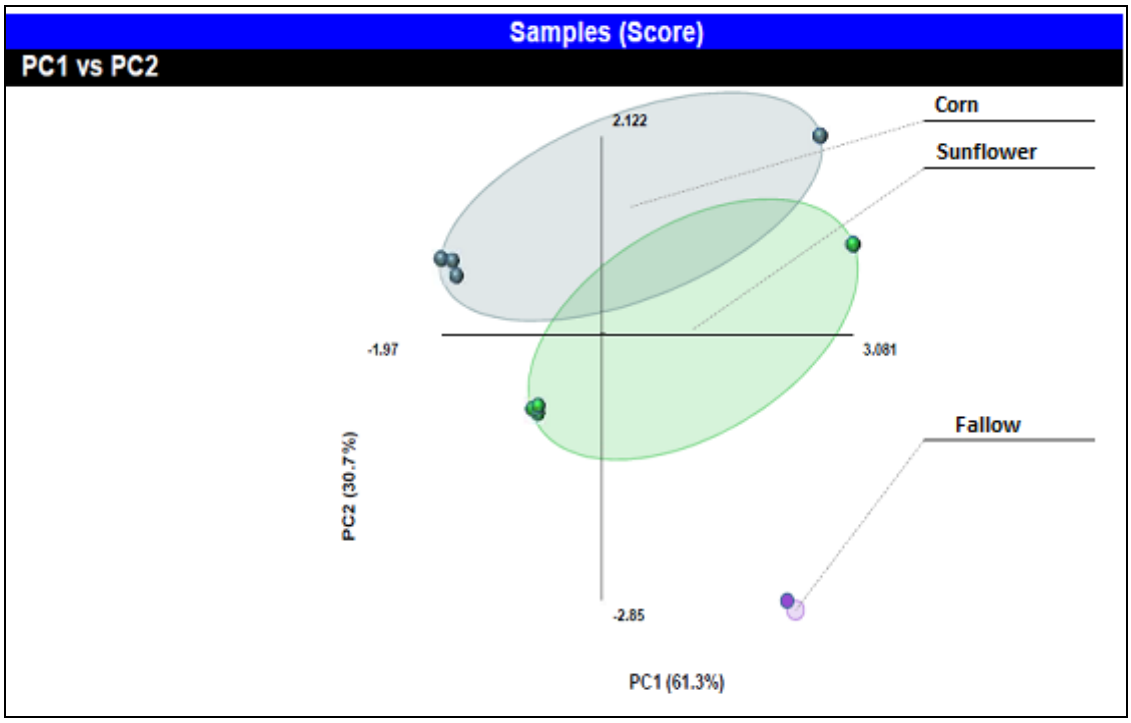

Fig. 3. PCA depending on the crops on sampling plots

Similar results from PCA for different categories of soils in the studied sampling plots are shown in Fig. 4.

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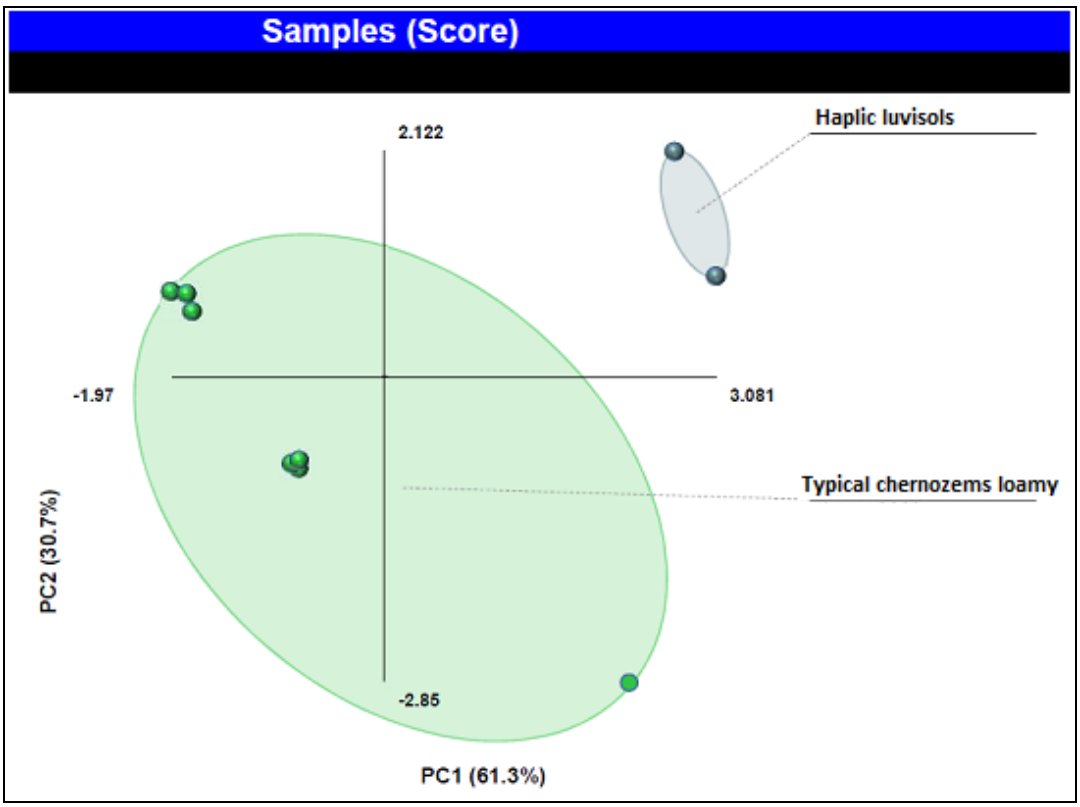

Fig. 4. PCA according to the soils in the sampling plots

The samples are divided into two groups depending on the type of soil. The plots with the same crops are grouped together according to their properties. In the top left corner in the zone of haplic chernozem are sampling plots 4, 5 and 6 planted with corn; near the middle are plots 1, 2 and 3 planted with sunflower, and at a distance on the right - the sampling plot with fallow land.

The results of the cluster analysis are presented in Fig. 5.

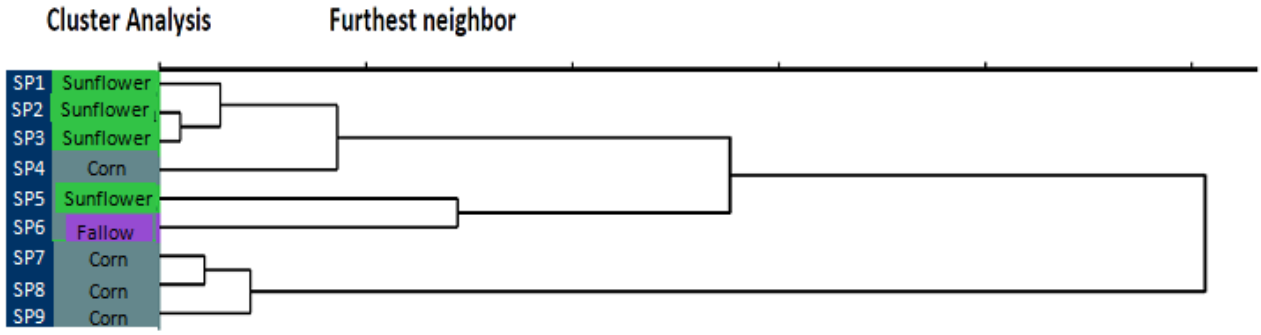

Fig. 5. Cluster analysis - grouping of the sampling plots depending on the type of soil and the way of its utilisation

Conclusions

The amount of Nitrate N in the soil depends on soil utilisation. In all sampling plots used for growing crops, which were planted with corn and sunflower, there was a significant difference in the amounts of Nitrate N as compared with the amounts in sampling plot 9 - fallow land (significance level < 0.0001).

Air temperature and humidity, and soil temperature do not have a statistically significant impact on the amount of nitrates and nitrites in the studied sampling plots. The amount of Nitrogen in the soil is statistically dependent on the pH and the moisture of the soil.

The amount of nitrates and nitrites in the soil depends on the type of the crops grown on it. Data analysis revealed three distinctive groups of soils in the plots depending on the crops - plots

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planted with sunflower, plots with corn and, at a significant distance from them - the data for the fallow land plot.

The sampling plots are divided into two clusters depending on the type of soil. The first group is comprised of all 7 plots with haplic chernozem, and plot 9 which is had a larger amount of nitrate and nitrite nitrogen in comparison to the other plots. The second group comprises the plots with grey forest soils.

In conclusion, the results show that the amount of nitrates and nitrites in the soil depends on the type, pH and moisture in the soil, as well as the soil utilisation and the crops grown on it.

References

[1] Dobrovolskiy G. V. Nikitin E. D., Conservation of soil as a building component of biosphere: functional-ecological approach. M.: Nauka, **2000**. 185 p.

[2] Terekhova V.A., Soil Bioassay: Problems and Approaches. Eurasian Soil Science, **2011**, Vol. 44, No. 2, pp. 173–179.

[3] Dobrovolskiy G. V. Nikitin E. D., Function of soil in biosphere and ecosystems. M.: Nauka, **1990**. 251 p.

[4]. Velev, S., Geography of Bulgaria. Physical and socio-economic geography, Geographical Institute of BAS. ForKom, Sofia, **2002**, 760 p.

[5] Hristov B., M. Teoharov,, Genetic-diagnostic properties of soils defined as highly eroded chernozems. Soil studies, agrochemistry and ecology, № 2, Sofia., **2008**, 37-44.

[6] Hristov B., Z. Petkova, M. Teoharov., General chemical and agrochemical characteristics of Regosoli i the hilly area of the Danube plane. Soil studies, agrochemistry and ecology № 1, Sofia, **2009**, 62-69

[7] Radojevic M., V. Bashkin, Practical Environmental Analysis, RSC, **2006**, 480 p. ISBN-10: 0854046799.

[8] Dean J., Analytical chemistry hadbook, McGraw-Hill, **1995**, 1280 p., ISBN-10: 0071410600

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