A case study in bioremediation

Treating waste water from coke ovens

A problem at the steelworks

At the Tata Steel site in Scunthorpe, industrial effluent is cleaned up using biological organisms at the water treatment facility known to those who work there as the 'Bio' plant.

Figure 1 The 'Bio' plant.

The first stage in making steel is to reduce iron ore to iron in a blast furnace using coke. Coke is made on site by heating coal in the absence of air. A by-product of this process is the formation of thiocyanate ions. Some of these ions dissolve in water used to clean or 'scrub' the gases produced in the coking process.

Water treatment

This contaminated water is collected in huge ponds along with water from other parts of the steel works and is pumped along pipes to the water treatment facility at a rate of 100 to 120 m^3 per hour. Thiocyanate ions are toxic to aquatic organisms and the concentration must be reduced to safe levels before the water can be released into the nearby River Trent. The effluent has a thiocyanate concentration of around 250 mg dm^{-3}. The Environmental Agency will not allow water to be fed into the River Trent with a concentration of above 10 mg dm^{-3}. In fact, the water treatment brings the concentration down to below 1 mg dm^{-3}, well below safe limits.

Treatment of the effluent takes place in huge open air concrete tanks. The tanks contain activated sludge. This key component of the process is biologically active material containing a range of organisms that can break down the contaminants such as thiocyanate ions in the water.

$$SCN^- + 3H_2O + 2O_2 \rightarrow HCO_3^- + NH_4^+ + SO_4^{2-} + H^+$$

Figure 2 Coal is converted to coke in coke ovens. Thiocyanate ions are a by-product.

This process is an example of bioremediation.

The biological changes that occur are aerobic, they need oxygen. Oxygen gas is supplied directly from a nearby BOC plant.

Pumping of oxygen into the water starts automatically when its concentration falls below a set level and stops when a set higher level has been achieved. The demand for oxygen is a measure of the activity of the bio organisms. If the demand falls it could indicate that the population of the organisms has been depleted. The inward flow of oxygen gas also helps to mix and circulate the water/sludge mixture.

The plant operates between 20 °C and 35 °C since this is the optimum temperate range for bio-activity of the organisms used.

The treated effluent and sludge mixture flows from the tanks into clarifiers where the sludge settles out and the treated effluent flows over the top into channels ready for discharge. The water is in the clarifier for about 15 hours and the overall treatment time from entry to discharge is between two and three days.

Water analysis

The water is analysed for thiocyanate at the plant three times a day using a simple colour comparison test. Samples of incoming effluent and water ready for discharge into the river are also taken back to the laboratory on the steel works for accurate analysis.

An acidic solution of iron(III) chloride is added to the water sample and the concentration of thiocyanate in it is measured photometrically by measuring the absorbance due to the iron(III) thiocyanate complex. A total of 16 separate tests are carried out every week.

Figure 3 Inside the analytical laboratory at the Tata Steel site.