

An influence of soil water sampler substance on chemical composition of porous moisture

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Abstract

Steel-teflone and quartz-teflone samplers are most popular nowadays, recommended by their producers as the ones that do not affect the chemical composition of collected moisture. Field comparative detection examination of two mentioned types of samplers shows considerable differences between concentration of particular elements in the moisture. An experiment was held during vegetative season 2002, on loess upland, in the centre of small blind drainage. Samplers were set on the 1.5 m depth, with the horizontal span of 2 m. In the obtained moisture, concentration of 9 elements (Ca, Na, K, Si, Mn, Fe, Ti, Sn, Mg) was examined, using ICP MS method. Experiment results show differences in average concentration and variability in concentration of particular elements in the moisture.

Key words: steel-teflone and quartz-teflone samplers, chemical composition of moisture

Introduction

The actual state of environment and dynamics of its changes accompanied by a need for detailed examination of landscape components and their change over time are main points of interest of physical geography. Recently special attention was paid to the role of an aeration zone as a conductivity medium not only for water, but also for dissolved chemical substances. A popular method of examining chemical composition of water infiltrating the unsaturated zone is to use soil water samplers. These samplers allow us to collect in-situ moisture and consequently observe water quality changes depending on environment dynamics. These features contributed to a great popularity of presented method in geochemistry, hydrochemistry, hydrology and soil science.

Several types of water samplers are available nowadays, different by shape, size, technical parameters and the material the sampler cup is made of (Fig. 1). Depending on the research aim it is possible and desirable to choose sampler type that fits best the task. Usually, first comes the question of an interaction between components of the collected moisture and a material the particular parts of the sampler are build of, with most care taken about sampler cup substance (Wenzel et al 1995, Beier et al 1992, 1988). The sampler's producers bring the information about detection limits of particular elements and ions, however these limits are calculated basing on interactions observed in distilled water and not in the real-type environment possibly with non-neutral reaction.

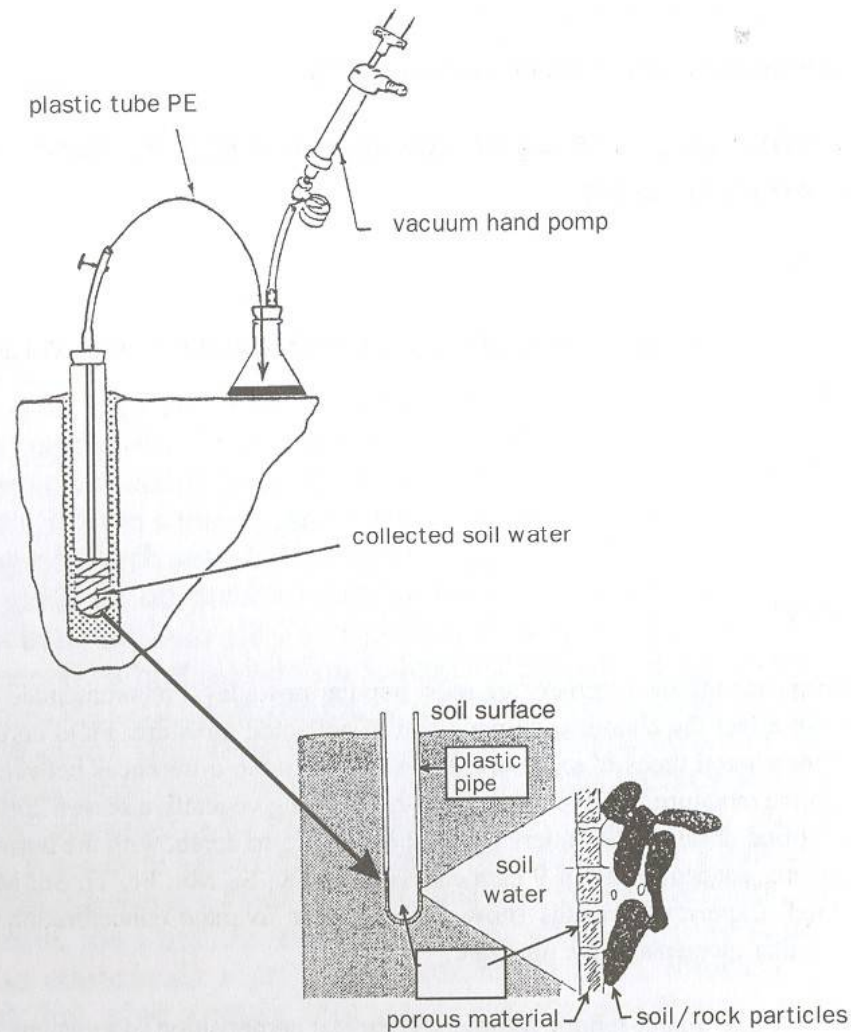


Fig. 1 Soil moisture sampler

At the end of 1990's two new types of high-quality repeated-use samplers appeared on the market. These were namely quartz-cup sampler and steel-cup sampler. Producer describes them as "perfect" (the perfect soil water sampler) – with limited self-detection, pores not bigger than 2 microns, light (59 g), not too large porous area (33 cm²), good hydraulic conductivity ($3.31 \cdot 10^{-7}$ cm/s) and water efficiency (2.1 ml/cm²/hour, that is –600 mb). The main goal of this paper is to compare chemical composition of porous water obtained from these two types of samplers working within the same lithological conditions. This research has been done on producer's commission.

Settings of an experiment

The comparative studies were held in the center of blind drainage at Sandomierska upland (Poland). Analysed basin has an area of approx. 2 km². A characteristic trait of an analysed terrain is episodic detainment of surface flow of precipitation water. This results in infiltration transformation of basin centre. Basic geochemical characteristics, qualified upon loess samples taken during installation of samplers are shown in Tab. 1.

The steel and quartz samplers were put in the middle part of a depression at depth of 1.5 m under the ground, with horizontal span of 2 meters. The porous moisture was taken once every 2 weeks and the obtained material was fixed with supra pure nitric acid at 1 : 100 rate.

Tab.1 Geochemical characteristics of the loess, data taken during installation of samplers

depth (m)	pH in KCl	pH in H ₂ O	wet (%)
0.00	4.92	6.03	27.2
0.75	4.3	5.4	25.1
1.00	4.96	5.82	33.8
1.50	3.7	5.4	21.3
2.00	4.5	5.57	20.6
2.40	5.28	6.03	19.4
2.95	5.24	6.3	19.6
3.10	5.42	6.56	16.6
3.50	4.3	5.5	16.6
3.70	5.55	6.46	18.8
3.90	5.43	6.45	20.2

Considering mineral composition of loess medium (Tab. 2), in the obtained moisture, concentration of 9 elements (Ca, Na, K, Si, Mn, Fe, Ti, Sn, Mg) was examined, using ICP MS method. Moisture reaction (pH) was also examined during water resumption from the sampler.

Tab. 2 Mineral composition of loess medium

Depth [m]		1.5
Clay minerals [%]		11.1–12.4
% in clay group	Beidelit	1.2–1.6
	Kaolinit	0.0–0.2
	Illit	7.5–11.2
Goethyt [%]		2.4
CaCO ₃ [%]		Non
The rests of mineral elements [%]		85.2–86.5

Results

In the period 9th June – 1st December, 2002, 8 quartz sampler porous moistures and 6 steel sampler porous moistures were obtained. This gives total of 6 porous moistures, used for the purpose of comparative analysis. The results of quantity analysis of research material are presented in Tab. 3.

An analysis of total and average concentration of particular elements shows considerable differences in quantities of components. One should note heterogeneous concentration of analysed substances (Tab. 3). From the point of view of comparative analysis, particular importance must be attributed to the domination of concentration of

silicone (14%) and iron (35%) in the moistures obtained by steel sampler. Considering reaction of examined media (compare Tab. 1, Tab. 3), one may attribute are related to reductive character of an environment and resulting liberation of ions Fe from steel sampler.

Let us now draw an attention to the dynamics of element's concentration. Apart from considerable differences in minimum and maximum concentration of particular elements (Tab. 3), as well as the time spot when extreme values were observed, one can note different tendencies for different elements in the moisture. As one can see in Fig. 2. regardless of the concentration level, analysed elements fall into one of the following group:

- showing concentration gain over time in both types of samplers (Ca, Mg, Si),
- showing concentration loss over time in both types of samplers (K, Ti),
- different tendencies in samplers (for quartz sampler positive tendency in concentration over time is shown by Na, while for steel sampler such a tendency is shown by Fe and Mn).

Tab. 3 Moisture composition of porous water ($\mu\text{g}/\text{dm}^3$)

Steel water sampler									
date	09.06.02	24.08.02	06.09.02	29.09.02	01.12.02	total	average	max	min
Na	17832.10	17806.55	7498.00	7222.75	7904.60	58264.00	11652.80	17832.1	7498
Mg	4803.40	5071.55	5461.10	5263.60	6369.60	26969.25	5393.85	6369.6	4803.4
K	18641.10	21308.55	17903.80	18503.45	20020.55	96377.45	19275.49	21308.55	1793.8
Ca	23849.45	27596.85	32253.65	30859.50	32713.75	147273.20	29454.64	32713.75	23849.45
Sr	72.35	89.75	93.65	91.25	96.35	443.35	88.67	96.35	72.35
Ti	3.45	3.60	3.15	2.95	2.10	15.25	3.05	3.45	2.1
Si	599.90	8253.05	7996.15	6417.20	7639.25	30905.55	6181.11	8253.05	599.9
Fe	112.30	271.55	149.30	176.40	173.15	882.70	176.54	271.55	112.3
Mn	208.40	294.80	248.10	474.80	378.30	1604.40	320.88	474.8	208.4
Quartz water sampler									
date	09.06.02	24.08.02	06.09.02	29.09.02	01.12.02	total	average	max	min
Na	4895.95	5008.55	6177.40	6563.40	6592.30	29237.60	5847.52	6592.3	4895.95
Mg	4699.50	4847.20	4328.90	4463.20	5614.35	23953.15	4790.63	5614.35	4328.9
K	19068.50	20670.65	17284.00	17991.00	15668.55	90682.70	18136.54	20670.65	17284
Ca	24298.75	24318.95	21902.40	23212.35	28758.70	122491.15	24498.23	28758.7	21902.4
Sr	83.35	77.00	64.55	70.05	86.00	380.95	76.19	86	64.55
Ti	3.90	4.00	3.45	4.10	3.30	18.75	3.75	4.1	3.3
Si	598.90	6816.60	7122.65	6718.40	5967.95	27224.50	5444.90	7122.65	598.9
Fe	134.10	157.55	105.35	116.40	138.30	651.70	130.34	157.55	105.35
Mn	393.15	128.75	110.30	120.00	112.60	864.80	172.96	393.15	110.3

Despite of differences, total concentration of porous moistures obtained from both types of samplers shows good convergence, high correlation coefficients ($r = 0.95$). Correlation can be grouped as follows:

- highly positive correlation: Si, Mg, Ti, Fe,
- highly negative correlation: Na,
- no correlation: K, Ca, Sr, Mn.

After confronting both the above lists one can draw a conclusion, that particular elements show considerable differences in concentration and dynamics depending on the sampler type used. The reason for such variability may not be easily determined, and thus one can not state, that one sampler “prevails” another (in absolute terms). Moreover the percentage share of particular elements in an average concentration of moistures is similar for both samplers, being perhaps the only one indicator that does not differentiate samplers in quality (Tab. 4).

Tab. 4 The percentage share of particular elements in an average concentration of moistures

	Steel water sampler	Quartz water sampler	Average concentration for: Steel/Quartz samplers
Na	16.1	9.9	1.62
Mg	7.4	8.1	1.13
K	26.6	30.7	1.06
Ca	40.6	41.5	1.20
Sr	0.1	0.1	1.16
Ti	0.004	0.006	0.81
Si	8.5	9.2	1.14
Fe	0.2	0.2	1.35
Mn	0.4	0.3	1.86

Conclusions

The ICP MS porous moisture analysis procedure used and the comparable experiment settings (samplers set near one to another in the homogenous medium, samples taken simultaneously, identical moisture fixing and conservation procedure) guaranteed credible and informative results of an experiment. One can assume, that observed specificity of sampler’s work and obtained differences in concentration of elements have to be attributed to technical parameters and self-detection of material, sampling devices are made of.

Possible technical differences, not listed in producer’s device description reveal themselves already at the stage of moisture gaining; for the same value of pressure employed (62 kPa), steel sampler cup gathers the porous water out of the profile faster. From the other hand, quartz cup sampler keeps achieved pressure for a longer period of time and gathers greater amount of water. Fast reaction of steel cup sampler to the pressure created favours gathering moisture present in direct neighbourhood of sampler cup, loosely coupled with the rock grains. One can conclude that technical parameters of sucking cup might indirectly influence moisture mineralisation.

It can be argued, whether material, the sampler cup is made of, can influence moisture composition. Examinations show considerable increment in concentration of iron in the sample obtained from steel sampler as compared to quartz sampler (35%), with concentration of silicon only slightly increased. Possibly in the slightly acidic reaction of a rock and porous water environment (pH 5.5) release of ions of iron takes place.

Before choosing any specific type of sampler thorough geochemical studies of profile should be conducted to avoid liberated ions from the cup affecting mineralization and blurring or invalidating the results. The question of differentiation in dynamics concentration of moistures for examined elements remains open. The steel sampler can be recommended for examinations held in the neutral and alkaline environments while quartz sampler should be used in acidic environment.

References

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