AGRICULTURAL UNIVERSITY OF ATHENS

LABORATORY OF SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

VOTANIKOS, 11855, ATHENS, GREECE

FINAL REPORT

Geomchemical behavior of macronutrients in various soil types amended with perlite. Column experiments

Final Report

In Athens, October 3, 2023, the following contracting parties:

1. The company under the trade name "Perlite Institute", with Tax Registration Number (EIN) 131914131 and headquarters at 2207 Forest Hills Drive, Harrisburg, Pennsylvania, that is lawfully represented for the purpose of signing the contract by Denise Calabrese acting in the capacity as Executive Director, hereinafter referred to as the "Association".
2. The RESEARCH COMMITTEE-Agricultural University of Athens, with Tax Registration Number (VAT) 090042767, of the ST Athens Tax Service and positioned in Athens 75, Iera Odos, 118 55, Votanicos, that is lawfully represented for the purpose of signing the contract by Deputy Rector of Economic Planning, Research and Development, Professor Thomas Bartzanas, hereinafter referred to as the "Contractor".
3. Professor Ioannis Massas, hereinafter referred to as the "Scientific Coordinator" of the present work.

Having taken into consideration:

a) The provisions of Law 4957/2022- Government Gazette 141/ A / 21.7.2022,
b) Perlite Institute's Board of Directors approval of the 2023 budget and research grant on December 14, 2022, based upon which the Perlite Institute has assigned to the Contractor the work summarized below.

Introduction

In continuation of the research project "INCORPORATION OF PERLITE IN SANDY SOIL AS A MEASURE TO REDUCE IRRIGATIONN WATER NEEDS OF TURF GRASS AND BOUGAINVILLE", which was carried out in the framework of the cooperation between the Agricultural University of Athens and the Perlite Institute, the research team of the A.U.A. University performed a further study on the effect of fine perlite on nutrients' retention in the rhizosphere soil environment. The aim of this study was to examine, through column leaching experiment, the hypothesis of reduced nitrogen, potassium and phosphorus leaching from soils with different physicochemical properties in the presence of fine perlite.

Experimental Design

For this purpose, a column leaching experiment was conducted using four different soils with a unique set of physicochemical characteristics and by applying a commercial fertilizer N-P-K formulation (20-20-20), to achieve the addition of macronutrients in the soils. It is noteworthy that nitrogen was added in the form of nitrate in the present experiment. Each column had a height of 25 cm to approximate a surface soil horizon and contained 100 g of soil (Fig.1). The addition of perlite to the soil columns was carried out at a rate of 20% v/v. The treatments were: T1: soil without perlite (Control), T2: soil with perlite in layers, T3: soil with perlite in mix. A supplementary batch experiment was also carried out to examine the absorptive properties of fine perlite regarding nutrient addition in the form of N-P-K fertilizer (stock solution).

Material and Methods

Column experiment

For the column leaching experiment, four topsoil samples with various physicochemical properties were chosen based on their pH. Half of the selected soils were acidic and the other

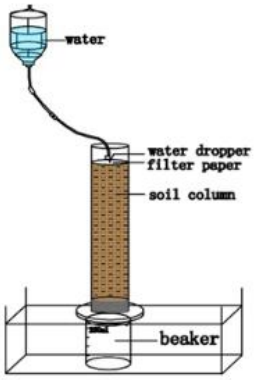

Fig. 1. Scheme of the experimental setup used in the column leaching study.

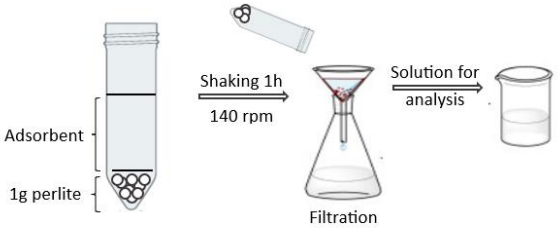

Fig. 2. Scheme of the experimental setup used in the batch experiment.

alkaline. The soils were analyzed for their pH and electrical conductivity (EC) values, the organic matter content and the grain size distribution (soil texture) following well accepted protocols (Soil Survey Laboratory Methods Manual 2004. Rebecca Burt, Editor. Soil Survey Investigations Report No. 42 Version 4.0.). The addition of macronutrients in the columns was achieved by fertigation using a commercial fertilizer (N-P-K) 20-20-20 formulation. The application was completed in 2 doses, in particular 100 ml in total were added. Then, the concentrations of macronutrients were determined in the collected leachate.

Batch Experiment

For the batch experiment one gram of fine perlite was weighed into a series of 50 mL falcon tubes and 25 ml of solution containing the appropriate N-P-K concentrations were added. The bottles were gently shaken at 140 rpm for 1h in a reciprocal shaker. Then the falcon tubes were centrifuged for 5 min at 2200 rpm (Fig.2). The supernatants were finally filtered through a Whatman paper No 42, collected, and then analyzed for N, P and K concentrations.

Results

The properties of the four soils are summarized in Table 1. The two soils (S1, S2) are acidic and the other (S3, S4) alkaline. Regarding soil texture, S1 is a Sandy-Clay, S2 and S3 are Sandy-Loam and S4 is Loam. The maximum EC value was recorded for S3 soil, while EC of the other three soils is considered as similar. Organic matter content showed high variability and ranged from 0,98 (S1) to 5,3% (S3).

Table 1. Physicochemical properties of the examined soils.

Soil	pH	E.C (μS/cm)	Texture	Sand (%)	Silt (%)	Clay (%)	Organic matter (%)
S1	4,63	720	Sandy Clay	45,2	14	40,8	0,98
S2	5,41	590	Sandy Loam	53	28	19	1,11
S3	7,23	1685	SandyLoam	58	24	18	5,3
S4	7,43	650	Loam	41	34	25	1,02

The concentration (C*f*) and mass (m) of nitrogen, phosphorus and potassium released from the soils are presented in Tables 2.1, 2.2 and 2.3. Mass refers to the volume of leachate in each case and was calculated as leachate concentration times leachate volume.

Table 2.1. Concentration of N in the leachate and total mass of the element passed through the column.

N					
Treatment		S1	S2	S3	S4
Control	C*f* (mg L^{-1})	261,781	357,115	450,428	280,832
	m (mg)	11,780	15,356	15,765	14,603
Soil+Perlite Layers	C*f* (mg L^{-1})	265,358	322,512	380,832	275,389
	m (mg)	9,544	15,786	6,474	13,082
Soil+Perlite Mix	C*f* (mg L^{-1})	263,802	340,008	469,090	269,246
	m (mg)	11,344	13,260	10,320	13,193

* Nitrogen initial concentration Ci(N)= 200 mg L-1, mass nitrogen m(N)= 20 mg

* Nitrate initial concentration Ci(NO3)= 57 mg L-1, mass nitrate m(NO3)=5.7 mg

Table 2.2. Concentration of P in the leachate and total mass of the element passed through the column.

P					
Treatment		S1	S2	S3	S4
Control	C*f* (mg L^{-1})	4,432	21,170	10,860	24,116
	m (mg)	0,199	0,953	0,488	1,085
Soil+Perlite Layers	C*f* (mg L^{-1})	14,542	12,667	38,846	42,059
	m (mg)	0,524	0,621	0,660	1,977
Soil+Perlite Mix	C*f* (mg L^{-1})	7,512	31,883	14,341	30,410
	m (mg)	0,338	1,435	0,645	1,368

*Phosphorus initial concentration Ci(P)= 87.2 mg L-1, mass phosphorus m(P)=8.72 mg

Table 2.3. Concentration of K in the leachate and total mass of the element passed through the column.

K					
Treatment		S1	S2	S3	S4
Control	C*f* (mg L^{-1})	20,90	44,80	105,00	62,00
	m (mg)	0,941	1,926	3,675	3,224
Soil+Perlite Layers	C*f* (mg L^{-1})	32,25	75,00	86,50	82,00
	m (mg)	1,163	3,678	1,471	3,898
Soil+Perlite Mix	C*f* (mg L^{-1})	26,70	58,00	121,00	76,00
	m (mg)	1,148	2,262	2,662	3,724

*Potassium initial concentration Ci(K)= 166 mg L-1, mass potassium m(K)=16,6 mg

Beyond the contract derived commitments, batch adsorption experiments were carried out to further study the adsorption of nutrients on fine perlite. The results are indicative since further experiments are needed to verify the outcome of this batch adsorption study.

The following diagram (Fig.3) depicts the results of batch experiment and shows perlite's capacity of nutrient adsorption.

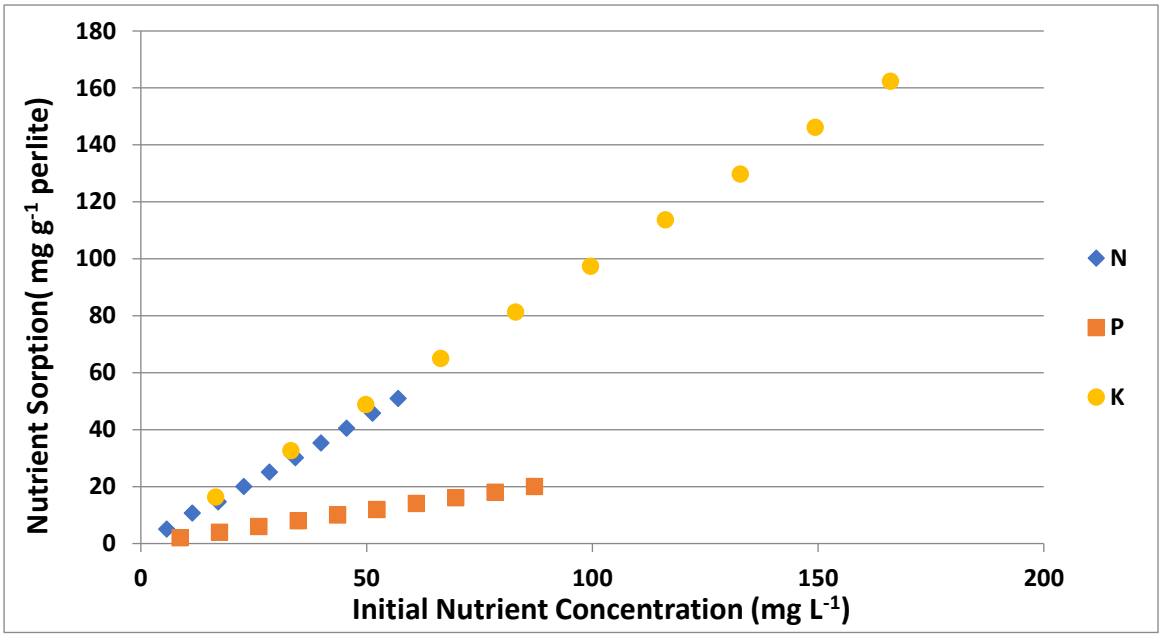

Figure 3. Sorption of macronutrients in batch experiment with fine perlite.

Conclusions of present study

In summary, this collaborative research effort between the "Perlite Institute" and the Agricultural University of Athens has provided valuable insights into the utilization of fine perlite as a soil amendment for nutrient retention and irrigation efficiency. The key findings can be summarized as follows:

• Perlite demonstrated remarkable nutrient adsorption capacity, exceeding ion exchange expectations and suggesting the involvement of physisorption mechanisms.

• The presence of perlite significantly affected leaching rates and nutrient mobility within the soil, underscoring the necessity for site-specific optimization.

• Soil characteristics played a pivotal role in determining the effectiveness of perlite, emphasizing the importance of customized approaches.

These conclusions collectively enhance our understanding of sustainable nutrient and water management practices in agriculture.