Editorial
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Depleted uranium - a health, environmental or societal issue?

Uranium is the heaviest element found in nature. Due to its natural abundance and its consequent ubiquitous presence in our food chain, the human body typically contains a very low, but measurable, level of natural uranium, ranging between 80 and 100 μg. The normal daily intake of uranium is about 1.5 μg, mainly through the intake of cereals, vegetables and salt. Natural uranium contains three isotopes: U-238 (99.3% by mass), U-235 (0.72% by mass) and U-234 (0.006 % by mass). For the production of electricity in a nuclear reactor the U-235 mass percentage is typically enriched from its natural level of 0.72% to about 2% or more. In the production of weapons grade uranium the U-235 is enriched to a much higher percentage. In the enrichment process depleted uranium (DU) is produced as a byproduct or waste material. DU generally has a U-235 mass content of about 0.2% and consequently its radioactivity is only about 60% of that of natural uranium. As nuclear energy and nuclear weapons were being developed over the past six decades, many thousand tonnes of DU have been produced. Meanwhile depleted uranium, the waste product, because of its high density and good mechanical properties, has found many uses: as counterweights for aircraft control, in the keels of racing yachts or as X-ray shielding and collimators in radiology and radiotherapy. Its principal military application is in armour-penetrating ammunition. It is in this latter role that concern has been expressed as to the possible health and environmental implications of deploying ammunition containing depleted uranium. The DU armour penetrator and its flying canon - the A-10 "Warthog" aircraft, were developed in the '70s, mainly to prevent Warsaw Pact tanks and troop carriers from entering Western Europe. On impact, the depleted uranium penetrator of an anti-armour round will self-ignite, melting the metal armour or concrete along its entry path and will rapidly oxidise once inside the armoured vehicle or reinforced shelter, depriving the combat crew of oxygen. The uranium oxides, in the form of a fine powder, will remain in the interior, presenting a health hazard to those who may re-enter the object: rescue crews - or children, for want of a playground in a war-ridden country. In the recent past DU ammunition has been used by U.S forces in at least three conflicts: the Gulf War in 1991, in Bosnia and Herzegovina in the mid 1990s and in Yugoslavia in 1999. Public concern arose following the still unexplained "Gulf War Syndrome", widely attributed to the DU ammunition used in that conflict for the first time on a large scale. It is the use of DU ammunition by NATO forces in its intervention in Yugoslavia in 1999 that is the principal subject of the papers presented in this volume of the *Archive of Oncology*.

The chemical toxicity of uranium has been extensively studied. Uranium is nephrotoxic, but studies of worker exposures to uranium over the past 50 years have shown only minor and transient renal disorders even after large accidental exposures of workers in uranium fabrication plants in the U.S and the U.K. As for its radiological toxicity, there has so far been no report in the literature of any human cancer occurrence that could be scientifically attributed to exposure to DU or indeed to natural uranium. Even for uranium miners their risk of lung cancer, excluding that due to smoking, is accepted as being dominated by their exposure to airborne radon progeny in the mines. Cancer induction in laboratory animals due to exposure to short lived uranium (such as U-233) at very high levels has indeed been demonstrated. The levels of uranium radiation dose to these animals were orders of magnitude above those likely to occur from the use of DU ammunition. The present scientific consensus is that DU exposure to humans, in locations where DU ammunition was deployed, is very unlikely to give rise to cancer induction. As all previous major studies have been on largely male cohorts of workers this consensus viewpoint should be moderated when exposures to children are being considered.

In the present context, apart from the obvious direct warfare aspects, there are three principal ways in which DU may present a health hazard to humans: by the inhalation of very small particles of oxidised DU, by handling complete or fragmented DU penetrators and by the ingestion of water or food containing DU. Inhalation and penetrator handling pathways may be of particular

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concern in children who, unattended, may seek their playground inside burnt-out military equipment or installations. It would appear that only a very small number of the many thousands of DU penetrators used in the 1999 Yugoslavian conflict struck heavy armour. In addition only a small number have been recovered from the target sites. Most of the DU penetrators fired are therefore destined to remain implanted and undetected in the soil of their target sites. The eventual fate of these is unclear. The DU penetrators can be expected to slowly dissolve and migrate from their point of implantation over the coming years and therefore DU could potentially enter local groundwater drinking water supplies and the locally produced food chain. The rate of dissolution and migration of the dissolved DU will be very site-specific, depending on factors such as soil chemistry and on the hydrogeological nature of the sites. An additional confounding factor is the highly variable content of natural uranium over the Balkan region. To recognise the presence of depleted uranium in soil, water supply or in the human body, natural and depleted uranium have to be distinguished. Indeed, this issue has been addressed in some of the papers presented in this volume of the *Archive of Oncology*, and suitable measurement techniques to this end suggested and executed.

However unacceptable all warfare may be, authors of most papers in this issue seem to concur in that the environmental or health hazard to the general population of the Federal Republic of Yugoslavia from the use of DU ammunition is likely to be negligible in comparison to the normal risks of life. Should the scientific community then, as rational and objective people, consider the matter closed? Not really. It should be noted that the general population in DU target areas continues to believe that their health has forever been affected by DU. This perception, however irrational it may appear to some, is a reality. While the physical conflict is over the DU remains in the ground and is perceived to be a continuing health hazard. There should therefore be, at a minimum, a systematic study to determine the extent, if any, of DU contamination of drinking water and the food chain in the DU target areas. If significant DU levels are found, biosampling (urine etc) should be considered. In this case particular attention should be paid to children. The results of such studies may help to re-assure people thereby reducing their anxiety. It must be stressed that radiophobia is not unique to the DU issue and is found throughout the world in respect to any issue with a "nuclear" dimension. There are many reasons for such radiophobia, too complex to discuss in this short editorial, but as radiophobia is a reality the stress and anxiety it causes can itself be considered as a real health effect. Is this then the ultimate health impact of depleted uranium? Perhaps not.

It may be interesting, especially to some Western readers of this issue of the *Archive of Oncology*, to note that a considerable part of the research work presented here has been sponsored by local government authorities. This is an interesting and welcome development in that local politicians in their concern for their constituencies, are ready to promote the sponsoring of research projects - "to find out the truth" - in order to calm the anxiety of their people. It would also be most welcome if international collaborative research projects with Yugoslav scientists could be promoted to address the DU problem. We would hope that this issue of the *Archive of Oncology* might assist in encouraging such international collaboration.