Geophysical Research Abstracts
Vol. 17, EGU2015-5292-1, 2015
EGU General Assembly 2015
© Author(s) 2015. CC Attribution 3.0 License.

Measurement of the open porosity of agricultural soils with acoustic waves

Jeanne Luong, Benoit Mercatoris, and Marie-France Destain
Gembloux AgroBioTech, University of liège, Gembloux, Belgium (jeanne.luong@ulg.ac.be)

The space between agricultural soil aggregates is defined as structural porosity. It plays important roles in soil key functions that an agricultural soil performs in the global ecosystem. Porosity is one of the soil properties that affect plant growth along with soil texture, aggregate size, aeration and water holding capacity (Alaoui et al. 2011). Water supplies regulation of agricultural soil is related to the number of very small pores present in a soil due to the effect of capillarity. Change of porosity also affect the evaporation of the water on the surface (Le Maitre et al. 2014). Furthermore, soil is a habitat for soils organisms, and most living organisms, including plant roots and microorganisms require oxygen. These organisms breathe easier in a less compacted soil with a wide range of pores sizes.

Soil compaction by agricultural engine degrades soil porosity. At the same time, fragmentation with tillage tools, creation of cracks due to wetting/drying and freezing/thawing cycles and effects of soil fauna can regenerate soil porosity. Soil compaction increases bulk density since soil grains are rearranged decreasing void space and bringing them into closer contact (Hamza & Anderson 2005). Drainage is reduced, erosion is facilitated and crop production decreases in a compacted soil. Determining soil porosity, giving insight on the soil compaction, with the aim to provide advices to farmers in their soil optimization towards crop production, is thus an important challenge.

Acoustic wave velocity has been correlated to the porosity and the acoustic attenuation to the water content (Oelze et al. 2002). Recent studies have shown some correlations between the velocity of acoustic waves, the porosity and the stress state of soil samples (Lu et al. 2004; Lu 2005; Lu & Sabatier 2009), concluding that the ultrasonic waves are a promising tool for the rapid characterisation of unsaturated porous soils. Propagation wave velocity tends to decrease in a high porous soil, since there are more voids filled with air and water, increasing the viscous losses. Fellah et al. (2003) showed that porosity can be determined from phase speed and reflection coefficient.

The propagation of acoustic waves in soil is investigated to develop a rapid method for the quantification of the porosity level of agricultural soils. In the present contribution, correlations are determined between the acoustic signatures of agricultural soil in function of its structural properties. In laboratory, compression tests are performed on unsaturated soil samples to reproduce different porosity levels. Ultrasonic pulses are sent through the considered samples. The propagated signals are treated in both time and frequency domains in order to determine the speed of the phase velocity and the reflection. Porosity is then determined and compared with water content measured by gravimetric method.

Alaoui, A., Lipiec, J. & Gerke, H.H., 2011. A review of the changes in the soil pore system due to soil deformation: A hydrodynamic perspective. Soil and Tillage Research, 115-116, pp.1–15.
Fellah Z.E.A., Berger S., Lauriks W., Depollier C., Aristegui C., Chapelon J.Y., 2003. Measuring the porosity and the tortuosity of porous materials via reflected waves at oblique incidence. The Journal of the Acoustical Society of America 113 (5), pp 2424-2433
Hamza, M.A. & Anderson, W.K., 2005. Soil compaction in cropping systems. Soil and Tillage Research, 82(2), pp.121–145.
Lu, Z., 2005. Role of hysteresis in propagating acousitcs waves in soils. Geophysical Research Letter, pp.32:1-4.
Lu, Z., Hickey, C.J. & Sabatier, J.M., 2004. Effects of compaction on the acoustic velocity in soils. Soil Science Society of America Journal, 68(1), pp.7–16.
Lu, Z. & Sabatier, J.M., 2009. Effects of soil water potential and moisture content on sound speed. Soil Science Society of America Journal, 73(5), pp.1614–1625.
Le Maitre, D.C., Kotzee, I.M. & O'Farrell, P.J., 2014. Impacts of land-cover change on the water flow regulation ecosystem service: Invasive alien plants, fire and their policy implications. Land Use Policy, 36, pp.171–181.

Oelze, M.L., O'Briena, W.D. & Darmody, R.G., 2002. Measurement of attenuation and speed of sound in soils. Soil. Sci. Soc. Am. J.