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What else might be in your Ceiling Dust?

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ED. NOTE: The following essay is extracted from the manuscript, "Nuclear Coal" which appears in Karl Kruszelnicki's 1995 book "Sensational Moments in Science" published by ABC Books. (Reprinted with kind permission of ABC Enterprises) The book is available for $17.95 from ABC Shops. Though lead is not specifically mentioned, lead does occur in coal naturally and some of the lead now found at sometimes mineable levels in ceiling dusts in urban areas surely comes from coal-burning - both house-hold and in power stations. All five power stations in Sydney's inner suburbs (two at Balmain, one each at Ultimo, Pyrmont and Botany) are now closed and converted to museums or housing estates. Plumes of toxic dusts have been shown to migrate 200 km from industrial stacks. Also, the end product of the radioactive decay of Plutonium, is Lead.

It was the Chinese who first used coal as a fuel back in 1100 BC. Even today, most of the electricity in the world is made by burning coal. In 1990, 66% of the world's electricity was made by burning fossil fuels, while nuclear power accounted for only about 15%. But according to Alex Gabbard of the Metals and Ceramics Division of the Oak Ridge National Laboratory in the USA, a coal-fired power plant gives off more radiation than a nuclear-fired power plant!

The process of making electricity is almost identical in a coal-fired power plant and a nuclear power plant. In each type of plant, heat turns water into steam. The steam is blasted onto the blades of turbines, which then spin. The turbines are attached to generators or alternators, which make the electricity. (There is one minor exception to this rule that steam turns the turbine blades. A helium-cooled nuclear reactor uses helium gas, not water/steam, to turn the turbines).

In a coal-fired power plant, the heat to turn water into steam comes from burning coal.

In a nuclear power plant, the heat comes from the splitting of atoms of uranium, thorium or plutonium. This splitting process, called fission, when enough fissionable nuclear fuel is placed close enough together, so that a nuclear reaction happens.

The difference between a coal-fired power plant and a nuclear-fired power plant is what provides the heat. But what's the same, is that in each type of electrical power plant, heat makes steam which makes electricity.

Now coal is a very impure fuel. It's mostly carbon, but there are impurities like silicon, aluminium, calcium, magnesium, sodium, titanium, arsenic, potassium, sulphur and mercury and tiny amounts of uranium and thorium. In fact, 73 different elements have been identified in coal! On average, coal has 1.3 parts per million of uranium and 3.2 parts per million of thorium. (In fact, until modern analytical methods were invented, these tiny amounts were simply too small to be measured.) These are very small quantities, but on the other hand a lot of coal gets burnt.

To run your average 1000 megawatt coal-fired power plant, you need to burn about 4 million tonnes of coal. That 4 million tonnes of coal contains 5.2 tonnes of uranium and 12.8 tonnes of radioactive thorium - as well as 0.22 tonnes of radioactive potassium-40. But that's just from a single 1000 megawatt plant in just one year.

The world-wide use of coal in 1991 was about 5,100 million tonnes. When that coal was burnt, some 6,630 tonnes of uranium and 16,320 tonnes of thorium were released into the biosphere.

That 6,630 tonnes of uranium included over 47 tonnes of uranium-235 - the stuff that goes bang. That 47 tonnes of uranium-235 could be made into some 1,700 World War II-style atom bombs, with a total combined explosive yield of 34 megatonnes. In fact, just a single 1,000 megawatt coal-fired power station releases enough uranium-235 to make a World War II-style atom bomb each year.

And if you look at the amount of coal that is predicted to be burnt in the 100-year period from the year 1937 to the year 2037, you're looking at 640 billion tonnes of coal. That enormous pile of coal contains about 830,000 tonnes of uranium, 2,000,000 tonnes of thorium and 35,000 tonnes of potassium-40 - all of it free to enter the biosphere! We are still not too sure where it all goes. Uranium and thorium are not very mobile, but potassium-40 can easily enter the food chain.

If in the year 2037 there are 8 billion people on the planet, that works out that for every person there will be a paddle pop's worth of uranium (about 100 grams of uranium) and three paddle pop's worth of thorium - all thanks to coal-burning.

When coal is burnt, the carbon combines with oxygen. The products of this reaction are heat (used to make electricity) and carbon dioxide. But in coal, there are also various inorganic impurities which don't get burnt.

These impurities turn into coal ash, which can make up between 3-30% of the weight of the coal, depending on the type of coal.

There are two types of coal ash - bottom ash, and fly ash. In 1975, the USA burnt 410 million tonnes of coal - leaving 63 million tonnes of ash, which was made up of 41 million tonnes of fly ash and 22 million tonnes of bottom ash. That's enough ash to cover an area 12 kilometres by 12 kilometres to a depth of 30 cm - and that was only one year's worth!

The bottom ash tends to be made from coarser, heavier particles, which don't get lifted up into the chimney. It's called bottom ash because it's collected from the bottom of the boiler.

Fly ash is the stuff that "flies" up the chimney. Fly ash can make up between 10-85% of the coal ash - depending on the type of burner, the type of boiler, the type of coal, etc.

Fly ash is about 50-90% glass. The glass forms as silicon melts during the burning of the coal. The glass is mostly in the shape of tiny balls, between 0.5-100 microns in diameter (for comparison, a human hair is about 70 microns in diameter). It turns out that heavy metals like uranium tend to stick to these microscopic balls of glass, that make up most of the fly ash. This ash is actually richer in uranium and thorium than the original coal, because while the carbon content was reduced during the burning, the amounts of uranium and thorium stayed the same.

Nowadays, coal-fired power plants have precipitators on the chimneys to catch the fly ash, but these precipitators are only about 99.5% efficient. So a small amount of fly ash does escape, contaminated with radioactive metals. Now it's only a very small amount of fly ash that escapes, but your average power plant burns up a lot of coal.

But besides the bottom ash and the fly ash, there's another source of radioactivity from a coal-fired power plant. The radioactive gas, radon-222, goes straight up the chimney when the coal is burnt. The precipitators that catch fine particles have no chance of capturing a gas.

When you add up all the radioactivity released from a coal-fired power plant, you find that a coal-fired power plant dumps much more radioactivity into the biosphere than a nuclear-fired power plant. According to the United States National Council On Radioactivity Protection And

Measurements, the radiation exposure from an average 1000 megawatt power plant comes to 490 person-rem/year for coal-fired power plants and 4.8 person-rem/year for nuclear-fired power plants. In other words, your average coal-fired power plant puts out about 100 times more radiation than a nuclear-fired power plant!

Of course, that factor of 100 just looks at the nuclear-fired power plant by itself. It doesn't include the complete nuclear fuel cycle, which starts with ore mining, goes to fuel processing and operation of the reactor, and finishes with waste disposal. In that case, the radiation dose per citizen from a nuclear-fired power plant rockets up to 136 person-rem/year. So, according to the Oak Ridge National Laboratory figures (that include the complete nuclear cycle), you'll still get over three times more radiation from a coal-fired power plant, than from a nuclear-fired power plant. A coal-fired power plant looks even less attractive when you include the carcinogenic chemicals created by the burning of coal.

Now at the moment, nobody really thinks much about coal waste. On one hand it might become the clean-up nightmare of the future, but on the other hand, coal waste has many potentially useful metals in it. For example, these radioactive metals that are present in coal are loaded with energy. In fact, there is one and a half times as much energy in the radioactive metals, as there is in the carbon! That potential energy is just being wasted.

Burning Coal Gives You Everything

Coal chemistry is a vast cauldron of witch's brew. One obvious result is vast amounts of the greenhouse gas, carbon dioxide, being released into the atmosphere. There are many carcinogenic chemicals made when coal is burnt. Oxides of sulphur are known to cause acid rain, and oxides of nitrogen cause breathing problems.

Look at arsenic, which is present in coal at about 5 parts per million .That works out to 26,000 tonnes of arsenic released into the biosphere each year.

Uranium-238 released from coal by burning, can go up a chimney as uranium-238, but can land as plutonium-239. Our atmosphere is loaded with neutrons, which come from cosmic rays colliding with our atmosphere. When a neutron hits uranium-238, it converts it into plutonium-239.

Uses For Coal Ash

At the moment, coal ash is being used mainly as landfill, in concrete and cement, in roads and pavements, and in bricks.

There have been a few specialised low-volume uses. Cenospheres [hollow balls of glass filled with nitrogen and carbon dioxide, which make up about 20% of the volume of fly ash] .have been used to make a tape for fire-proofing and insulating high-voltage cables, and also to make a closed-pore insulation material for the Space Shuttle. Fly ash has also been used to improve the yield of rice paddies.

Where Is Coal?

It's hard to get consistent figures about who has the world's recoverable coal reserves. According to The World Energy Council, China leads with 45%, followed by the USA with 17%, the former USSR with 12, and South Africa with 5%.

Australia has about 4% of the world's coal reserves. It is also the largest coal exporter in the world. In 1993, Australia exported 131.8 million tonnes of coal. That coal contained about 171 tonnes of uranium.