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How war debris could cause cancer

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- Oliver Tickell

COULD the mystery over how depleted uranium might cause genetic damage be closer to being solved? It may be, if a controversial claim by two researchers is right. They say that minute quantities of the material lodged in the body may kick out energetic electrons that mimic the effect of beta radiation. This, they argue, could explain how residues of depleted uranium scattered across former war zones could be increasing the risk of cancers and other problems among soldiers and local people.

Depleted uranium is highly valued by the military, who use it in the tips of armour-piercing weapons. The material's high density and self-sharpening properties help it to penetrate the armour of enemy tanks and bunkers. Its use in conflicts has risen sharply in recent years. The UN Environment Programme (UNEP) estimates that shells containing 1700 tonnes of the material were fired during the 2003 Iraq war.

Some researchers and campaigners are convinced that depleted uranium left in the environment by spent munitions causes cancer, birth defects and other ill effects in people exposed to it. Governments and the military disagree, and point out that there is no conclusive epidemiological evidence for this. And while they acknowledge that the material is weakly radioactive, they say this effect is too small to explain the genetic damage at the levels seen in war veterans and civilians. Studies back this up: in 2005, Albert Marshall of Sandia National Laboratories in New Mexico showed that even the most heavily exposed soldiers during the Gulf war of 1990-91 had only around a 1 per cent greater risk of developing lung cancer compared with those who hadn't been exposed.

Organisations such as the UK's Royal Society, the US Department of Veterans Affairs and UNEP have called for more comprehensive epidemiological studies to clarify the link between depleted uranium and any ill effects.

Meanwhile, various test-tube and animal studies have suggested that depleted uranium may increase the risk of cancer, according to a review of the scientific literature published in May 2008 by the US National Research Council. The review cites a wide range of studies, including one from 2007 by John Wise and colleagues at the University of Southern Maine in Portland which showed that depleted uranium dust induced mutations in the chromosomes of human lung cells (*Chemical Research in Toxicology*, vol 20, p 815). The authors of the NRC report argue that more long-term and quantitative research is needed on the effects of uranium's chemical toxicity. They say the science seems to support the theory that genetic damage might be occurring because uranium's chemical toxicity and weak radioactivity could somehow reinforce each other, though no one knows what the mechanism for this might be.

Now two researchers have a new theory that they say explains how depleted uranium could cause genetic damage. Chris Busby of the Institute of Plant Nutrition and Soil Science (IPNSS) in Braunschweig, Germany, and the University of Ulster, UK, and Ewald Schnug, director of the IPNSS, claim that uranium atoms in the body could act as "radiation antennas". They argue that uranium atoms could be capturing photons of background gamma radiation and then re-emitting their energy as fast-moving electrons that act on the surrounding tissue in the same way as beta radiation.

This "phantom radiation" could be over 1000 times more damaging than the alpha particles released by depleted uranium's slow nuclear decay, according to their preliminary calculations.

Their theory invokes a well-known process called the photoelectric effect. This is the main mechanism by which gamma photons with energies of about 100 kiloelectronvolts (keV) or less are blocked by matter: the photon transfers its energy to an electron in the atom's electron cloud, which is ejected into the surroundings.

An atom's ability to stop photons by this mechanism depends on the fourth power of its atomic number - the number of protons in its nucleus - so heavy elements are far better at intercepting gamma radiation and X-rays than light elements. This means that uranium could be especially effective at capturing photons and kicking out damaging photoelectrons: with an atomic number of 92, uranium blocks low-energy gamma photons over 450 times as effectively as the lighter element calcium, for instance.

Busby and Schnug say that previous risk models have ignored this well-established physical effect. They claim that depleted uranium could be kicking out photoelectrons in the body's most vulnerable spots. Various studies have shown that dissolved uranium - ingested in food or water, for example - is liable to attach to DNA strands within cells, because uranium binds strongly to DNA phosphate. "Photoelectrons from uranium are therefore likely to be emitted precisely where they will cause most damage to genetic material," says Busby.

Busby and Schnug base their claim on calculations of the photoelectrons that would be produced by the interaction between normal background levels of gamma radiation and uranium in the body. "Our detailed calculations indicate that the phantom photoelectrons are the predominant effect by far for uranium genome toxicity, and that uranium could be 1500 times as powerful as an emitter of photoelectrons than as an alpha emitter." Their computer modelling results are described in a peer-reviewed paper to be published in this month by the IPNSS in a book called ***Loads and Fate of Fertiliser Derived Uranium***.

Hans-Georg Menzel, who chairs the International Commission on Radiological Protection's committee on radiation doses, acknowledges that the theory should be considered, but he doubts that it will prove significant. He suspects that under normal background radiation the effect is too weak to inflict many of the "double hits" of energy that are known to be most damaging to cells. "It is very unlikely that individual cells would be subject to two or more closely spaced photoelectron impacts under normal background gamma irradiation," he says.

Despite his doubts, Menzel raised the issue last week with his committee in St Petersburg, Russia, and says that several colleagues "intended to collect relevant data and perform calculations to check whether there was any possibility of a real effect in living tissues". Organisations in the UK contacted by *New Scientist*, including the Ministry of Defence and the Health Protection Agency, say they have no plans to investigate Busby's hypothesis.

Robin Forrest at the UK Atomic Energy Authority in Culham, Oxfordshire, is more positive. "It does seem that the photoelectric effect in very small uranium particles may explain some of the radiological problems with uranium," he says. "I hope that the organisations charged with radiological protection investigate this further."

Radiation biophysicist Mark Hill of the University of Oxford would also like to see a fuller investigation, though he suggests this might show that the photoelectric effect is not as powerful as Busby claims. "We really need more detailed calculations and dose estimates for realistic situations with and without uranium present," he says. Hill's doubts centre on an effect called Compton scattering, which he believes needs to be factored into any calculations. In Compton scattering, gamma photons striking an atom lose energy and momentum to an electron and bounce away, rather than being absorbed and transferring all their energy as in the photoelectric effect.

With Compton scattering, uranium is only 4.5 times as effective as calcium at stopping gamma photons, so Hill says that taking it into account would reduce the relative importance of uranium as an emitter of secondary electrons. If he is right, this would dilute the mechanism proposed by Busby and Schnug.

Busby is now working with Vyvyan Howard at the University of Ulster on test-tube experiments with depleted uranium in living cell cultures aimed at investigating the damage to DNA under different combinations of gamma irradiation and uranium concentration. He is also designing experiments aimed at finding out how far photoelectrons travel in tissue when a range of particle types and sizes are irradiated at different energies. Menzel, however, is dubious about the value of such experiments. "I believe this theory can be proved or disproved by detailed attention to what we already know," he says.

The arguments over depleted uranium are likely to continue, whatever the outcome of these experiments. Whether Busby's theory holds up or not remains to be seen, but investigating it can only help to clear up some of the doubts about this mysterious substance.

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