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THE CHEMICAL CHARACTERISTICS OF SETTLEABLE PARTICLES FROM THE AIR AND THEIR INFLUENCE ON THE SOIL

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Abstract: This study investigates the chemical characteristics of settleable particles from the air, with a diameter greater than 10 μm, which are deposited on the ground under the action of gravity. Particles can settle on any surface and, in time, influence the quality of the soil and crops. Considering that they are part of the soil, it is interesting to study them from an agrochemical point of view. Therefore, by determining the content of organic matter can be appreciated the fertility of the soil, the pH is an important characteristic since plants develop properly in neutral soils, and the insufficiency of phosphorus nutrition negatively influences all processes of plant growth and development. The aim of this paper was to determine the pH, the humus reserve and the phosphorus content in the settleable particles in the Hunedoara area. The collection points were: Răcăștie, Peştişu Mare, street Tudor Vladimirescu and street Revoluției. In order to have a more complete assessment, these determinations were also carried out on a sample of the soil from the same area such as Răcăștie. The particles samples were collected between 2018 and 2022 and the soil one in 2022. The sedimentary particles chemically analysed in this work were collected in accordance with the STAS 10195–75 recommendations.
Keywords: settleable particles, pH, humus reserve, phosphorus

INTRODUCTION

The deposited dust from the air, as a result of natural and artificial sources can travel far away from their source [1], and deposit over to any available surface. The diameter of this sedimentary particles is greater than 10μm [2]. Their settlement on the ground alter the quality of the soil, crops and life in general. For example, according to Jickells et al., iron–containing dust particles transported into the oceans through the atmosphere influence ocean's biogeochemistry and climate [3] and according to Mahowald et al. the desert dust transported on long distances is the major sources of phosphorus and iron in the atmosphere [4].

The purpose of this article was to determine the quality of this particles, from an agrochemical point of view therefore the pH, the humus reserve and the phosphorus content were determined as they influence the properties of the soil in terms of agricultural characteristics. For instance, the pH determines the mobility and accessibility of nutrients into the soil, hence the importance from the point of view of plant nutrition [5,6]. Humus reserve is also very important for the plant's nutrition process [7] as the soil fertility is closely related to the quantity and quality of humus [8]. The insufficiency of phosphorus nutrition negatively influences all processes related to the plant's growth and development [5]. Following Grant C. studies, there has been determined that, in many plant species the phosphorus supply at the beginning of the season is crucial for the optimal yield of the crop whereas a low amount of this element during early stage of the plant growth will limit crop production [9].

MATERIALS AND METHODS

The sedimentary particles chemically analyzed in this work were collected [10] in accordance with the STAS 10195–75 recommendations. The data on the collecting points and periods, respectively on the total amount of gathered particles, is presented in Table 1 and the containers with the samples are shown in Figure 1.

Table 1. Data on settleable particles collected from the air

Sample number	Collecting points	The collecting period	Total amount of settleable particles collected, g
Sample 1	Răcăștie; Peştişu Mare; Tudor Vladimirescu and Revoluției Street from Hunedoara	February to June 2018	5.72
Sample 2	Răcăștie; Peştişu Mare; Tudor Vladimirescu and Revoluției Street from Hunedoara	February to May 2019	3.58
Sample 3	Răcăștie; Peştişu Mare	April to May 2022	1.34

Sample 1 Sample 2 Sample 3

Figure 1. The containers with the samples

Figure 2. Finely crushed and homogenized sample

The homogenized and finely crushed samples (Figure 2) were chemically analyzed to determine the pH, humus and phosphorus level (samples 1 & 2) and only humus (sample 3) as the amount of dust collected was too little. For further comparison, there was used a forth soil sample taken from the same area in 2022 and subjected to the same testing as samples 1 & 2.

— The pH determination

The soil's pH is a characteristic easily determined yet it is an important parameter in assessing its fertility [5]. Considering that these particles once deposited on the soil will become part of it, by determining the pH, they were included in one of the soil reaction classes established by Florea et al. (1987) with modifications.

For the studied samples, the pH was potentiometric determined in aqueous solution with a glass electrode pH–meter. The *soil: water* ratio used was *1:2.5*. The pH measurements were done two hours after the preparation of the suspension, during which time the suspension was intermittently stirred [5]. Table 2 presents the resulted pH for the analyzed samples.

Table 2. The pH of the analyzed samples

	Sample 1	Sample 2	Sample 4
pH	8.14	9.40	7.75
Working temperature, °C	21.7	21.8	21.8

— The humus determination

The humus was determined titrimetrically using the Walkley and Black method [8] as modified by Gogoaşă. Each sample in a quantity of 0.2 g was passed through a fine sieve and put in a flat–bottomed flask. Then reagent 1 (potassium dichromate) and reagent 2 (concentrated sulfuric acid) were added, after which the samples was heated to 98°C for 30 minutes. After cooling was added distilled water and 2–3 drops of diphenylamine. The titration was done with Mohr's salt (0.2n) (Figure 3 a,b) [8].

a) b)

Figure 3. The control sample (a) and samples 1 & 2 (b) after titration with Mohr's salt

The humus content was determined with the relationship [8]:

$$\text{Humus (\%)} = \frac{(a-b)\cdot 0{,}0010362\cdot 1{,}16\cdot 100}{m}$$

where:

m – represents the amount of soil taken in the analysis (g);

a – represents the amount of Mohr's salt 0.2 n used for the titration of the control sample (the equivalent of potassium dichromate introduced in the sample to be analyzed) (ml);

b – represents the amount of Mohr's salt used to titrate excess potassium dichromate from the analyzed sample (ml);

0.0010362 – represents the content of humus that is oxidized by 1 ml of potassium dichromate solution 0.2 n (g);

1.16=100/86 – represents the correction factor in relation to the percentage of carbon recovery;

100 – represents the factor for percentage reporting.

Table 3 indicate the results obtained in regard to the humus content for samples 1, 2 & 4.

Table 3. Humus content

	Sample 1	Sample 2	Sample 4
Humus, %	Organo–mineral material with very high humus content	5.59	3.9

The total quantity of humus in the soil can be established by *direct* or *indirect* methods. One of the direct methods consists in measuring the weight loss by slow calcination in the presence of air [8] thus the organic matter from sample 3 (where the humus content could not be determined titrimetrically) was calculated by measuring the weight loss by slow calcination in the presence of air at 600º C. The organic matter content of sample 3 after calcination (Figure 4) was 29%.

Figure 4. Sample 3 after calcination

— Phosphorus determination

The mobile phosphorus was determined using Egner – Riehm method [8]. Each sample was subjected to the following steps: extraction (I), filtration (II) and dosing (III). The extraction has been carried out by passing the samples through a 2mm sieve and then inserted in plastic bottles with lactate ammonium acetate working solution. The bottles were then placed in a mechanical shaker which rotated continuously at a speed of 30–35 spins/minute for one and a half hour, at a maximum temperature of 20°C. After the extraction time, the solution was strained through a phosphorus (P), potassium (K) and nitrogen (N) free paper filter. From the aqueous extract 5 ml was taken and diluted with distilled water, then was added Reagent 1 (reducing mixture containing hydrochloric acid, stannous chloride and ascorbic acid) and then Reagent 2 (ammonium molybdate). The reading of the results was done with a UV–VIS spectrophotometer, at a wavelength λ=715nm (Figure 5) and the resulting values of phosphorus content for samples 1, 2 & 4 are shown Table 4.

Figure 5. Reading the results with the UV–V

Table 4. Phosphorus content

	Sample 1	Sample 2	Sample 4
Phosphorus	280 ppm	250 ppm	260 ppm

RESULTS AND DISCUSSION

— pH

As specified in the specialized literature, most cultivated plants grow well on neutral soils that have a pH in the range of 6.8 – 7.2 or slightly acidic (pH = 6.3 – 6.8), but they cannot support a pH below 4.5 or above 8.3 [5].

Figure 6 shows the pH of samples 1, 2 and 4 collected in 2018, 2019 and respectively 2022, in the Hunedoara area.

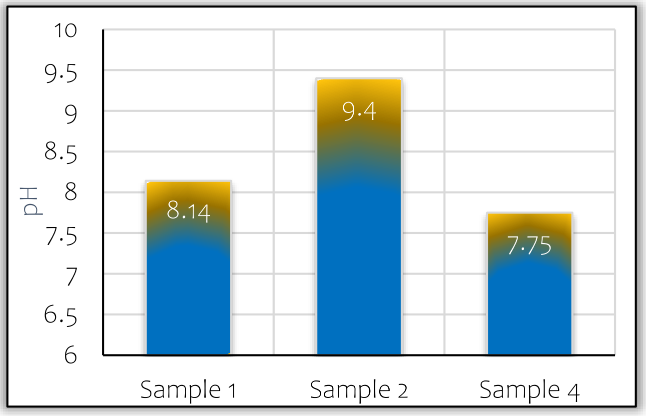

Figure 6. The pH of the analyzed samples

Analyzing the graphic (Figure 6) and taking into consideration the fact that most crops cannot support a pH above 8.3, it can be concluded that neither sample 1 nor sample 2 favors the soil in terms of pH. Even sample 4 (soil from the Hunedoara area) has a pH = 7.75 which exceeds the maximum recommended value of 7.2 suitable for an agricultural soil. Regarding the soil reaction class according to Florea et al. [5], we note that sample 1 is *weakly alkaline*, sample 2 – *strongly alkaline*, and sample 4 – *weakly alkaline*.

— Humus reserve

The humus reserve contained in sample 2 and sample 4 are shown in Figure 7. Sample 1 had an inconclusive result due to its darker tinge and the color shift from blue to green could not be perceived. However taking into account that the sample contains a rather large amount of phosphorus which is the main component of humus [5], it is accurate to conclude that sample 1 is rich in humus. For sample 3 subjected to slow calcination at 600°C, an organic matter content of 29% was obtained, so this sample also contains humus.

Considering the fact that sample 4 has a lower humus content than sample 2, a first hypothesis could be that the dust in the air contains humus and ultimately it enriches the soil.

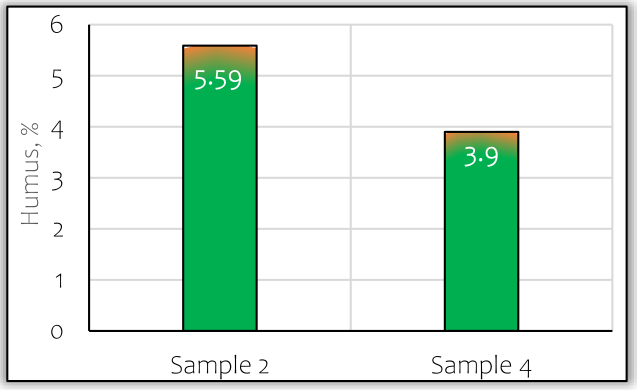

Figure 7. Humus reserve in samples 2 and 4

Regarding the evaluation of the soil according to the humus content (according to Cernescu and Florea) it can be observed that sample 1 and 2 can be included in the category of soils with a *very high content of humus*, since the reserve of humus in sample 1 is very high, and in sample 2 the resulted value is 5.59%. Also, sample 4 with a humus content of 3.9% is considered a soil with a *moderately content of humus*.

— Phosphorus

The processed samples (Figure 8) have a phosphorus content higher than 72ppm and thus are included in the class of very high mobile P content (extractable in acetate – lactate). Consequently the phosphorus reserve of the analyzed samples is very impressive.

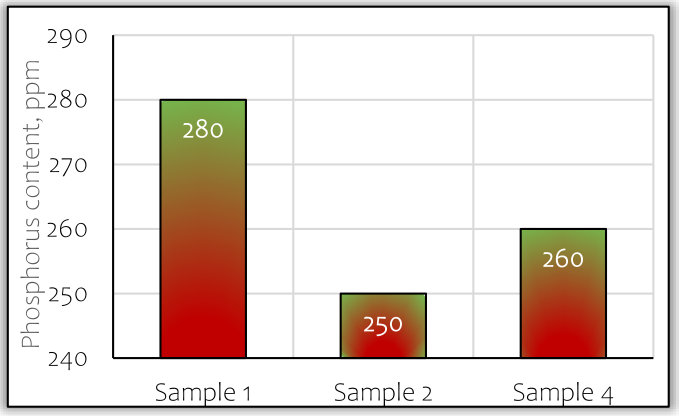

Figure 8. Phosphorus content in the analyzed samples

Given the conventional character of these determinations, the so–called limit values within which the plants react well, appropriately or not at all are valid only in the soil conditions of the country where the respective method was developed. According to Pietras, in his study on the origin of dust particles in the atmospheric air of Krakow (2016–2018) there were identified 20 chemical elements of which the most common was carbon (87.31%), but phosphorus was also identified among the other elements [11].

CONCLUSIONS

After analyzing the results of the determinations, the following can be concluded:

- From an agrochemical point of view, it seems that sample 1 & 2 do not positively influence the soil as the pH has values of 8.14 and 9.40 and crops grow well in soils with a pH of up to 7.2. Even the soil sample with a pH of 7.75 exceeds the specified suitable value;
- The amount of humus of 5.59% contained in the dust deposited on the soil in 2019 is much higher than that resulted from the soil sample. It seems that this would be due to higher pollen content in the atmosphere, considering that the collection of the powders was done in the spring;
- The phosphorus supply of the analyzed samples is very good.

In conclusion, we can assume that although the settleable particles in the air enrich the soil once deposited because of their high content of humus and phosphorus, they also do not favor it from an agrochemical point of view because of their high alkaline pH.

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