La medida de la respiración de suelo como herramienta docente en edafología

Measurement of soil respiration as a teaching tool in edaphology

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Resumen

La edafología es una asignatura universitaria compleja por la variabilidad de conocimientos que integra y su interconexión con otras ciencias. Es por ello que la experimentación cobra en esta disciplina una importancia vital para mejorar la compresión del estudiante. Experimentar el suelo en el laboratorio lo priva de su realidad funcional, y la experiencia de campo es compleja por las dificultades de desplazamiento de los estudiantes desde sus centros universitarios. Para paliar unos y otros inconvenientes, el objetivo de este trabajo fue la medida de la respiración de los suelos (mg O_2/kg suelo) del jardín de la Facultad de Ciencias de la Universidad de Granada (Spain), empleando un método manométrico (OxiTop Control measuring system). Esta experiencia práctica permitió la participación continuada en el tiempo de los estudiantes, recogió la vitalidad funcional del suelo y sirvió para mostrar la conexión de la edafología con otras ciencias. A través de un aprendizaje autorregulado y cooperativo basado en el problema de los cambios de respiración del suelo en el tiempo y el espacio, los estudiantes adquirieron competencias específicas correspondientes a la temática edáfica, así como competencias transversales tales como la capacidad de análisis, razonamiento crítico, comprensión del método científico y capacidad de discusión.

Palabras clave: Innovación docente, Edafología, Respiración del suelo.

Abstract

Soil science is a complex university course by the variability of knowledge that integrates and its interconnection with other sciences. That is why experimentation in this discipline becomes vital to improve student understanding. Experiencing the soil in the laboratory actually strips it of its functional and field experience is complex because of the difficulties of moving students from their universities. To alleviate each other drawbacks, the objective of this work was to measure soil respiration (mg O2/kg ground) Garden of the Faculty of Science of the University of Granada (Spain), using a manometric method (OxiTop Control measuring system). This experience allowed continued participation in the students' time, collected soil functional vitality and served to show the connection of soil science with other sciences. Through a self-regulated learning and problem-based cooperative of soil respiration changes in time and space, students acquire specific skills relevant to the subject soil and transferable skills such as analytical skills, critical thinking , understanding the scientific method and ability discussion.

Key words: Teaching innovation, Soil, soil respiration.

Fecha recepción: Enero 2011 **Fecha aceptación:** Abril 2011

Introduction

Edaphology (pedology, soil science) is fundamentally an interdisciplinary science, and even though as of 1883 with Dokuchaev's masterpiece: The Russian Chernozom, one can already speak of its own methodology, the truth is that a close dependence continues to be maintained with methods incorporated from other disciplines, as reflected in the classic division of soil science into sections such as soil chemistry or soil physics (Diaz-Fierros, 2011). On the other hand, the materials studied by him are essentially dependent on biology and geology. While the soil is defined as an independent natural entity or unit of the landscape in which inanimate matter and living matter interact, it is also true that there is a lack of its own material that is not included in any of the aforementioned sciences. Likewise, the data provided by soil science is useful for agronomists, foresters, urban planners, civil engineers, archaeologists or even

Quaternary geomorphologists. Therefore, great relationships and dependencies of soil science with other disciplines are recognized from the point of view of method, content and application, which makes it especially complex for the university student. The baggage and variability of knowledge required of the student makes learning difficult, but without a doubt, it is an inherent fact of soil science and understanding its interconnections is the first of the skills that the student must acquire.

Understanding the soil as a dynamic and living natural body is also a basic idea contained in all soil science manuals (Porta et al., 2011). The soil performs multiple functions for terrestrial ecosystems such as biogeochemical recycling, regulation of the quantity and quality of surface water, buffering chemical and physical changes inopportune for the survival and development of plants and animals, as well as the distribution of energy (Sánchez-Marañon et al., 2002). The maximum expression of the functioning and vitality of the soil is its respiration, beyond the mere exchange of gases between the soil and the atmosphere by mass flow and diffusion. There are endless research works on the importance of soil respiration, due to the heterotrophic organisms developed there, especially for the natural carbon cycle (Bauer et al., 2012). The concentration of CO2 and O2 in soil air differs from that in the atmosphere and its explanation lies in microbial respiration (Schaetzl and Anderson, 2005). Contrary to researchers, teachers have paid little attention to the educational practice of this aspect of the soil, which, however, is essential to convey the idea of a living soil on which natural systems and ultimately also humanity depend. and at the same time it is a focal point of maximum efficiency to show the relationships of soil science with other sciences.

The European Higher Education Area, within the framework of the Bologna Declaration and echoing certain pedagogical practices (Kirschner and Meester, 1988; Escribano and Del Valle, 2008), is promoting an educational framework in which learning is based on the practice and resolution of thematic problems of the disciplines in question. We are also witnessing the need to promote self-regulated learning (Peñasola et al., 2006) as well as cooperative learning (Sharan and Sharan, 1992). The teacher's task should not only be to teach content, but to teach how to learn in an autonomous context, where the learner finds motivation for the achievement of goals, the expectation of improvement or self-esteem for a job well done; while the teacher is required to turn academic tasks into social experiences as well.

The objective of this work is to design a teaching experience in the university teaching of edaphology on soil respiration, in which the student acquires specific skills of the subject and understands its interrelation with other scientific disciplines, all in an educational framework that combines the self-regulated and cooperative nature of learning, as basic pillars of the guidelines that the academic authorities of higher education are indicating.

Material and methods

The students and the subject

The human material was made up of 30 students in the second year of the Degree in Environmental Sciences at the University of Granada, who during the 2011-2012 academic year are studying soil science. This is a subject of 6 credits (150 hours) of a basic nature and with 60% of non-contact activities in the classroom. Among the specific skills that students must acquire are those related to the contents of soil characterization (morphology, components, properties, genesis, classification and cartography), in addition to acquiring skills and abilities in the laboratory and handling of basic instrumentation of chemical and physical nature. Among the transversal skills that this course must cover, the understanding of the scientific method, the capacity for analysis and synthesis, problem solving, and critical reasoning also stand out.

The experiment

The problem posed to the students was the measurement of soil respiration and the need to assess the factors involved. Students are offered the possibility of experimenting on this topic in a continuous way in the gardens of their own educational center (Faculty of Sciences, University of Granada, Spain), which facilitates their availability by being part of the classroom, in this case, a natural classroom, since the urban soils of the gardens are a patch of nature within the city (Johnson and Catley, 2009). It is a garden over 35 years old that contains different tree and shrub species from the Mediterranean climate on Anthrosols and Technosols (IUSS Working Group WRB, 2006). These soils are built in part by additions of filling material, from the waste from the construction works of the buildings of the university campus itself, and later contributions on the surface of organic material (peat and chopped remains of pruning). The base of these soils is an in situ residue of the original pre-existing soil of the Vega de Granada (Fuvisols), which appears in a variable way between 40 and 60 cm deep.

A total of 21 students showed their willingness to participate in this project, with whom we built 4 groups or teaching units of five-six people, in order for each of these groups to make their own sampling, the material and subsequent results of which would be used independently. cooperative by the rest of the groups and students. For this communicative relationship, the different social networks were used, a blog built to follow up on the experience (http://manuel-edafologia.blogspot.com.es), as well as the University of Granada's own teaching Web platform. Each group should sample the soil and subsequently measure its respiration, for which they were offered the possibility of using a cylindrical sampler to take samples up to 40 cm deep.

Measure

Through a tutorial-workshop activity, the students were provided with background information and bibliographical sources on the concept and influencing factors in soil respiration, as well as being instructed on the fundamentals of the measurement and the handling of the equipment necessary for it. . The rationale for this measure is as follows.

The aerobic respiration process, which is a consequence of soil biological activity (Rowell, 1994), can be summarized in the following reaction in which glucose is oxidized to carbon dioxide:

$C6H12O6 + O2 = 6CO2 + 6H2O$ + Energy

The amount of oxygen consumed by organisms, while carbon dioxide is released at the same time, is an effective measure of the intensity of the soil respiration process, which depends primarily on the organic matter content, temperature and soil moisture.

We use a manometric method (OxiTop Control measuring system, Platen and Wirtz, 1999) that registers the depression caused by the oxygen consumed in a 960 mL hermetically sealed glass flask, in which a quantity of soil (100 – 300 g) and a beaker with 50 mL of 1 M NaOH, whose purpose is to absorb the released CO2 and not appear in the form of free gas. The result is a curve of pressure changes (hPa) over time (minutes). The total incubation period was 7 days, except in an initial case of 5 days. From the pressure changes (negative values) the oxygen consumed (mg) can be calculated using the general gas equation. Since the value of temperature intervenes in this equation, it was controlled in the proximity to the breathing flasks. The groups of students modified the experimental conditions in view of the experience that the previous groups were accumulating. In all cases, gravimetric humidity was measured (w, difference in mass before and after evaporation at 110 ºC).

Results

Self-regulated learning:

I – First measurements of soil respiration.

The first of the groups to experiment (G1, Table 1) chose grass-covered ground as the sampling point, which is the most frequent situation in the garden. A second group (G2), however, chose the opposite situation and with less areal occupation, which is that of flowerbed soils. The flower beds are some scattered nuclei within the area with grass, but covered with scrub and containing chopped pruning remains that form an artificial mulch. Although the clay and organic matter content has not been determined, the organoleptic feel of the parterre soil, exhibiting more adherence and plasticity as well as a darker, reddish color, presupposes it is richer in clay and organic matter than the soil under grass. Figure 1 shows the pressure curves that groups G1 and G2 obtained for the first few centimeters of soil with grass and parterre.

II - Differences in biological activity in the soil profile

The possibility of obtaining undisturbed soil with a cylindrical steel tube divided into two halves (split tube sampler, Eijkelkamp Co.), aroused in one of the most competitive groups of students the curiosity to experience changes in respiration at different depths in the soil. Reaching up to 40 cm thick, the pupils

Table 1. Respiration measurements (O2 consumption) in garden soils carried out as a university teaching activity for the Edaphology subject by several groups of students (G1-G4).

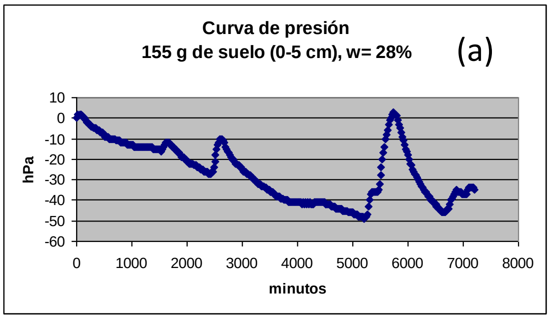
GRUPO	Fecha	Muestra (suelo de …)	Temperatura (ºC)	Humedad (w, %)	O_2 consumido (mg/kg)
G1	08-13/03/2012	Césped 0-5 cm	15-24	28	420
G2	13-20/03/2012	Parterre 0-10 cm	16-20	34	2871
G3	21-28/03/2012	Césped bajo árbol 0-14cm	18-20	31	581
G3	21-28/03/2012	Césped bajo árbol 14-27cm	18-20	12	235
G3	21-28/03/2012	Césped bajo árbol 27-40cm	18-20	14	163
G4	30-06/03-04/2012	Césped 0-10	16-20*	27	465
G4	30-06/03-04/2012	Césped 0-10	16-20*	42	608
G4	30-06/03-04/2012	Césped 0-10	16-20*	57	650

* in complete darkness

They obtained a soil cylinder of 7854 cm3 that they divided into three portions: 0-14, 14-27 and 27-40 cm. The differences, and also similarities, in the pressure curves obtained are shown in Figure 2.

III – The effect of soil moisture

As the end of this teaching experience, it is worth highlighting the initiative of another group of students who raised the problem of the effect of moisture content on biological activity. His postulate was based on the fact that the water bathing the microsites of the microorganisms should be an incentive to multiply the microbial populations and therefore, the oxygen consumption would increase. From a superficial sample, the students obtained subsamples of 85 g to which different amounts of distilled water (0, 10, 20 ml) were added. Certainly, Figure 3 demonstrates this catalytic effect on the pressure curves, although it was a surprise that the changes from one situation to another will only reach 5 hPa.



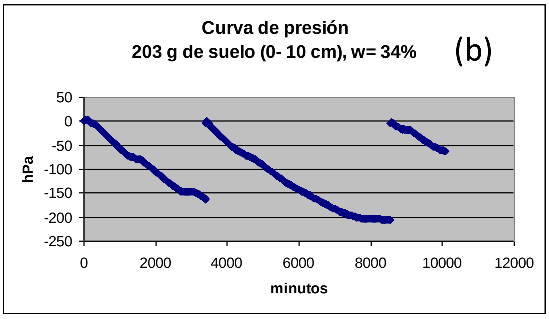


Figure 1. Pressure curves of soil respiratory activity obtained by groups G1 (a) and G2 (b)

Cooperative learning:

I - Spatial variability of soil respiration

The joint efforts of the different groups of students were able to add up and result in Table 1. The students have learned through cooperative experimentation that soil respiration is a functional property with spatial variability. This variation is especially proven between lawns and flowerbeds, as well as between surface and subsurface horizons.

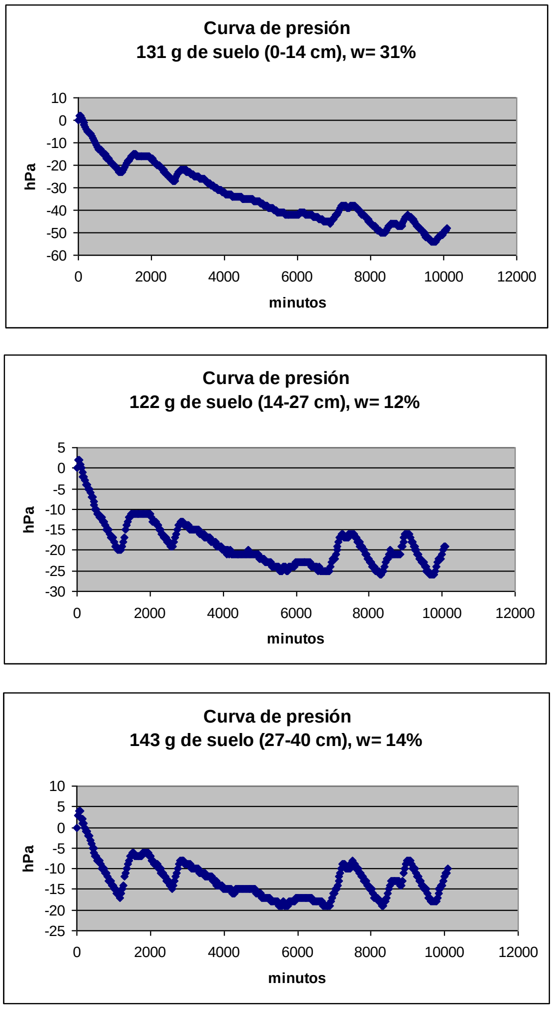
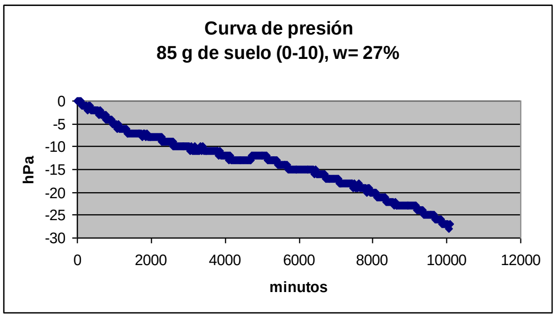


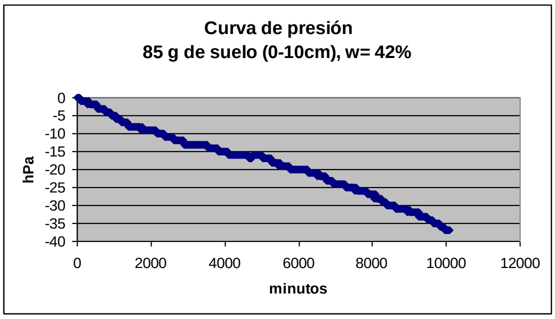
Figura 2. Curvas de presión de la actividad respiratoria del suelo a diferentes profundidades obtenidas por el grupo G3.

Discussion

The first measurements of the groups G1 and G2 not only showed important differences in the oxygen consumption or respiration of the soil between the lawn areas and the flower beds, but also established the bases of the experiences for the following groups. The students were able to experience that differences in the properties of the soils lead to a different functioning of the soil. They hypothesized that microbial populations must have been more active in the beds, probably due to a higher content of organic matter and greater moisture retained in the soil due to its finer texture. Likewise, the students verified anomalies in the pressure curves. On the one hand, the pressure increases in Figure 1a corresponded to daytime periods in which the laboratory temperature was higher. The pressure values due to oxygen consumption were recovered again during the night or weekends without occupation of the laboratory and without heating. On the other hand, figure 1b reflects that the breathing flasks had to be opened twice. The depression reached in the bottle indicated that all the oxygen had been consumed and therefore, it had to be opened and then closed again to continue the measurement until the end of the 7 days of incubation. The amount of sample was probably excessive for the volume of oxygen held in the airtight breathing flasks. The amount of sample must be adjusted according to the degree of respiratory activity of the soil (less quantity the greater the respiration).

The measures of the G3 group were aimed at verifying the antecedents and hypotheses established by the previous groups. Soil samples at different depths have different properties, especially the humic profile changes, and consequently normalized respiration at 20 ºC varied from 581 to 163 mg O2/kg in 7 days of incubation (Table 1). Figure 2 shows that there is rapid oxygen consumption in the first 30 hours of incubation for all samples (greater slope of the pressure curves) and that later respiration slows down, especially in samples below 14 cm. , tending towards its stabilization (-20 hPa) in the sample taken between 27 and 40 cm deep. Apparently, the lower content of organic matter influences a lower respiration of the soil, although in the experience the moisture content could also have influenced. On the other hand, even though the heating was not turned on in the laboratory, so the experimental temperature conditions were less variables than in the case of groups G1 and G2, it can be seen in figure 2 that all the curves have anomalies with the generation of saw teeth in the same periods of time: during the hours of weekdays in which it was lab light on.





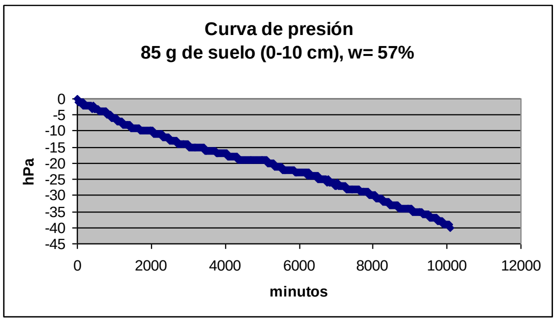


Figura 3. Curvas de presión de la actividad respiratoria del suelo a diferentes contenidos de humedad obtenidas por el grupo G4.

The experience of the G4 group investigated the effect of light and humidity. Under conditions of absolute darkness, because the breathing flasks were placed inside a closed cabinet, and even with a higher thermal oscillation than in the experience of the G3 group, the pressure curves (figure 3) no longer exhibited anomalies. It is also evident that the same soil sample increases its respiration with increasing humidity, but to a lesser degree than samples with different organic matter content. The differences are 418 mg O2/kg between the superficial and deep samples of the G3 group experience and 185 mg O2/kg for the same sample with moisture contents that differ by 30%.

conclusion

Students have learned the scientific learning process. The influence of chemical and physical factors on the measurement of soil respiration has transmitted the interdisciplinarity of soil science. The vitality of the soil, as the central axis of the essence of the soil, has also been discovered, not learned theoretically. The teaching methodology used has made it possible to cover the specific competences of knowledge of the soil and also the transversal ones such as handling basic instrumentation, in addition to those more general such as initiative, work capacity and socialization. The students experienced the scientific method, reproducing a "feedback" learning that includes: 1-compilation of previous knowledge, 2-observation of the fact, phenomenon or entity, 3-measurement of its attributes, 4-establishment of hypotheses, 5-verification of hypothesis, and 6-analysis of the results with which to update previous knowledge.

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