# RESEARCH REGARDING THE NITROGEN COMPOUNDS DISTRIBUTION IN A LAB-SCALE EXPERIMENTAL CATCHMENT
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# *CERCETĂRI PRIVIND DISTRIBUȚIA COMPUȘILOR AZOTULUI ÎNTR-UN BAZIN EXPERIMENTAL*

**Boncescu C.[1)], Diminescu M.A.[*1)], Vuţă L.I.[1)], Dumitran G.E.[1)], Ştefan V.[2)] [1]**
[1)] University Polytehnic Bucharest, Faculty of Power Engineering, Department of Hydraulics, Hydraulic Machinery and Environmental Engineering;
[2)] National Institute of Research - Development for Machines and Installations Designed to Agriculture and Food Industry - INMA Bucharest / Romania
*Tel: 0722581615; E-mail: mihaela.diminescu@yahoo.com*
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## ABSTRACT

*The purpose of this paper is to identify the effects of applying fertilizer on water quality in a drainage basin. A lab-scale experimental catchment was set up. Then a nitrogen-base fertilizer was applied, followed by assessment of nitrates and nitrites concentrations in soil and groundwater. The values recorded for the nitrates and nitrites are far higher than the maximum allowable values of these compounds in the drinking water. In this context, the water quality problem is quite serious, the values of nitrates and nitrites being exceeded 8.4 times and 11.5 time respectively.*

## REZUMAT

*Scopul acestei lucrări este de a identifica efectele aplicării îngrășămintelor asupra calității apei într-un bazin hidrografic. A fost creată o instalație experimentală la scară de laborator. Apoi a fost aplicat succesiv un îngrășământ bazat pe azot, urmat de evaluarea concentrațiilor de nitrați și nitriți în sol și apa subterană. Valorile înregistrate pentru nitrați și nitriți sunt mult mai mari decât valorile maxime ale acestor compuși în apa potabilă. În acest context, problema calității apei este destul de serioasă, valorile nitraților și nitriților fiind depășite de 8,4 ori, respectiv 11,5 ori.*

## INTRODUCTION

The drainage water quality is strongly related to the geology of the soil, which, by weathering processes, determines the soluble constituents found in the irrigated area. Of the water added to the soil, either in the form of rainfall or irrigation, part is lost through runoff and direct evaporation at the soil surface. The other part permeates into the soil, filling up the soil pores and restoring the soil moisture content up to field capacity under free drainage. The stored water is now available for plant root extraction to satisfy the water requirement of the crop.

Degradation of ground water and surface water quality means accumulation of high contents, over the allowable values, of sediment and chemicals that can affect the living environment of different bodies.

Poor farming methods can increase the concentrations of nutrients, bacteria and sediment. High levels of nutrients can lead to eutrophication of water bodies, which ultimately affects aquatic ecosystems. The main nutrients that cause eutrophication of water bodies are nitrates and nitrites from excessive use of nitrogen fertilizers on agricultural land (*Mititelu-Ionuș et al, 2019*). Most nitrogen fertilizers are readily soluble in water, which requires implementation in stages to prevent losses by leaching (*Plaza-Bonilla et al, 2015*). Thus, nitrates are driven by water and accumulate in groundwater and surface water later. This makes water treatment more difficult and affects the development of aquatic ecosystems.

The agriculture in Romania and worldwide is largely polluting and the pollution phenomenon is well known by the specialists in environmental protection (*Reay et al, 2012*). There are numerous studies regarding the groundwater pollution due to agricultural poor practice, development of new methods for nitrogen compound determination, bioremediation of soils and so on (*Badiadka and Kenchaiah, 2009; Boukirat et al, 2017; Ni Z, 2017*).

[1] *Boncescu C., Lecturer Ph.D.Eng; Diminescu M.A., Lecturer Ph.D.Eng; Vuţă L.I., Assoc.Prof. Ph.D. Eng.; Dumitran G.E., Assoc.Prof. Ph.D. Eng.; Ştefan V., Ph.D.Stud.Eng.*

Also, recent studies, which refers to the contribution of different factors in increasing agricultural production, shows that over 30% of the crops growth is due to fertilizers followed by seeds selection and crop rotation (*Li et al, 2018; Yousaf et al, 2017*).

## MATERIALS AND METHODS

The current study evaluates the impact of fertilizers on groundwater quality. For carrying out the experimental part, a catchment basin was built, with the following features: length *L* = 60 cm, width *l* = 36.5 cm, surface *S* = 2190 cm$^2$ and the soil slope *J* = 0.05 (Fig.1).


**Fig. 1 - Experimental catchment basin**

The objective was to determine the concentrations of nitrate and nitrite in the runoff water and in the groundwater as well (*Marinov et al, 2009*), as a result of the use of a nitrogen base liquid fertilizer on the basin. The following parameters were assessed: the runoff coefficient, the time of concentration and the infiltration rate.

In the upstream area of the basin rains have been simulated, on a surface of 365 cm$^2$, over 4 weeks, on bare soil (weeks 1, 2 and 3) and on soil with vegetation (week 4) (allium, parsley and radishes).

**Fig. 2 - Experimental catchment basin in week 4**

The following factors have been measured: the volume of rainwater, the rain intensity and duration, the travel time of water through the soil from upstream to downstream area, the volume of drained water and the infiltration time of water.

The runoff coefficient, $c$, was determined with relation 1.

The volume of the water drained, at the end of each week, $h_Q$, was measured, and was related to the weekly volume of the rain water, $h_p$.

$$c = \frac{h_Q}{h_p} < 1 \quad (1)$$

The time of concentration shows the travel time needed by water to flow from the most faraway point of the watershed to the outlet section. It was determined by using the equation 2, for two of the raining days. Thus, for a water speed in steady-state regime of $10^{-4}$ cm/s, the time of concentration, $t_v$, is:

$$t_V = \frac{7}{5}\left[\frac{(n*l)^3}{(\alpha*i)^2(\sqrt{J})^3}\right] \text{ [s]} \tag{2}$$

with *n* is the Manning coefficient (n=0.017 s/m1/3 for soils without vegetation), *l* the length travelled by the particle, in meters, *i* the intensity of the precipitation, in m/s, *J* the soil slope, and α:

$$\alpha = \frac{i-0.0001}{i}. \tag{3}$$

The height of uniform distributed rain, $h_{rain}$, is given by:

$$h_{rain} = \frac{V_{rain}}{S} \text{ [cm]} \tag{4}$$

where:

$v_{rain}$ is the amount of water rained, in $cm^3$, and *S* is the soil surface, in $cm^2$.

Rain intensity is:

$$i = \frac{h_{rain}*10^{-2}}{t_{rain}} \text{ [m/s]} \tag{5}$$

where:

$t_{rain}$ is the rain duration, in seconds.

The infiltration rate has been calculated as follows:

$$u(t) = \frac{1}{2} * w * t^{-1/2} + \frac{k}{0.5} \tag{6}$$

where: *u* is the infiltration speed, in cm/min,

*k* is the hydraulic conductivity of the soil, in cm/min,

*w* represents the water absorption capacity of the soil, in cm/min, depending on the initial soil moisture, in cm, and varies between 0.005…0.16 (*Marinov et al, 2009*).

The value of the absorption capacity of the soil is *w*=0.10 [cm/min] and the hydraulic conductivity of the soil has been calculated as being the ratio between the infiltration time and the rain height:

$$k = \frac{h_{rain}}{t_{inf}} \text{ [cm/min]} \tag{7}$$

with $t_{inf}$ the infiltration time, in minutes.

During the 4 weeks of the experiment, a liquid fertilizer was used. According to the instructions, a solution with a nitrates concentration of 180 mg/L $NO_3^-$ and a nitrites concentration of 0.025 mg/L $NO_2^-$ was obtained. Soil fertilization was performed two times, at 7 days distance between: the first fertilization used 3000 mL and the second one 1000 mL.

For the assessment of nitrate concentration in the soil, 20 g of soil were weighed and then 100 mL of distilled water was added. The resulting mixture was homogenized, filtered and analysed with *AQUANAL – plus* spectrophotometer at a wavelength of 480nm (*Marinov et al, 2009*).

Analyses were performed as follows: *a)* before applying fertilizer; *b)* after the first application of the fertilizer; *c)* simulating a rain the next day after the fertilization, followed by analysing of the probes the following day; *d)* a day after applying the second fertilization.

## RESULTS

Table 1 presents the results obtained for the runoff coefficient.

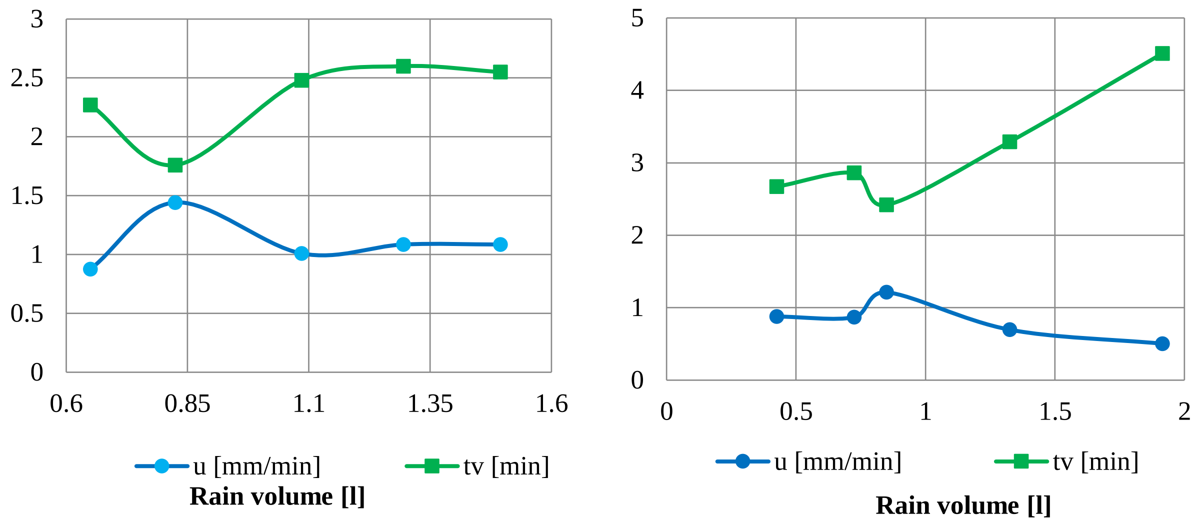
**Table 1**

**Values of the runoff coefficient, c**

| | Volume of the rain | Volume of drained water | Runoff coefficient, c |
|---|---|---|---|
| | [L] | [L] | [-] |
| First week | 8.24 | 1.66 | 0.201 |
| Second week | 1.915 | 0.414 | 0.216 |
| Third week | 2.3 | 0.509 | 0.221 |
| Fourth week | 1.36 | 0.301 | 0.221 |

The values presented in the literature for the runoff coefficient vary between 0.2 and 0.8 (*Marinov A.M.et al, 2009; Dumitrache and Diacu, 2010)*. For the last two weeks of the experiments the values obtained are equal; thus, it can be considered that the soil reached the equilibrium and the runoff coefficient value is c=0.221, framing the soil in the agricultural category.

The time of concentration and the infiltration rate are closely related. Figure 3a and 3b show their variation over time, for the two days of measurements. It can be noticed that the time of concentration and the infiltration rate are inversely related. Thus, when the soil reaches the saturation, the infiltration rate decreases and the time of concentration raises the water drop being dragged down by the soil water content.



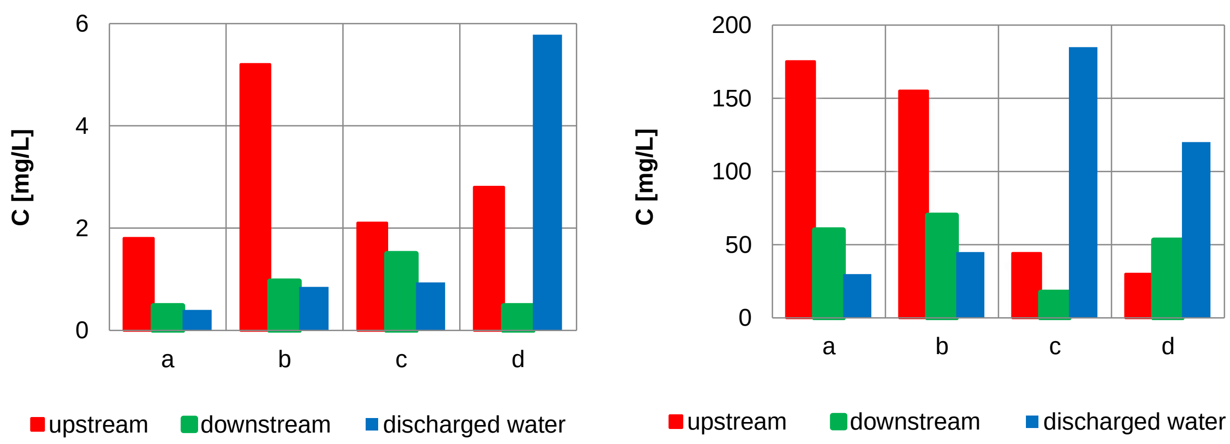

*a)* *b)*

**Fig. 3 - Variation of the time of concentration and infiltration rate, depending on soil moisture in the second day A) and in the third day B)**

Figures 4a and 4b present the values of nitrates and nitrites concentration over the catchment basin in time. According to the figures, it can be noticed that, after the fertilization process, the nitrates concentration in the upstream area is decreasing while in the downstream area is increasing.

For the nitrites concentration, both areas are characterized by increasing values. The nitrates concentration decrease is due to water movement and to their conversion to nitrites.

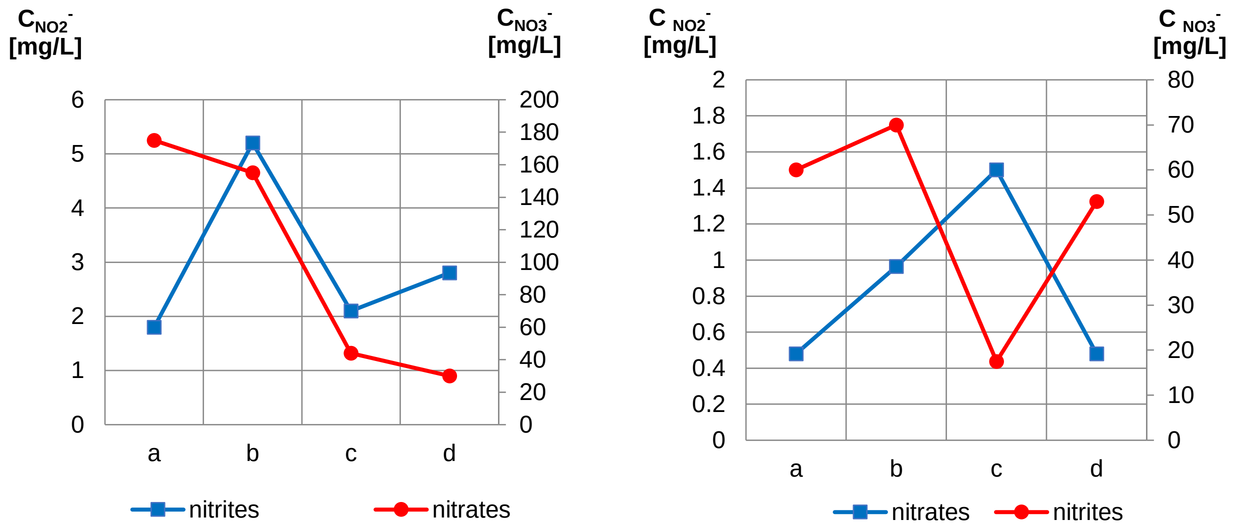
After the rain, a large concentration of nitrates is recorded in the discharged water simultaneously with a decreasing concentration into the soil, due to their washing. Further on, the concentration decreases since the nitrates are converted to nitrites.




*a)* *b)*

**Fig. 4 - Nitrates a) and nitrites b) concentration over the catchment basin**

In figure 4 and figure 5 the changes of water quality can be noticed. By using a fertilizer with C=100 mg $NO_3^-$ /L nitrates concentration and C=0.025 mg $NO_2^-$ /L nitrites concentration, the water became polluted: the nitrates concentration increases up to C=120 mg $NO_3^-$ /L and the nitrites concentration reaches up to C=5.78mg$NO_2^-$/L.




*a)* *b)*

**Fig. 5 - Values of nitrates and nitrites concentration in the upstream *a)* and in the downstream area *b)***

## CONCLUSIONS

The purpose of this study was to determine the effect of fertilizers on the groundwater quality. Thus, the nitrates and nitrites values were measured, in soil and in discharged water. In order to establish the soil type, the runoff coefficient, the time of concentration and the infiltration rate have been calculated.

In order to identify the effects on groundwater quality, a vegetable fertilizer was used and applied according to the instruction. After two applications of the fertilizer, at 7 days distance between, high amounts of nitrates and nitrites were found: C=120 mg/L $NO_3^-$ and C=5.78 mg/L $NO_2^-$. For a runoff coefficient of 0.221, a medium infiltration rate of 1 mm/min and a medium time of concentration of 2.7 min, the following values were registered in the discharged water:

- an increase in nitrates concentration 4 times greater than the initial situation and 2.4 times greater than the maximum admissible concentration;
- an increase in nitrites concentration 14 times greater than the initial situation and 11 times greater than the maximum admissible concentration.

If the discharged area would be used as drinking water source, it would be polluted and unsuitable. The water quality falls within the lower class, being slightly alkaline with a pH of 7.82.

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