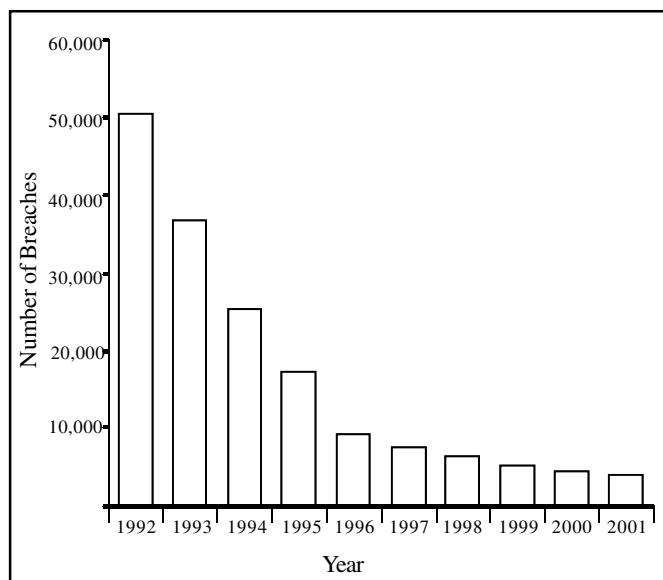




Drinking Water Quality

- In England and Wales drinking water quality is regulated by the Drinking Water Inspectorate (DWI). The DWI checks that our drinking water meets the water quality regulations.
- Water quality is tested at water treatment works, in the distribution networks (e.g. pipes) and at consumers' taps.
- The government sets legal standards for drinking water quality; most of these are based on EC Directives which are themselves based on World Health Organisation (WHO) guidelines.
- In 2001 the water companies in England and Wales carried out 2.8 million tests of which 99.86% passed.
- The DWI takes enforcement action including prosecutions against any company that breaches regulations
- Since 1992 there has been a continuous reduction in the number of breaches of the standards, despite an increase in the number of tests made (Fig 1). The improvement since 1992 is mainly due to fewer breaches of coliform, faecal coliform, aluminium and pH standards.

Fig 1. Number of Breaches of Numerical Standards



In 2001, there were 3348 individual breaches in water supply zones (i.e. the water getting to consumers' taps). The breakdown of these breaches is shown in Fig 2.

Table 1 summarises the sources, acceptable levels and methods of treating drinking water pollutants.

Where does our drinking water come from?

- In England and Wales 66% comes from surface water (reservoirs, lakes, rivers), 34% comes from groundwaters (aquifers such as sandstone) from which water is drawn by wells or bore holes
- The water is tested at water treatment works before flowing through the water mains to be consumed
- Groundwater is usually cleaner than surface water

Fig 2. Contraventions of Standards in Water Supply Zones 2001

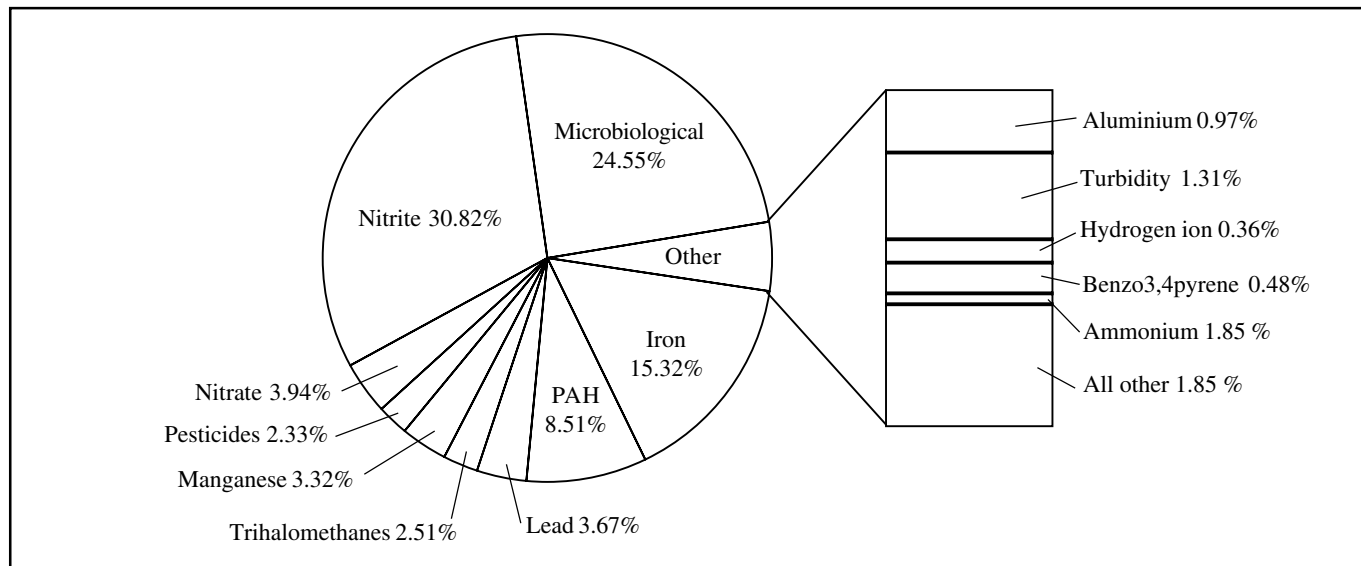


Table 1. Sources, acceptable levels and methods of treating drinking water pollutants

Criteria	Amount Allowed	Key Points	Treatment
Aluminium	200 µg/l	<ul style="list-style-type: none"> Upland rivers and streams may contain naturally high levels of aluminium. Alternatively, high levels may result from the use of aluminium sulphate as a coagulant in the treatment works or if it leaches from cement linings. It is very rare to find aluminium problems in groundwater. Aluminium uptake may be associated with neurodegenerative diseases such as Alzheimer's disease 	Careful regulation of amount added as a coagulant
Ammonium	0.5 µg/l	<ul style="list-style-type: none"> Ammonium salts are naturally present in trace amounts in most water sources 	Decomposed during disinfection
Calcium	250 µg/l	<ul style="list-style-type: none"> Along with magnesium, it is responsible for water hardness 	-
Chloride	400 µg/l	<ul style="list-style-type: none"> Occurs, with sodium, in very small concentrations in all sources 	-
Coliforms	0 per 100 ml	<ul style="list-style-type: none"> Coliforms are used as an indicator that faecal contamination has occurred and that the water may contain much more dangerous bacteria. 	<ul style="list-style-type: none"> Storage in reservoirs allows UV to kill some bacteria Chlorination and ozonolysis Slow sand filters
Cryptosporidium		<ul style="list-style-type: none"> This parasitic protozoan causes cryptosporidiosis, a diarrhoeal illness which can become serious in individuals who are immunocompromised This organism is widespread in drinking water sources 	<ul style="list-style-type: none"> Storage in reservoirs allows UV to kill some bacteria Chlorination and ozonolysis Slow sand filters
Fluoride	1500 µg/l	<ul style="list-style-type: none"> May occur naturally in groundwater. Some water companies fluorideate at the treatment works to reduce tooth decay 	-
Hardness	No Standard	<ul style="list-style-type: none"> Hardness is caused by the presence of ions such as calcium and magnesium. Very hard water will not form a lather with soap. Hard water also leads to scaling of distribution pipes and domestic pipes and boilers; the latter then have reduced efficiency. However, some studies have found that hard water reduces the incidence and severity of cardiovascular disease. 	<ul style="list-style-type: none"> Lime is used to convert soluble calcium or magnesium salts into insoluble ones that can be removed by sedimentation. Ion exchange resins
Iron	200 µg/l	<ul style="list-style-type: none"> When high iron concentrations are found in the distribution network the usual cause is deterioration of iron pipes. For this reason the increase in iron concentration between the treatment works and the consumer's tap can provide a useful indicator of mains condition. Although iron can affect the taste and appearance of the water, there are no health risks associated with breaches of the standard. 	Water treatment involves coagulants or aeration which oxidises the soluble ferrous ions (Fe ²⁺) into insoluble ferric ions (Fe ³⁺) which can be removed by filtration.
Lead	50 µg/l	<ul style="list-style-type: none"> Major source of lead is from the pipes that lead from the water mains in the road to people's houses and the pipes in consumers houses. The greatest risk of leaching occurs where water is acid e.g. in upland areas or when the water is soft. In 2003, the current UK standard of 50 µg/l will be reduced to 25 µg/l and by 2013, the UK is required to reduce this to 10 µg/l Since 1992 there has been a continuous reduction in the number of breaches of this standard mainly because of the measures taken by water companies to decrease the ability of the water to dissolve the lead in the pipes. 	Control of acidity and softness of water by adding lime and orthophosphate reduces the solubility of lead in the pipes.
Manganese	50 µg/l	<ul style="list-style-type: none"> Some upland surface water and some groundwaters contain high natural manganese but high concentration may also occur if manganese filters deteriorate. As with iron, manganese poses little health risk but it can affect taste and results in staining. 	Treatment involves aeration, where the soluble form is converted into an insoluble form which can then be filtered out. Groundwater may be treated with sodium silicate which results in iron and manganese forming insoluble complexes.

Table 1. Sources, acceptable levels and methods of treating drinking water pollutants (continued)

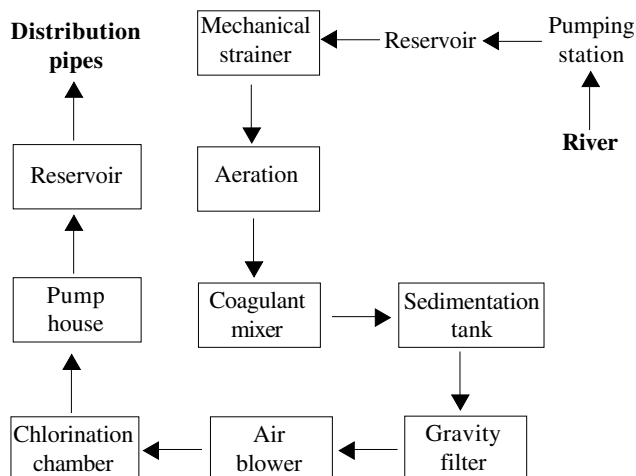
Criteria	Amount Allowed	Key Points	Treatment
Nitrate	50mg/l	<ul style="list-style-type: none"> If nitrate levels exceed the regulatory limit (50 mg/l) in final drinking water, the cause is always poor treatment The major source of NO_3^- in water is diffuse pollution from agricultural land. (A point pollutant is one that comes from a single easily-identifiable source such as a factory. A diffuse pollutant does not come from a point source; rather it is the cumulative effect of lots of small, unspecified sources over a large area). 	<ul style="list-style-type: none"> Blending with cleaner water Storage to allow natural denitrification Removal by ion exchange (a resin replaces the NO_3^- ions with Cl^- ions) Microbial denitrification
Nitrite	0.5 mg/l	<ul style="list-style-type: none"> In 2001 this standard was the one which was most commonly failed The current standard of 0.1 mg/l is usually exceeded because of the formation of chloramines when chlorine and ammonia react together. When the chloramines break down nitrites are released. Nitrites may lead to the problem of methaemoglobinemia (where the haemoglobin in the blood is unable to carry sufficient oxygen) and the development of carcinogenic nitrosamines in the stomach The new EC Drinking Water Directive contains a revised combined standard for NO_2^- & NO_3^- as well as a separate NO_2^- figure which applies at the treatment works. 	Careful use of chlorine and ammonia at treatment works so as to regulate the production of chloramines.
Polycyclic aromatic hydrocarbons (PAH)	0.2 µg/l	PAHs are present in coal tar linings which were used to protect water mains before 1970.	Activated carbon filter
Pesticides	0.1 µg/l	<ul style="list-style-type: none"> 1980 EC Drinking Water Directive set a limit of 0.1 µg/l for each pesticide and a total pesticide limit of 0.5 µg/l. These limits still apply. Sources: agricultural land, weed control on paved areas, road verges, golf courses and railway lines In 2001, 11 pesticides were found at concentrations higher than 0.1 µg/l but in no cases were concentrations thought to be harmful to health. In some cases the substances which are formed as a pesticide degrade are more toxic than the original pesticide 	<ul style="list-style-type: none"> Activated carbon filters Reaction with ozone
pH	5.5-9.5	If water is too acidic it may corrode pipes. If too alkaline, salts will be deposited which will slow the flow in the pipes	Addition of alkalis and acids if necessary
Odour and taste	No Standard	Odour and taste occur naturally, especially in surface water sources in the summer	Organic substances which influence odour and taste are removed by activated carbon filters or ozone
Total dried solids	1500 mg/l	This is a measure of the naturally-occurring minerals in water	Coagulation
Total Organic Carbon (TOC)	No Standard	TOC represents the total amount of organic matter in the water. The concentrations found throughout the UK do not present any risk to health	<ul style="list-style-type: none"> Adsorption using activated carbon Coagulation
Trihalomethanes (THMs)	100 µg/l	THMs are formed during the disinfection process by reaction between chlorine and naturally-occurring organic substances.	Activated carbon filters
Turbidity	4 Formazin Turbidity Units	<p>High turbidity can result from:</p> <ul style="list-style-type: none"> Ineffective coagulation at the treatment works. This might occur if the sediment was not incorporated into floc or if the floc could not be removed efficiently Corrosion of the water mains Turbidity is considered a useful surrogate for pollutants such as iron and aluminium that are present in particulate form 	Coagulation & filtration

Table 2. Treatment techniques

Activated carbon filters (AC filters)	<ul style="list-style-type: none"> • Use activated charcoal • The charcoal is treated with oxygen in order to open up millions of pores between the carbon atoms • This effectively increases the surface area of the charcoal which increases the amount of pollutants that can be adsorbed (chemically or physically attached to the surface) on to the charcoal • AC filters are particularly useful for removing organic pollutants from water – many of which would otherwise affect its taste and odour • Substances that will be adsorbed by these filters include: trihalomethanes (THMs), pesticides, industrial solvents, polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs) • AC filters do not remove microbes, nitrates, fluoride or hardness
Chemical precipitators	<ul style="list-style-type: none"> • Compounds are added to the water that chemically react with particular pollutants or which neutralise the repelling charges of ions which are then able to form a floc that will sediment out. The products of the reaction either then sink or float to the top so that they can be removed • Substances that can be removed by chemical precipitation: lead, chromium, silver, mercury, arsenic
Chlorination	<ul style="list-style-type: none"> • Chlorine is a powerful oxidising agent and kills most bacteria and some viruses. Activated carbon filters can then remove any excess chlorine and some potentially toxic chlorine compounds that have been formed • Chlorination removes: most bacteria, iron, hydrogen sulphide, some viruses
Ozonolysis	<ul style="list-style-type: none"> • Ozone is produced electrically from oxygen. It is a more powerful oxidising agent than chlorine, and breaks down most organic molecules. UV light will then break down the ozone into oxygen after about 20 minutes
Ion exchange resins	<ul style="list-style-type: none"> • Water is pumped through a resin that usually contains sodium. Contaminants such as iron, manganese and many heavy metals, along with the calcium and magnesium responsible for hardness, are removed in exchange for sodium ions
Ultraviolet light	<ul style="list-style-type: none"> • UV light kills or deactivates pathogens by disrupting their DNA or proteins. UV has limited effect on <i>Cryptosporidium</i> cysts

Practice Questions

The figure below shows stages in water treatment



- (a) Outline the scientific principle of each of the following stages:
- reservoir storage (2)
 - flocculation (2)
 - sedimentation (2)
 - fluoridation (2)

Answers

- (a) (i) allows sedimentation; uv kills pathogens;
- (ii) neutralisation;
of repelling/electrical charges;
- (iii) water left to stand/no kinetic energy of movement;
material sinks;
- (iv) strengthens enamel;
reduces tooth decay;

Sources of information: Drinking Water Inspectorate www.dwi.gov.uk

Acknowledgments: This Factsheet was researched and written by Kevin Byrne Curriculum Press, Unit 305b, 120 Vyse Street, Birmingham. B18 6NF Environmental Science Factsheets may be copied free of charge by teaching staff or students, provided that their school is a registered subscriber. No part of these Factsheets may be reproduced, stored in a retrieval system, or transmitted, in any other form or by any other means, without the prior permission of the publisher. ISSN 1351-5136