Vertisolization in an Overpopulated World

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As we closed out 2011, our world population expanded to 7 billion people, with projections of 9 billion by 2045. The food and fiber needed for all of these people require increased use of energy and soil. Thus, increases in population have fostered a continuous reduction in the ability of the soil to produce food and fiber yields because of the many threats it faces such as soil erosion, soil sealing, soil pollution, soil scalping, salinization/sodicization, decline of organic matter, loss of biodiversity, and fires. These threats to the soil functionally degrade it, reducing or wiping out its productivity and ecological functions.

The causes of degradation are many, but all of them are mainly due to improper soil management, careless disregard of the environmental limitations, or the pedo-bio-geochemical cycles. Because of this, most of the soil lost every year in the world belongs to the first three classes of land capability. This elucidates an ongoing struggle across all humankind between the increasing necessity of soil to ensure sustenance and the progressive soil lost to degradation. In the middle of this fight, there are many soil-devoted international organizations such as FAO and UNESCO as well as international centers (USDA, European Joint Research Centre, etc.), universities, and scholars that promote, carry out, and disseminate results of research aimed at surmounting soil threats given consideration of actual and future human and climatic scenarios. Sustainable use of the soil as a resource demands an increase in the knowledge of soil as well as other soil-related factors.

In this context, an additional soil threat linked to ongoing climate change might affect the economy and the geopolitical arrangement of the future: Vertisolization. The term is well known by soil scientists and (with its suffix "zation") indicates the process that transforms a certain soil into a Vertisol. Vertisols are recognized by all soil classification systems, and the common requisites to classify a soil as such are a fine earth with 30% clay, the presence of slickensides and big wedge-shape peds, and the occurrence of cracks that open and close periodically. The most common parent materials are sediments (marine, fluvial, and glacial) and calcareous and basic rocks. Here, deep and wide cracks open when clay reaches its maximum shrinking after it has swelled, which may happen under climatic conditions consisting of an alternating of rainy and dry periods.

Vertisols are mainly found in Australia, India, central and southern Africa, eastern China, southern U.S., and Brazil, but considerable quantities of this type of soil are also present in the Mediterranean Basin from southern Europe to the Near East. In all of these regions, Vertisols are recognized as being responsible for damages to roads and buildings, as the energy developed during both swelling and shrinking is considerable, and infrastructure usually succumbs.

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Because of these forces, it is understandable that Vertisols represent a real hindrance for the bio-diverse agricultural use of a territory as many long-standing plants are not able to survive on these soils since

(i) their roots are massively broken during crack formation;
(ii) after root breaking, tolerance against drought is greatly decreased and infections may enter the plants; and
(iii) after swelling, gas exchange is almost zero.

By contrast, natural Vertisols mainly host savannah vegetation. This means that agricultural use of Vertisols is optimally restricted to grassland. However, after the beginning of the dry period, such lands are unusable even for grazing. Where irrigation is available, some herbaceous crops can be grown. However, Vertisols also exert a positive role in the geochemical cycles that regulate climate on the earth: the combination of grassland and the presence of high contents of clay (and expandable clay minerals) favor the formation and accumulation of stable organo-mineral complexes in which the organic matter is protected from biologi-
cal degradation. Hence, Vertisols subtract carbon dioxide from the atmosphere, contributing, in medium to long periods, to the reduction of global warming.


A Negative or a Positive?
So, should we view Vertisolization as a negative or positive process? As in all questions dealing with humans or nature, the answer is never simple and needs detailed consideration. First, we must consider soil mineral composition. To be classified as a Vertisol, taxonomy systems require a certain amount of clay (more than 30%), with little regard to the type of clay. Yet, there are many sediment-derived soils that crack deeply but contain only 20 to 25% clay; they’re mainly made of expandable minerals such as smectites and vermiculites and could be considered vertic intergrades. Thus, irrespective of clay content and composition, many soils do crack a little at shallow depths. Soil moisture regime (aquic, udic, and ustic) may serve to effectively prevent strong shrinking of clay or clay minerals. Yet such soils may continue to have vertic properties. In these soils, the process of Vertisolization has taken place even though a real Vertisol did not form.

Two sets of circumstances describe the unique importance of these quasi-vertic soils. First, soils with much less than 30% clay (but with 15–20% expandable minerals) can still demonstrate marvelous vertic behavior, but we do not call them Vertisols. Maybe a future committee will solve this problem. Second, there are many soils that are simply too moist to crack at depth, even though they have high clay content. In many regions where these soils are found, the predicted climate change will bring less rain and warmer summer temperatures than presently experienced; changing the previously moist soils to Vertisols. On the basis of the tendency lines of 50 years of precipitation and temperature means, the Mediterranean Basin will begin to experience this change in 2030–2035, maybe a decade later in other parts of the world. As the global population grows toward 9 billion, we will have less soil to cultivate than what is presently available. This phenomenon will also indiscriminately affect many of the so called “first world countries.”

To overcome the problem, we undoubtedly must learn to save water for irrigation, but in a drier environment, we also need to increase our knowledge of these soils; concoct locally appropriate soil management; and collaborating with agronomists and plant breeders, find crop varieties that make us able to use these soils in a sustainable way. By doing this, we will also be able to benefit from the positive effects of carbon sequestration exerted by Vertisols. In an even more overpopulated planet, Vertisol management is a global challenge for scientists of all soil-related disciplines.