Chapter 6

WATER

The correct sampling methods of water circuits are vital for the gathering of reliable information for the formulation of effective water management systems. Depending on the nature of the quality analyses to be performed, different pre-treatment and preservation techniques must be employed. Also, the integrity and accuracy of the data obtained from the analyses must be verified. Two methods can be used for this purpose i.e. preparation of an ionic balance and analysis of duplicate samples at a number of independent laboratories.

6.1 Characterisation of waters

It is essential that the characteristics of input water and wastewater be known in order to design efficient treatment systems. Regular testing is necessary so that processes can be adapted to accommodate changing loads. Such routine testing also enables the long-term assessment of processes. The use and discharge of water is regulated by statutory bodies, which may insist on regular testing and record-keeping. The type of test performed depends on the accuracy required, the use of the data and the use of the water. These tests can be broadly classified as follows:

- Tests for gross pollution: biochemical oxygen demand (BOD), chemical oxygen demand (COD), suspended solids, ammonia and grease.
- Tests for appearance and aesthetic acceptability: taste, colour, odour, and turbidity.
- Tests for materials that are a health risk: fluoride, nitrate, chloride, magnesium, heavy metals and sulphate.

- Tests that determine suitability for incidental uses: corrosivity, iron, manganese, calcium and magnesium salts, coloured ions e.g. copper.
- Operational tests: used to optimise or check plant performance, coagulation and flocculation, sludge assessment and simple analytical tests.

(Brady *et al.*, 1994).

6.1.1 Chemical equilibria, pH and buffers

Many chemical equations can be described as chemical equilibria, where reactants A and B form products C and D and vice versa as shown below:

$$A + B <-> C + D$$

The concept of chemical equilibria is valuable in predicting the behaviour of several important species in wastewater. In this regard, the concept of solubility product constant (Ksp) is important to evaluate the maximum concentration of a sparingly soluble salt in water under specific conditions (normally one atmosphere and 25°C):

$$CaSO_4 <-> Ca^{2+} + SO_4^{2-}$$

$$\begin{aligned} Ksp &= [Ca^{2+}] \,.\, [SO_4^{2-}] \\ &= 3x10^{-5} \text{ moles/l} \end{aligned}$$

Due to the "common ion effect" the solubility of Ca^{2+} is even farther reduced by the presence of excess sulphate ions (e.g. from another sulphate like Na_2SO_4) in solution.

The ability of a sample to resist change to its pH is referred to as its *buffering capacity*. An understanding of this characteristic of a sample is important when later considering treatment processes in which acid or alkali is added to a sample, as in anaerobic digestion, nitrification, chlorination, coagulant addition and pH correction. Buffers are usually composed of mixtures of weak acids (or bases) and the salts of a weak acid. The degree of buffering capacity can be measured by titrating the sample with N/50 acid and is recorded on a calcium carbonate scale as alkalinity (Clark, 1994).

6.1.2 Physical tests

Tests for colour, turbidity, taste and odour are widely used to establish the aesthetic quality, or potability, of waters.

Colour in water means that the water will absorb light energy in the visual spectral range. Water is colourless, so any colouration will record the presence of impurities in that sample. Colour is usually measured visually and is thus subjective.

Turbidity is a measure of the ability of water to scatter light. Small particles in the water scatter and absorb light, so that the light does not pass directly through the water. The overall turbidity of a sample will depend on the number, size, shape and refractive index of the particles in suspension. Turbidity is measured on a turbidity scale of units established for a standard suspension. The presence of taste and/or odour in water is detected by the response of human senses to the particular chemicals. Thus it is also largely subjectively measured, usually by a panel of individuals.

The conductivity of a water sample measures the ability of the sample to carry an electric current. Compounds that dissolve in solution to give individual ions will result in a high conductivity relative to those compounds that do not dissociate. The major influence on conductivity is therefore the concentration of dissolved inorganic salts in the water. The relationship between dissolved salts and conductivity depends on the materials present, temperature, concentrations and pH of the sample. There is thus no consistent relationship between conductivity and total dissolved solids. Conductivity is used to gather routine data and highlight changes in the water, which may warrant further investigation. Conductivity is determined by measuring the electrical resistivity of a sample between two electrodes. Resistivity is the product of the resistance and the distance between the electrodes (Clark, 1994).

6.1.3 Principles of analytical chemical methods

Concentrations are normally determined on a mass per volume basis. They are conveniently expressed in mg/*l*, which is equivalent to g/m^3. As 1*l* of water has a mass of approximately 1kg, these values can also be taken as parts per million (ppm). The types of analytical method used in wastewater analysis can be described as titrimetric, colorimetric, spectral and potentiometric. The first two are more traditional techniques, while the last two are based more on instrumental techniques (Drew Chemical Corporation, 1978). (These methods have not been used in the practical section of this thesis and are thus not discussed in any detail).

6.1.4 Solids determination

To determine the total amount of solids present in a sample, a fixed volume of the sample is evaporated and the residue dried at 105°C and weighed.

To determine the amount of material not in solution i.e. suspended solids, the sample is filtered and the dried residue weighed. Soluble solids can be separated from the filtrate and then weighed or they can be determined by subtracting the suspended solids from the total solids. The suspended solids indicates the material that might be removed by a settling process.

If a dried sample is heated to 600ºC in air, the organic material will burn and the weight loss can be attributed to the organic content of the sample. This is usually interpreted as the degradable fraction of the sample, although not all organic materials are degradable and some inorganic compounds, like clay minerals and inorganic colloids (e.g. $Al(OH)_3$), decompose and lose weight at this temperature. The material remaining after heating is recorded as the fixed residue.

6.2 Water use in the coal mining industry

Water use in the mining industry includes the following:

- Potable water
- Recreation
- Irrigation and rehabilitation
- Cooling water
- Dust suppression
- Process water in plants
- Mine service water
- Tailings

The surface and ground water environments of individual mines vary, as do the effects of point and/or diffuse effluents on these environments.