Suspended solids: forms, sources and measurement

Natural waters contain small suspended particles in the size range (diameter) of < 1 μm to a few mm. Under normal conditions, turbulence keeps such particles suspended on timescales of hours to days (or even longer), but they eventually settle by gravity and are deposited to lake or river bottoms. Suspended solids (SS), also called suspended particulate matter (SPM), is a broad term that includes a wide variety of inorganic and organic particles derived from many sources in watersheds and within water bodies themselves. External (allochthonous) sources of inorganic (or mineral) SS include soil and streambank erosion and resuspension of bottom sediments by wind-induced turbulence or bottom-feeding fish. Internal (autochthonous) sources of organic SS include primary production of algae, microbial food webs based on algal production, zooplankton and fish feeding/excretion activities, and decomposition of aquatic vegetation. External sources of organic SS include runoff from agricultural and urbanized lands, wind-blown leaves and other partial decomposition products of terrestrial vegetation.

The sum of the mineral and organic SS usually is referred to as total suspended solids, TSS. TSS concentrations range from ~ 1 mg/L in pristine lakes to tens of mg/L in eutrophic lakes and hundreds of mg/L in rivers and impoundments in watersheds with highly erodible soils and streambanks. TSS is measured gravimetrically by weighing the residue dried at ~ 100 °C that was collected on a glass fiber filter (nominal pore size of 0.45 μm) from a known volume of water. Volatile suspended solids, VSS, a measure of organic SS, is the difference between the dried weight of residue and the weight after firing the filter at ~ 550 °C. The ash remaining after firing, called the fixed residue, represents the mineral SS.

Through its central role in scattering and absorbing incoming light, SS is the main factor that determines the clarity of water in most lakes and rivers; in Minnesota, light absorbance by CDOM is also a determining factor, largely in forested regions of the NLF ecoregion. The extent of light scattering and absorption by SS depends not only on its mass concentration, but on the number of particles and their shape and surface properties. These factors vary widely for SS in different water bodies and even over time in a given lake. For these reasons, analytical equations to retrieve SS or its mineral and organic fractions from satellite imagery are not possible.

Empirical relationships have been reported, however, using the scattering peak at ~ 705 nm and band combinations in the NIR or green regions, where plant pigments absorb minimally. In previous work, we found strong relationships between reflectance at 705 nm and SS ($r^2 = 0.77$-
0.93) using airborne hyperspectral imagery on optically complex waters of the Minnesota, Mississippi, and St. Croix Rivers in the Minneapolis-St. Paul area (Olmanson et al. 2013). We also developed a retrieval equation \( r^2 = 0.80-0.90 \) for volatile suspended solids (VSS) using the ratio of reflectance at 705 to 670 nm. A two-term equation consisting of the band at 705 nm and the 705:670 nm reflectance ratio worked well to predict mineral SS.

Reference