

## Soil Fines: Small Particles with a Big Impact

A recent article in the *Journal of Natural Resources and Life Sciences Education* presents a graphical approach for teaching the relationship among soil fines, soil chemistry, and soil structure. This relationship is very important, as it determines which soils are arable, which will drain, and which will allow transport of suspended contaminants such as microbial pathogens. This article will be of interest to anyone teaching crop science or soil chemistry, but because these effects are general, it will also be useful for instructors of courses such as contaminant hydrology, environmental engineering, or petrology.

According to the USDA, soil fines are particles smaller than 50  $\mu\text{m}$  or 0.050 mm. This size range also includes a number of contaminants, such as viruses, bacteria, and algae. In addition, this size range includes nanoparticles, a class of engineered particles smaller than 100 nm or 0.0001 mm that have potential applications in medicine, manufacturing, and environmental cleanup (Fig. 1). However, because of toxicity concerns, it will be important to understand how nanoparticles move through soils and aquifers.

The article highlights the effect of three key metrics in soil chemistry. The first is pH, which determines whether the solution is acidic, neutral, or basic. The second is salinity, expressed as ionic strength, which determines whether the solution is fresh or salty. The third is sodicity, expressed as sodium adsorption ratio, which measures the relative balance of monovalent salts such as sodium versus divalent salts such as calcium. Taken together, these three metrics determine whether soil fines remain independent, called *dispersion*, or stick together to form microscopic aggregates, called *flocculation*. Generally speaking, dispersion is to be avoided, being associated with poor soil structure and mobile particulate contaminants. Flocculation is better, being associated with good soil structure and immobile particles. However, flocculation is also associated with high salin-

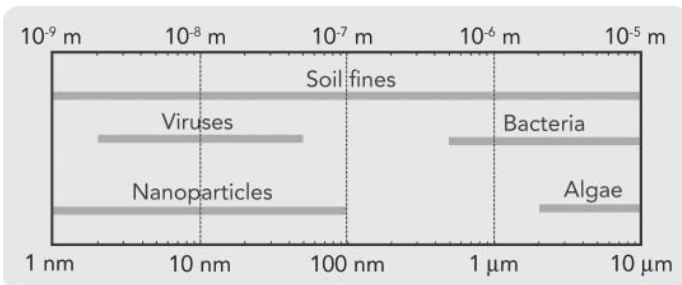


Fig. 1. Size range of soil fines and selected other particles.

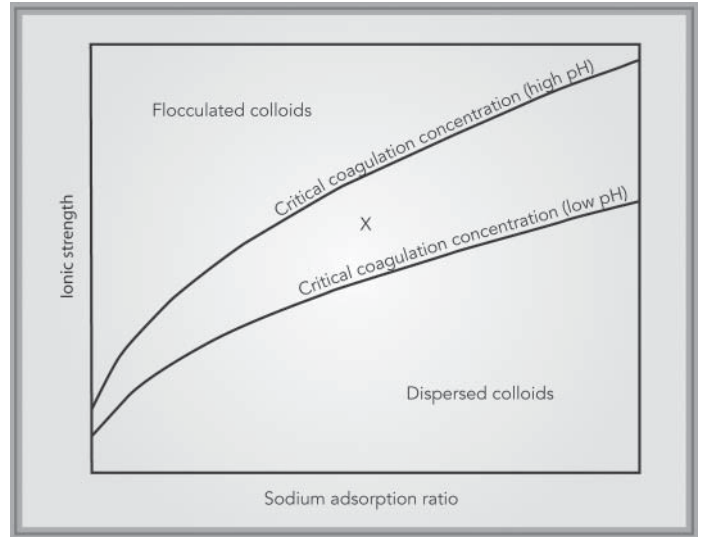


Fig. 2. Quirk-Schofield diagram showing complimentary zones of dispersion (below the line) and flocculation (above the line). Point X is in the zone of flocculation at low pH and in the zone of dispersion at high pH.

ity, which prevents crop growth. This limitation highlights the need for students and practitioners to appreciate the interrelationships among pH, salinity, and sodicity. This is where a graphical approach can help.

Assuming normal soils in temperate climates, the relationship among pH, salinity, and sodicity is illustrated in Fig. 2, which shows complimentary zones of dispersion and flocculation. This figure is called a Quirk-Schofield diagram, in honor of the pioneering work by J.P. Quirk and R.K. Schofield, who examined the roles of salinity and sodicity in the *Journal of Soil Science* over 50 years ago (1955, 6:163-178). The additional effect of pH is illustrated following the example of I. Lebron and D.L. Suarez, who investigated the role of pH on soil stability in the *Soil Science Society of America Journal* 15 years ago (1992, 56:1412-1421).

The recent article in the *Journal of Natural Resources and Life Sciences Education* makes three unique contributions. First, the article shows how to use Quirk-Schofield diagrams in the context of contaminant transport, aquifer hydraulics, and petroleum engineering, which extends their utility beyond their usual application to soil science. Second, the article presents new Quirk-Schofield diagrams showing the effect of pH on three common clay minerals: kaolinite, illite, and montmorillonite. Third, this article is written by and for educators, providing a one-stop introduction to the important role of soil fines in natural environments. It also includes a short discussion of the relevant basics of surface chemistry and numerous references to the classic and recent peer-reviewed literature.

Mays, D.C. 2007. Using the Quirk-Schofield diagram to explain environmental colloid dispersion phenomena. *J. Nat. Resour. Life Sci. Educ.* 36:45-52. View the full article online at [www.jnrlse.org/issues.php](http://www.jnrlse.org/issues.php).