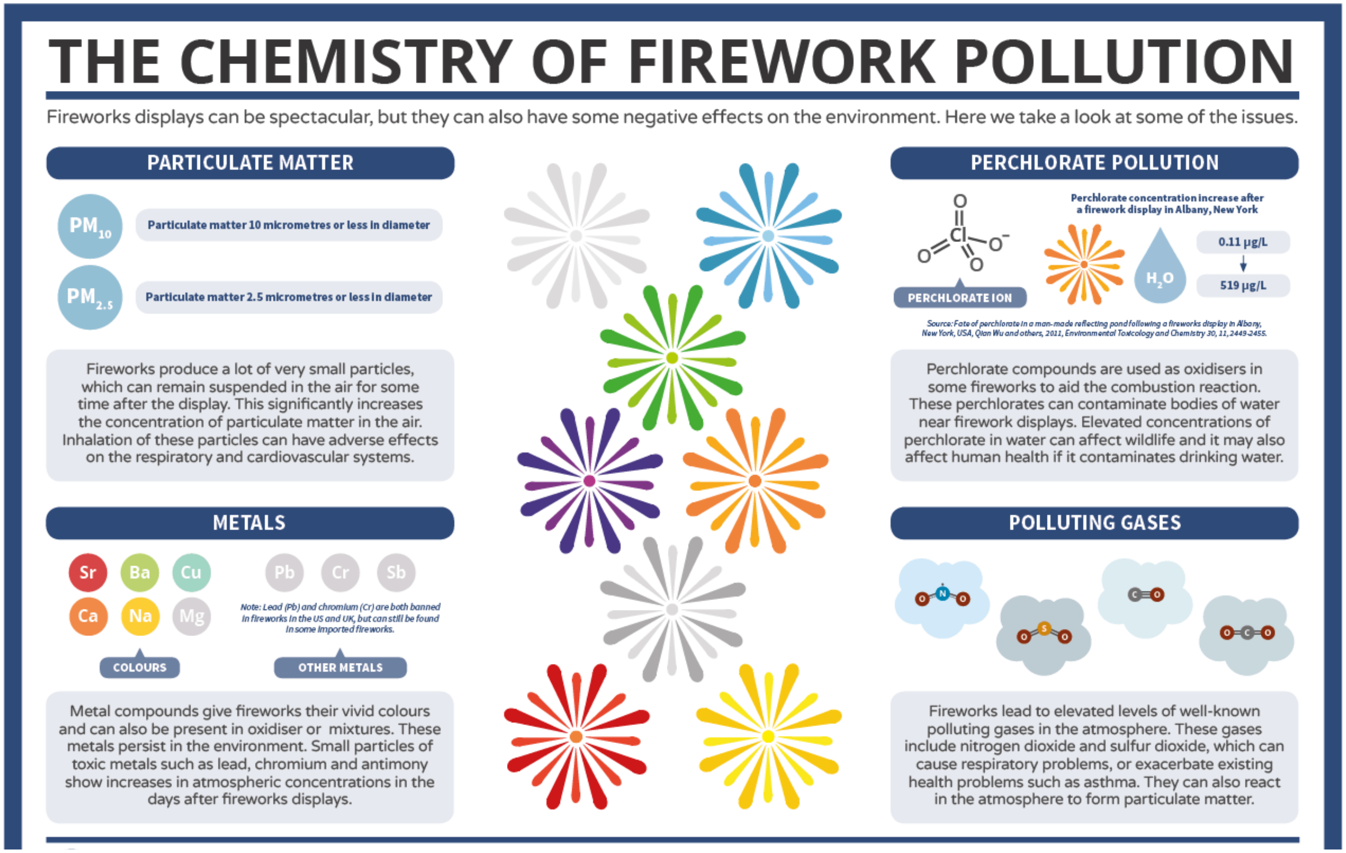
Atmospheric Chemistry

The Dark Side of Fireworks – The Chemistry of their Environmental Effects

By Andy Brunning — January 5, 2017



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Many of us enjoyed watching spectacular fireworks displays to usher in the new year. However, the vibrant colours of fireworks belie the effects that they can have on the environment. With this graphic, we take a look at some of the issues that they can cause.

To an onlooker, it seems as if fireworks simply disappear without a trace after delivering their fiery payload to the skies. This isn't the case though – they leave behind billions of tiny particles, a complex chemical mix born from the various components that made up the firework. The particulate matter left behind after a firework's demise is one of the most significant polluting issues, and one that scientists have looked into in some detail.

Of particular interest to those investigating environmental problems linked to fireworks are some of the smallest particles left behind, generally referred to as particulate matter (PM for short). Particulate matter is usually divided into two categories of interest: PM10, which refers to particles with a diameter of 10 micrometres or less, and PM2.5, which refers to particles with a diameter of 2.5 micrometres or less. For the purposes of comparison, a human hair has a diameter of 50-70 micrometres.

After a fireworks display, a number of studies have shown that the concentration of particulate matter in the local atmosphere is noticeably increased for days after the display. Just this week in Germany, particulate levels reached 26 times the EU recommended limit of 50 micrograms per cubic metre of air, with figures suggested that across the country over 4,000 tons of particulates were ejected into the atmosphere by fireworks displays. Meanwhile, a study in the US found that particulate concentrations increased by up to 370% in the 24 hours after an Independence Day firework display.

These higher levels of particulates can have effects on our health. The particles remain suspended in the air and can be breathed in. This can cause respiratory problems, or exacerbate conditions such as asthma. Long term exposure to particulate matter is associated with respiratory and cardiovascular disease.

It's not only the presence of these particles that can cause problems – the chemical nature of some of them can also have detrimental effects. The colours of fireworks derive from compounds of different metals, and some metal compounds are also used as components in the explosive mixture. Small particles of these metals are dispersed by the fireworks' explosions; barium, compounds of which can be used to give green colours, is one such example.

Other metals have been banned from fireworks in some countries due to their toxicity – these include lead and chromium. However, imported fireworks from countries where these metals are not banned can still lead to them being released during fireworks displays, and increased levels have been recorded in the local atmosphere after displays.

As well as the metals, another kind of compound can also cause problems. Perchlorate compounds are used in some fireworks as oxidisers – chemical compounds which release oxygen and help fuel the combustion reaction inside the firework. Perchlorate can contaminate water when it settles to earth after fireworks displays, and studies have shown that perchlorate concentration in nearby bodies of water can increase significantly, in some cases increasing by over 1000 times the usual average value.

Perchlorate can pose a risk to aquatic organisms, but in some cases it may also pose a risk to us. There is concern that ingestion of perchlorate might interfere with the production of thyroid hormones if it gets into the body. After fireworks displays there is the possibility of perchlorate contaminating drinking water supplies.

Finally, pollutant gases we're already familiar with can also be produced by fireworks. These include gases such as nitrogen dioxide and sulfur dioxide, which can cause respiratory problems if their concentration in the local atmosphere is heightened. Whilst the levels of these compounds produced by fireworks pales in comparison to those produced by the burning of fossil fuels or the combustion of petrol in cars, it can still have an impact at a local level. Their effects were examined in a previous post on atmospheric pollutants.

Scientists aren't idly sitting by in light of these problems. Efforts are being made to make 'greener' fireworks that have less of an impact on the environment. Recently, compositions which reduce the need to use perchlorate compounds in firework compositions have been developed, and other efforts have been made to reduce the presence of harmful combustion products. That said, there's still plenty still to do to reduce the environmental effects further.

So next time you're at a fireworks display, do enjoy the colours – but bear in mind the environmental impact!

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References & Further Reading

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- Effect of Independence Day fireworks on concentrations of fine particulate matter – D J Seidel and A N Birnbaum
- Fallout from fireworks: perchlorate in total deposition – J Munster and others
- Fate of perchlorate in a man-made reflecting pool following a fireworks display – Q Wu and others
- Perchlorate behaviour in a municipal lake following fireworks displays – R T Wilkin and others
- Fine particulate matter in the United Kingdom – Air Quality Expert Group
- Hazardous metals in ambient air due to New Year fireworks – J A Licudine and others

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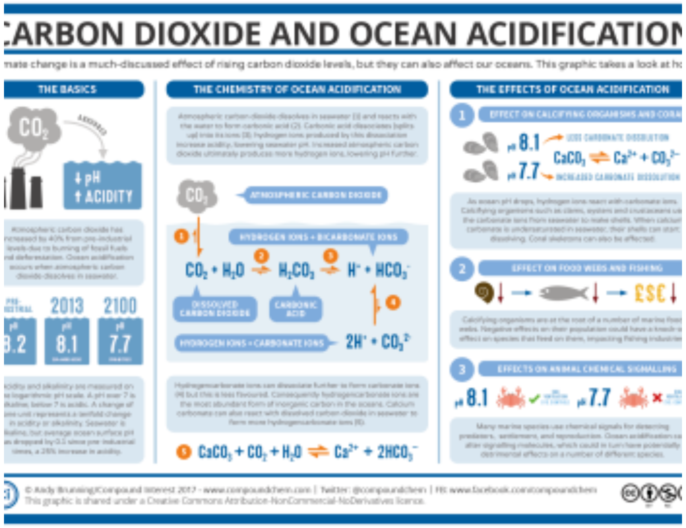

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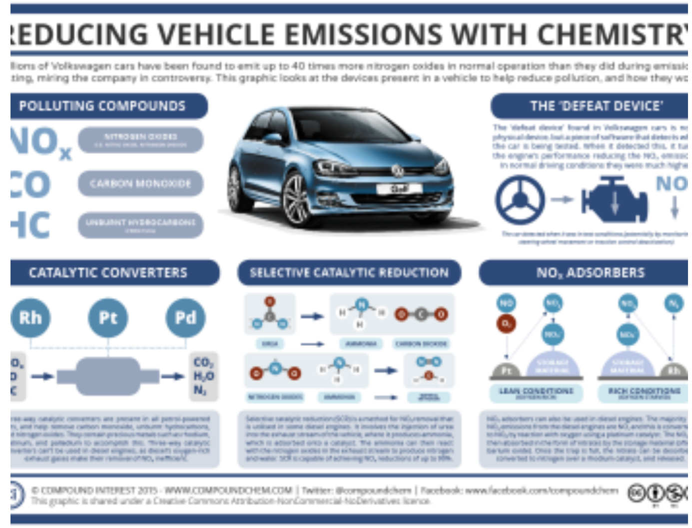

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