7.5 Sedimentation

Particles may be separated from water on the basis of their weight. Particles heavier (more dense) than water will sink, whilst those less dense will rise. If the water is quiescent or semi-quiescent then the particles can collect at the base or surface of the water, from where they may then be removed. Sedimentation (sometimes called *gravitation* or *settlement*) is the separation of particles heavier than water, whilst particles less dense than water are separated by *flotation*.

When a particle settles in water it does so at a constant velocity which arises from the balance of three forces. These comprise:

- the downward gravitation force arising from the density difference between the settling particle solids (ρ_s) and the water (ρ)
- the buoyancy force relating to the displacement of the water by the particle, which relates to the water density, and
- the drag force, which is a function of the particle cross-sectional area (and so its effective diameter d) and is dependent on the flow regime around the particle.

Because of the dependency of drag force on the flow regime the relationship between the settling velocity and size of a settling particle is itself dependent on particle size. Larger, denser particles settling more rapidly are associated with larger Reynolds numbers (Section 3.3) which pertain to more turbulent flow. However, for almost all practical considerations within water and wastewater treatment, *laminar* flow dominates during particle settlement and flotation. This being the case, the settling velocity v_s is given by *Stokes Law*:

$$v_s = \frac{g\,(\rho_s - \rho)d^2}{18\mu} \qquad (7.22)$$

where g and μ are gravitational acceleration and liquid viscosity as before.

Example: particle settlement

What is the settling velocity of a 50μm diameter silt particle of density 2500kg/m^3 in water at 20°C?

According to Equation 7.22, particle settling velocity is given by:

$$v_s = \frac{g\,(\rho_s - \rho)d^2}{18\mu}$$

At 20°C the water density is approximately 1000 kg/m^3 and the viscosity 0.001 kg/(m.s) (Table 11).

So, converting all quantities to kg, m^3 and s, the settling velocity is:

v_s = 9.81 x (2500 – 1000) (50 x 10^{-6})^2/(18 x 10^{-3}) = 0.00204 m/s (i.e. 2 mm/s)

Exercise 7.4

What is the approximate diameter of a particle of 1.23 g/ml density if it settles at 150 microns/s at 25°C?
