Chromium

What is chromium and where does it come from?

Chromium is a natural element that is relatively common and widely distributed in soils and rocks and occurs in rivers and seawater. People are most familiar with chromium as a bright, shiny metal which is used to plate car bumpers, handles and other items. But in nature chromium usually exists combined with other chemical elements (for example oxygen and potassium) in the form of chromium compounds. Many chromium compounds are also manufactured commercially and these typically exist as powdery solids, most of which are brightly coloured. For example, chromic oxide and chromium nitrate are green powders and potassium chromate is a yellow crystalline solid.

Chromium also forms alloys (i.e. mixtures with other metals), notably with steel.

What is chromium used for?

Chromium metal is very resistant to corrosion and so is widely used to plate steel and is an important constituent of stainless steel.

Chromium compounds are also used in a wide range of processes and products. Some common examples are:

Electroplating

- chromium trioxide
- chromium sulphate

Paints and inks

- chromic oxide and chromic sulphate are green pigments
- lead chromate and chromium chromate are anti-corrosive pigments

Wood preservatives

- chromium acetate
- sodium dichromate
- chromium trioxide

Leather tanning

- chromic sulphate
- potassium chromate
- sodium chromate

Textiles

- chromic sulphate is a green dye
- chromium oxide, chromium acetate and chromium nitrate are used to fix dyes

Refractories

- 'chromite' the main ore of chromium is used to make fire bricks for lining furnaces

Chromium is also present as an impurity in oil-based fuels and lubricants and in coal and so is also present in these products.

How does chromium get into sewage treatment works?

No chromium is added at sewage treatment works as part of the treatment process. Any chromium in sewage is there because it has somehow entered the sewerage system via drains in homes, or business premises, or from drains in the streets and roads. There are five main routes by which chromium-containing materials can end up in sewers and, under each of these headings, a range of specific actions can contribute to chromium reaching sewage treatment works. For example:

Industrial activities

- businesses such as textile printing works, or electroplaters may discharge process waste containing chromium compounds directly into the local sewer

Service activities

- a garage mechanic may wash out paint spraying equipment and flush residues of paint containing zinc chromate down the drain

Run-off

- particles of dust accumulating on roads and pavements may contain traces of chromium from the burning of oil-based fuels and coal and will be washed down the drains when it rains

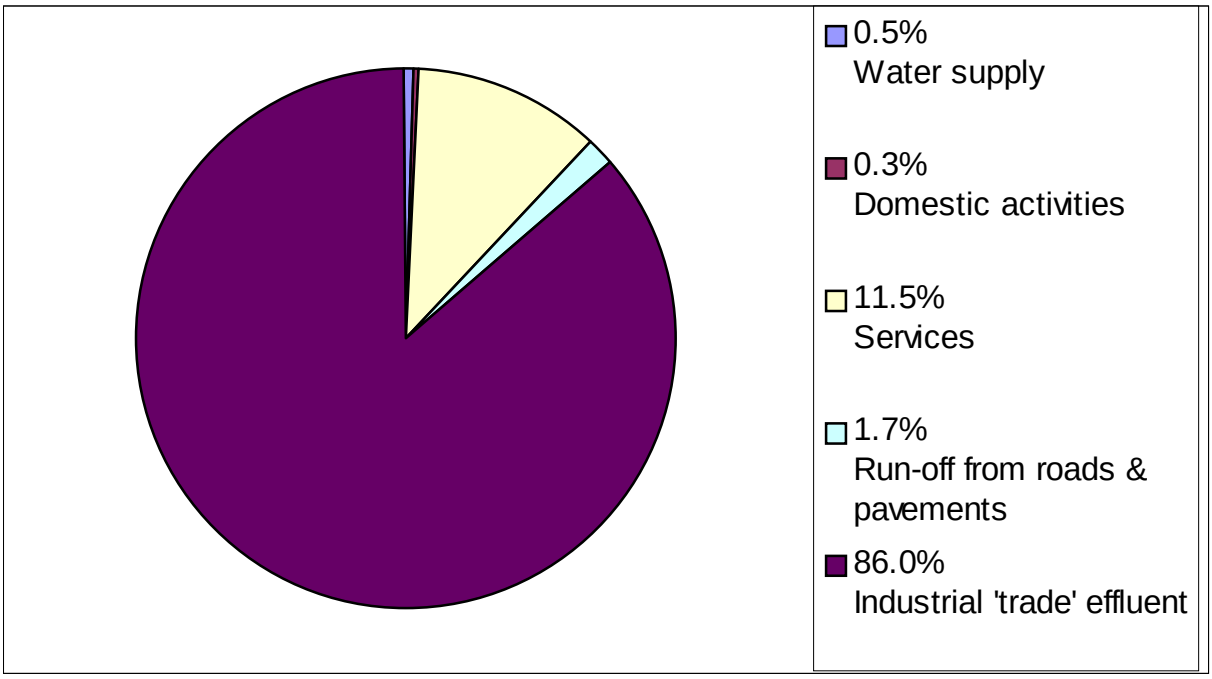
Domestic water supply

- chromium occurs naturally in all water sources and is also therefore present in the drinking water supply, so anybody using water for drinking, cooking, washing, bathing or going to the toilet, flushes water containing chromium into the sewer

Domestic activities

- chromium occurs naturally in meat, fish, fruit and vegetables and so is present in all human wastes which are flushed down the toilet
- Inputs of chromium from domestic activities and the domestic water supply are relatively very low (around 1% of the total).

The chart gives an estimate of the relative contributions of chromium which typically come from each of the main sources of input to sewers.



Estimated inputs of chromium to sewer from different sources in England
(Note: The estimates shown are typical values averaged for the whole of England, but are likely to vary depending on local population characteristics)

The numbers given in the chart are approximations based on the best currently available information, but nevertheless provide some interesting insights into how chromium gets into the sewage treatment system:

- Most of the chromium entering the sewerage system comes from industrial activities such as electroplating and textile dyeing and printing.
- Services facilities such as garages, photo processing labs and labs in schools, colleges and hospitals also make significant inputs of chromium (around 11-12% of the total). These inputs come from activities such as cleaning out paint spraying equipment (garages) and flushing away waste chemical reagents (laboratories).
- Run-off from roads and pavements makes a small contribution (around 2%). Chromium occurs naturally in gas, oil and coal and so when fuel is burned exhaust particles containing small amounts of chromium are dispersed into the atmosphere and may settle out on hard surfaces. Chromium containing dust will also be deposited directly in locations where chromium is being smelted.

Releases of chromium from sewage treatment works

Sewage treatment works perform an important function in reducing the amount of chromium in sewage, before it is discharged to rivers.

Chromium can enter the sewage system in a wide variety of materials – as the pure metal, or as one of the many compounds of chromium. But once in sewage, chromium exists in one of two chemical forms – so-called 'trivalent' chromium or 'hexavalent' chromium. These chemical states determine how chromium reacts with other materials and also how it may effect living things (see next section).

Trivalent chromium has a strong tendency to stick to solid particles, but hexavalent chromium much less so. Much of the chromium entering the sewage treatment process as trivalent chromium is therefore typically bound to suspended solid materials (faeces etc) rather than being dissolved in the effluent. One of the main functions of sewage treatment works is to remove these solid materials from the effluent and separate them as sludge. It follows that any chromium bound to the solids will also be removed from the effluent to the sludge.

Typically between 50% and as much as 80% of the total chromium received at a works is removed from the final effluent before discharge.

The potential for chromium to cause health or environmental problems

Chromium occurs naturally in all foods and water and in small amounts 'trivalent' chromium is an essential part of the human diet. Prolonged contact with some chromium compounds can however cause dermatitis and swallowing very large amounts of chromium can cause vomiting, diarrhoea and kidney failure. Chromium in the 'hexavalent' form is generally more toxic than metallic or 'trivalent' chromium and can cause cancer in workers who are exposed over a long period of time.

Based on what is known about the medical effects of chromium, government-sponsored research has proposed a safe limit for chromium in rivers which people use for bathing and water sports. This says that, providing the level of chromium does not exceed 0.5 milligrammes per litre of water, there should be no health problems caused because of skin contact or people accidentally swallowing river water. In fact, average levels of chromium measured in UK rivers are generally well below this level, except in certain locations with a naturally high level of chromium in the rocks and which are affected by run-off from old mine workings.

Although chromium occurs naturally in rivers, as for humans, too much can damage wild plants and animals. Chromium in the dissolved form is potentially quite toxic to aquatic animals and plants, especially to young life-stages such as fish larvae. As for humans, the toxicity of chromium to river life depends on whether it is present in the trivalent or hexavalent chemical form. The toxicity of chromium is reduced when it is bound to particulate matter in the river water and this is more likely to be the case with trivalent rather than hexavalent chromium. "Hard" water (i.e. water containing a high level of calcium carbonate) generally reduces the toxicity of all forms of chromium. The Environment Agency uses a set of Environmental Quality Standards (EQSs) when assessing the level of chromium in rivers. These Standards specify the concentrations of chromium below which no harmful effects on aquatic animals and plants are to be expected. The standards incorporate wide safety factors and also take account of the "hardness" of the water:

- For *dissolved* chromium, the acceptable average concentration in river water for salmonid fish varies from 0.005 to 0.050 milligrammes per litre (depending on the hardness of the water, i.e. more dissolved chromium is allowed as water hardness increases)
- For *dissolved* chromium, the acceptable average concentration in river water for cyprinid fish (i.e. coarse fish) varies from 0.150 to 0.250 milligrammes per litre (depending on the hardness of the water)

The information given in the Pollution Inventory is not, however, directly comparable with the Environmental Quality Standards. The Pollution Inventory shows only the total weight of chromium which is discharged by each sewage treatment works every year - it does not give the concentration of chromium in the receiving river. Neither does the Inventory show the maximum concentrations of chromium which each works is permitted to discharge.

So to understand the significance of releases of chromium from sewage treatment works in your area, you will need to obtain further information about measured levels of chromium in the stretch of river you are interested in and how these compare with the statutory EQS. This information can be obtained from your local Environment Agency office.

Controlling releases of chromium from sewage treatment works

Monitoring evidence indicates that, in general terms, chromium releases from sewage treatment works are not significantly impairing the quality of rivers in England and Wales. Countrywide action to further reduce chromium outputs is not therefore seen as a priority at the present time.

Where breaches of the Environmental Quality Standards for chromium in rivers in England and Wales have occurred, these have mostly been associated with run-off from old mine workings or direct discharges to rivers from industrial sites, rather than from sewage treatment works.

Industrial sites that discharge chromium into sewers are policed by the water industry, through a system of consents. If high levels of chromium in a stretch of river can be traced back to a particular industrial discharge to sewer, then remedial action can usually be taken through the consent process.

The Pollution Inventory

The Pollution Inventory is more correctly described as an emission register. It is a national record of the amounts of metals and chemicals that are released into the air, or are discharged into rivers or are deposited on the land every year in England and Wales. It does not take into account the impact of the materials on the environment. Materials recorded in the Pollution Inventory may be released into the environment direct from industrial processes. Specified industrial sites,

such as oil refineries and power stations, must report their releases every year to the Environment Agency.

But Pollution Inventory materials do not just feature in major industrial processes. Many domestic and commercial activities also use these materials, which often end up being flushed down drains into the sewerage network and are eventually discharged into rivers via sewage treatment works. The Pollution Inventory now, therefore, also includes information about releases from sewage treatment works. Sewage treatment works generally discharge large volumes of water which may contain low concentrations of Pollution Inventory materials.

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