

## 2.4 Chemical contaminants

### 2.4.1 Metals

#### 2.4.1.1 Aluminium

Aluminium is a natural constituent of many raw waters, particularly acidic surface waters derived from upland catchments particularly in conifer afforested catchments and its presence is highly episodic related to precipitation. Aluminium compounds may also be introduced into treated water as the result of its use as a coagulant to remove colour and turbidity. Aluminium can deposit within the distribution system and give rise to aesthetic problems. The UK drinking water quality regulations include a national standard for aluminium of 200 µg/l. The standard for aluminium is based on avoiding problems of cloudiness and discolouration rather than being health-based. Aluminium in raw water can be removed by coagulation and filtration. The use of aluminium sulphate as a coagulant in water treatment should normally result in a residual concentration of no more than 50 to 100 µg/l Al. Aluminium in small water supplies can be removed by use of filtration or membrane techniques.

#### 2.4.1.2 Iron and manganese

Iron and manganese derived from minerals and sediments can be present in particulate or dissolved form in groundwaters and surface waters. Iron and manganese concentrations in surface waters are usually less than 1 mg/l but much higher concentrations (up to 50 mg/l Fe and 30 mg/l Mn) can be encountered in groundwaters.

Iron and manganese deposit in treatment and distribution systems and can also interfere with the efficiency of UV disinfection by coating treatment units. Iron and manganese suspensions cause aesthetic problems including metallic taste and discolouration of water fittings and laundry. High dissolved iron and manganese concentrations can also increase chlorine demand and thus reduce the efficiency of chlorine disinfection. The UK drinking water quality regulations include national standards for iron and manganese of 200 µg/l and 50 µg/l, respectively. Iron and manganese can be removed by filtration although oxidation, coagulation and sedimentation may be required for high concentrations particularly if the metals are in dissolved form. An oxidation (aeration) process is invariably required when groundwaters contain more than 1 mg/l of dissolved iron or manganese.

### 2.4.1.3 Lead

The concentration of lead in raw waters rarely exceeds 20 µg/l but higher concentrations do occur in water drawn from strata containing galena or other lead ores. High levels of lead in drinking waters are usually caused by the dissolution of lead (plumbosolvency) from lead pipework, tank linings or use of leaded alloys in water fittings. Traces of lead may also be derived from lead solder and from PVC pipes containing lead-based stabilisers. The UK drinking water quality regulations specify a standard for lead of 10 µg/l to be met by 2013. For small water supply systems the best approach is the replacement of lead-containing materials with non-leaded alternatives. Treatment methods are available to reduce plumbosolvency – see Section 6.10.2. Water that has been standing in lead pipes for long periods, for example overnight, should not be drunk. In these circumstances, the tap should be run for 30 to 60 seconds to clear the pipes before taking water for drinking or cooking.

### 2.4.1.4 Arsenic

Arsenic is introduced into water through the dissolution of minerals and ores, from industrial effluents, and from atmospheric deposition; concentrations in groundwater in some areas are sometimes elevated as a result of water-rock interaction in the aquifer. The most prevalent species of arsenic in water are inorganic. The predominant form is either arsenic (V) (arsenate), which predominates in oxidising conditions, or arsenic (III) (arsenite), which is present in reducing conditions.

Inorganic arsenic is a documented human carcinogen. A relatively high incidence of skin cancer and possibly other cancers that increase with dose and age has been observed in populations ingesting water containing high concentrations of arsenic. The standard for arsenic is 10 µg/l.

Arsenic (V) can be removed effectively by iron or aluminium coagulation. If present as arsenic (III) then pre-oxidation (e.g. using chlorine) is required. Other potential removal techniques include ferric oxide, activated alumina, ion-exchange and reverse osmosis.

### 2.4.2 Nitrate

Nitrate ( $\text{NO}_3^-$ ) occurs naturally in water as a result of the oxidation of ammonia, which is released during mineralisation of organic nitrogen. In some areas agriculture is the major source of nitrate in surface waters and groundwaters. The discharge of nitrate-containing effluents from sewage treatment works contributes to the concentration of nitrate in some surface waters.

Ion-exchange, biological de-nitrification and certain membrane processes can reduce nitrate concentrations. Of these, only ion-exchange and membrane processes are likely to be practicable for small water supplies. It may be appropriate to consider controls over agricultural activities within catchment areas as a long term means of reducing the leaching of nitrate into water supplies, if these are the source.

### 2.4.3 Ammonia

Most natural waters contain traces of ammonia or ammonium compounds. The ammonia found in water may occur naturally or it may indicate that recent pollution has taken place. Certain anoxic groundwaters may contain elevated concentrations of ammonia (greater than 1 mg/l as  $\text{NH}_4$ ) resulting from natural ammonification and denitrification processes. Ammonia may also be derived from the decay of organic material in the soil resulting in small concentrations in water; unpolluted river waters rarely contain more than 0.05 mg/l  $\text{NH}_4$ . On the other hand, the presence of ammonia could indicate contamination from human or animal sources. Elevated concentrations in water should be investigated to ascertain the cause.

The UK drinking water quality regulations set an indicator parameter value for ammonia of 0.5 mg/l  $\text{NH}_4$ . However, the appearance of even small amounts of ammonia (e.g. above 0.05 mg/l  $\text{NH}_4$ ) in a groundwater which is normally free from ammonia warrants further investigations.

Ammonia can be removed from water by aeration (after increasing pH to 11), ion-exchange, biological denitrification and breakpoint chlorination. Of these, only chlorination is likely to be applicable to small supplies. Chlorination converts ammonia to chloramines (see Section 6.9.3) which are less potent disinfectants than chlorine itself and can give rise to taste and odour complaints. Therefore, when designing chlorination systems for ammonia-containing waters, the chlorine capacity must be sufficient to produce a free chlorine residual.

#### 2.4.4 Pesticides

The use of pesticides for agricultural and non-agricultural purposes is widespread and there are approximately 450 different active ingredients in pesticides licensed for use in the UK. In surveys of UK surface and groundwater sources, the most commonly reported pesticides are atrazine, simazine and dieldrin. In the past, atrazine was used almost entirely for non-agricultural control of weeds on roadside verges and railways and much of the use of simazine was attributable to non-agricultural uses. Controls on agricultural uses and withdrawal of approvals for non-agricultural uses of these pesticides were introduced in the UK in 1992. Other pesticides commonly reported in water sources used for public supplies include isoproturon, mecoprop and chlorotoluron. The UK drinking water quality regulations specify standards of 0.1 µg/l for individual pesticides and 0.5 µg/l for total pesticides. These standards do not have any toxicological basis. Some pesticides, e.g. atrazine and simazine, have been found in water sources used for drinking water supplies at levels exceeding 0.1 µg/l. Peaks in pesticide concentrations have been observed in surface waters following heavy rainfall.

Careless or improper use or storage of pesticides can contaminate water sources. Pesticides must not be used near wells. Sheep dip chemicals (organophosphates and synthetic pyrethroids) present a particular risk to water sources. Sheep dip chemicals should be handled carefully, used sheep dip should be disposed of properly (i.e. not to a soakaway), and freshly dipped sheep should be kept away from water supplies.

Several 'advanced' water treatment processes have been investigated for the removal of pesticides including ozonation, activated carbon adsorption and oxidation processes using combinations of oxidants. Concentrations of individual pesticides found in typical surface waters can be reduced to less than 0.1 µg/l by adsorption on granular activated carbon (GAC) with an empty bed contact time of typically 15 to 30 minutes, depending on the pesticide, its concentration, GAC type and system design. Ozonation will also reduce pesticide concentrations to varying degrees. It is unlikely that treatment to remove pesticides from small supplies will be practicable and where significant concentrations are detected it will be necessary to consider provision of an alternative supply.



### **2.4.5 Chlorinated solvents**

Contamination of groundwaters by chlorinated solvents can result from accidental spillage of chemicals, leakage from underground storage tanks, leakage from disposal sites and deliberate discharges to soakaways. The rate of transport of the solvents through the aquifer is dependent on the properties of the aquifer; rapid transport can occur if the overlying material is highly porous or fissured. Contaminated water can travel large distances, making it difficult to pinpoint the source of pollution.

The UK drinking water quality regulations specify standards of 3 µg/l for 1,2-dichloroethane and 10 µg/l for the sum of the detected concentrations of tetrachloroethene and trichloroethene. Solvent concentrations can be reduced by aeration or activated carbon adsorption. Activated carbon adsorption is likely to be the method of choice for small water supplies although provision of an alternative supply may be an economic consideration.

## **2.4.6 Disinfection by-products**

### **2.4.6.1 Trihalomethanes**

Trihalomethanes (THMs) are formed as a result of reactions between chlorine and some organic substances present in raw waters. Highly coloured surface waters which contain humic and fulvic acids are particularly prone to THM formation. The UK drinking water quality regulations specify a standard for Total THMs of 100 µg/l for the sum of the detected concentrations of four specified THMs (trichloromethane, dichlorobromo-methane, dibromochloromethane and tribromomethane).

THM formation can be controlled by reduction of the organic content of the water before disinfection, modification of the disinfection practice or the use of disinfectants other than chlorine, such as ultraviolet radiation or ozone but ozone may cause other problems by reacting with organic matter. THMs precursors can be removed to some extent by adsorption on activated carbon.

### **2.4.6.2 Bromate**

Bromate is not present in source waters but is formed by oxidation of bromide if ozonation is used for water treatment. Elevated bromide concentrations occur where saline intrusion occurs into fresh aquifers in coastal areas, increasing the potential for bromate formation during ozonation. Bromate is also a potential impurity in sodium hypochlorite, a commonly-used disinfectant. The UK drinking water quality regulations specify a standard for bromate of 10 µg/l.

The formation of bromate during ozonation depends on several factors including concentrations of bromide and ozone and the pH. It is not practicable to remove bromide from the raw water and it is difficult to remove bromate once formed, although granular activated carbon filtration has been reported to be effective under certain circumstances. Bromate formation can be minimised by using lower ozone dose, shorter contact time and a lower residual ozone concentration.