The risks of depleted uranium contamination post-conflict: UNEP assessments

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Perhaps the most endangered natural resource in times of war is truth. So concluded, in the year 2000, the United Nations Environment Programme's (UNEP) first post-conflict environmental assessment. For the safety of local populations and international workers in post-conflict situations, it is essential that reliable and accurate information be available to evaluate the risks to life and human health from the environmental consequences of war, and to take appropriate measures for their mitigation.

Depleted uranium (DU), the main by-product of uranium enrichment, is a chemically and radiologically toxic heavy metal. It is mildly radioactive, with about 60% of the activity of natural uranium. This dense metal is used in munitions for its penetrating ability and as a protective material for armoured vehicles. The health effects resulting from DU exposure depend on the route and magnitude of exposure, as well as characteristics such as particle size, chemical form and solubility. Where DU munitions have been used, the penetrators, penetrator fragments, and jackets or casings can be found lying on the surface or buried at varying depths, leading to the potential contamination of air, soil, water and vegetation from DU residue.

To evaluate and address the potential contamination of the environment by depleted uranium, UNEP has conducted environmental assessments and measurements on DU-targeted sites in the Balkans and in Iraq. In addition to these surveys, UNEP has carried out a range of capacity-building activities in environmental assessment techniques for Iraqi Ministry of Environment staff to identify, assess and address potential, immediate and long-term DU-related risks to human health and the environment.

UNEP has from the beginning maintained close cooperation with the International Atomic Energy Agency (IAEA) and the World Health Organization (WHO) in this field of work. According to respective mandates, all radiological calculations necessary to conclude on radiological conditions in areas contaminated with DU residue have been performed by the IAEA—and then discussed with partner organizations—while WHO is responsible for calculations regarding the toxicology of DU, and has developed scenarios and published health-related materials on the basis of UNEP's findings.

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UNEP in the Balkans

As part of the post-conflict assessments conducted by UNEP in the Balkans, three environmental assessments of sites targeted with depleted uranium were carried out. The first, which made environmental contamination data from zones attacked with this type of ammunition publicly available for the first time, was conducted in Kosovo in 2000–2001. It was followed by surveys in Serbia and Montenegro in 2001–2002 and in Bosnia and Herzegovina in 2002–2003.

Kosovo 2000–2001

UNEP's work on depleted uranium started midway through 1999, with a desk study of the potential effects of the possible use of DU during the conflict, which was conducted as part of the general assessment of the impact of the Kosovo conflict on the environment and human settlements.[1]

The following year, the North Atlantic Treaty Organization (NATO) provided UNEP with new information concerning the use of DU during the Kosovo conflict, including maps, number of rounds used, and coordinates of the targeted areas. With accurate details regarding where DU penetrators are likely to have struck, inspectors are able to conduct far more precise assessments. UNEP was able to carry out the first ever international environmental assessment of DU when used in a real conflict situation.

Because one and a half years had elapsed since the conflict, the overall aim of the UNEP mission was to examine the possible risks from any remaining DU contamination of ground, water and biota, and from solid pieces of DU (i.e. intact or fragmented penetrators) still in the environment. The key questions facing the mission were: what are the present levels of DU contamination in Kosovo? What are the corresponding radiological and chemical risks, both now and in the future? Is there any need for remedial measures or restrictions? If so, which measures are reasonable and realistic?

The final report, *Depleted Uranium in Kosovo: Post-conflict Environmental Assessment,*[2] published in March 2001, concluded that analyses of the samples collected showed only low levels of radioactivity. Furthermore, the results suggested that there was no immediate cause for concern regarding toxicity. However, major scientific uncertainties persisted over the long-term environmental impacts of DU, especially regarding groundwater.

Due to these scientific uncertainties, UNEP called for precaution and recommended action to be taken for the clean-up and decontamination of the polluted sites, for awareness-raising among the local population, and for future monitoring.

Serbia and Montenegro 2001–2002

During the Kosovo conflict, a few sites outside Kosovo, in Serbia and Montenegro, had also been targeted with ordnance containing depleted uranium. It was therefore evident that a second phase of scientific work would be needed following the Kosovo assessment. This started in September 2001 and was concluded in March 2002 with the publication of the report *Depleted Uranium in Serbia and Montenegro: Post-conflict Environmental Assessment in the Federal Republic of Yugoslavia*.[3]

The report provided additional information and revealed important new discoveries on the environmental behaviour of DU. Experts found that more than two years after the end of the conflict, particles of DU dust could be detected from soil samples and from sensitive bio-indicators like lichen. However, as the levels were extremely low, it was only through state-of-the-art laboratory analyses

that these could be detected. Based on the findings, UNEP could confirm that contamination at the targeted sites was widespread, though no significant level of radioactivity could be measured.

Furthermore, during this assessment the UNEP team used modern air sampling techniques and detected airborne DU particles at two sites. While all levels detected were below international safety limits, these results added valuable new information to the scientific body of knowledge concerning the behaviour of DU and had important implications for site decontamination and construction works.

As in the Kosovo case, UNEP called for precaution, monitoring and awareness-raising for the local population. Clean-up and decontamination had started in both Serbia and Montenegro when the assessment was ongoing, and detailed recommendations on these issues were given in the report.

Bosnia and Herzegovina 2002–2003

Finally, DU was used in Bosnia and Herzegovina during bombings in the mid-1990s, and UNEP undertook an assessment of the impacts in September 2002. Fifteen sites were selected for analysis, of which five were areas where NATO had reported using DU munitions. The remaining ten were areas where the local population or authorities had concerns that DU may have been used. The final report, *Depleted Uranium in Bosnia and Herzegovina: Post-conflict Environmental Assessment,* was released in March 2003.[4]

This report contained four significant findings. First, detailed laboratory analyses of surface soil samples revealed low levels of localized ground contamination. While local ground contamination could be detected up to 200m from the impact zone, it was typically detected within a 100m radius.

Second, penetrators buried near the ground surface and recovered by UNEP had decreased in mass by approximately 25% over seven years. Based on this finding, and correlated with penetrators examined in UNEP's earlier studies, it was possible to determine that a DU penetrator could be fully oxidized to corrosion products, including uranium oxides and carbonates, within 25 to 35 years of impact. Following that time period, no more metallic DU from penetrators would be found buried in the soil of the Balkans.

Third, DU contamination of drinking water was found for the first time at one of the surveyed sites. The concentrations were very low and the corresponding radiation doses insignificant for any health risk. Nevertheless, because the mechanism that governs the contamination of water in a given environment is not known in detail, it was recommended that water sampling and measurements should continue for several years, and that an alternative water source should be used when DU was found in drinking water.

Finally, DU contamination of air was found at two sites, including air and surface contamination inside two buildings at two different sites. Resuspension of DU particles due to wind or human activities was the most likely cause. The concentrations were very low and resulting radiation doses insignificant. However, precautionary decontamination and clean-up steps were recommended for the buildings on site, as they were being used by the military and the civil population.

The levels of DU contamination were not a cause for alarm, but some uncertainty remained.

Overall, the findings of this study were consistent with the findings of UNEP's earlier assessment work in the region: the levels of DU contamination were not a cause for alarm, but some uncertainty remained with respect to future potential groundwater contamination from penetrator corrosion products.

UNEP in the Persian Gulf

The 1991 Gulf War was the first conflict in which depleted uranium munitions were used extensively. In total, some 300 metric tons of DU-containing munitions were fired by the United Kingdom and the United States in the course of the war, with DU remaining in the environment as dust or small fragments. While no independent scientific assessment of the impacts of the 1991 conflict has been conducted in Iraq to date, UNEP participated in an assessment led by IAEA in January 2002 of the possible long-term radiological impacts of DU residue at 11 locations in Kuwait. Although the findings of the report, which was published in 2003, were not alarming, further policy action and additional research were recommended to resolve uncertainties relating to the use and effects of DU munitions in the country.

The Second Gulf War[5] broke out on Iraqi territory on 19 March 2003. Approximately 120,000 troops from the United States, 45,000 from the United Kingdom, and smaller forces from three other nations, collectively called the Coalition Forces, were deployed for the operation.

The war itself was preceded by air attacks on selected Iraqi targets, which continued during the land invasion. Several air attacks were conducted by A-10 Thunderbolt II aircraft, which utilized DU munitions. DU munitions were also used by UK and US tanks in several land battles, mainly against Iraqi tanks. The UK Ministry of Defence has reported that its troops fired approximately 1.9 metric tons of DU munitions during this conflict, and in June 2003 it provided UNEP with the coordinates of DU firing points of the UK Challenger 2 tanks. Information concerning the overall quantity of DU munitions used and the corresponding coordinates of the firing points from the United States has, as yet, not been made available.

Assessing the environmental impacts of the conflict

UNEP continuously monitored the potential environmental impacts of the conflict throughout its duration and organized a series of round-table meetings to share findings on key environmental issues and coordinate activities with relevant stakeholders, such as the Iraqi government ministries.

Following the conflict, in April 2003, UNEP published a *Desk Study on the Environment in Iraq*.[6] The report outlined the environmental vulnerabilities in Iraq resulting from years of conflict, the low priority attached to the environment by the previous regime, and the unintended effects of sanctions in the 1990s. In July 2003, the United Nations Development Group and the World Bank jointly carried out a needs assessment for Iraq, covering 14 priority sectors and three cross-cutting themes. As the lead agency on the environment, UNEP provided substantive input to this report.[7] Field missions to Iraq were undertaken in mid-2003, and in October 2003 the findings were published in UNEP's progress report on the *Environment in Iraq*.[8]

Both the desk study and the progress report identified the need for an environmental assessment of selected contaminated sites in order to identify risks to human health and livelihoods and to initiate urgent risk reduction measures.

In early 2004, UNEP actively participated in drafting the United Nations' action plan for Iraq, *A Strategy for Assistance to Iraq*. The strategy brought together a range of prioritized programmes addressing humanitarian, reconstruction and development needs to be undertaken by the UN family, its partners and others working closely with the Iraqi authorities. Presented at a donor conference in Abu Dhabi in February 2004, the strategy was used as a basis for follow-up and to secure financial pledges.[9]

To identify priorities for 2004 and 2005, UNEP held a number of major consultation sessions with Iraq's Ministry of Environment. In July 2004, UNEP was awarded a project for "strengthening environmental governance in Iraq through environmental assessment and capacity-building", which was supported by the United Nations' Iraq Trust Fund through funds made available by the Government of Japan. It was under this programme that UNEP undertook to build the capacity of Iraqi environmental authorities to assess and address the potential damage caused by the use of depleted uranium munitions during the 2003 war.

Capacity-building for the assessment of depleted uranium in Iraq

The possible health effects on the Iraqi population of DU residues on the battlefield raised concern both among the Iraqi population and in other parts of the world. In April 2005, UNEP convened a meeting in Geneva with the IAEA and WHO to discuss, coordinate, agree and plan collaborative work on the environmental and health effects of DU residues in Iraq. The three organizations also agreed to work with the Iraqi Radiation Protection Center (RPC) of the Iraqi Ministry of Environment on DU-related matters.

Given that the prevailing security constraints prevented international experts from travelling to Iraq, the project focused on delivering capacity-building and training to national staff outside Iraq to enable them to conduct fieldwork in country.

UNEP's depleted uranium capacity-building project in Iraq, detailed in a report published in August 2007,[10] had five main objectives: to train officials from Iraq to undertake a field-based assessment of depleted uranium using internationally accepted methodologies and modern equipment; to provide the trained officials with precise information on sites to assess and type of samples to collect; to supervise remotely the assessment and retrieve samples; to analyse the field observations, monitoring results and samples to draw conclusions on the effectiveness of the capacity-building activities; and to review the results and provide recommendations to the Ministry of Environment on follow-up action.

UNEP provided training to Iraqi experts from the RPC through three workshops designed to cover all the aspects of DU assessment in the affected areas. The first, which was held at the Spiez Laboratory in Switzerland in May 2004, focused broadly on environmental inspections and laboratory analyses, rather than specifically on depleted uranium. UNEP and Spiez Laboratory experts trained participants in the basics of environmental inspections, as well as soil, air and water pollution, hazardous chemicals and waste management.

The second workshop—on DU site investigation techniques—took place in June 2005 in Amman, Jordan. The objective of the workshop was to provide training, equipment and technical assistance to selected Iraqi professionals. Eleven experts from the Ministry of Environment's RPC and four from the Ministry of Health received basic technical training. Participants were trained in the use of instruments that were then handed over to the Head of Delegation, as well as in equipment to be provided in the near future. Selection criteria for the equipment included durability, portability and suitability to the operating environment of Iraq.

A third workshop held in Geneva in August 2005 concentrated on site investigation techniques in urban areas. The practical session of the workshop had a comprehensive agenda covering nearly all the measurement techniques that are useful in urban areas. It also comprised detailed training on sampling methods, clean-up and small-scale decontamination measures. The practical work focused on realistically simulating the prevailing conditions on a site targeted by DU weapons. Measurement and clean-up techniques were demonstrated by the UNEP expert team and experimented in detail by each participant. Sampling strategies and techniques were also developed.

Map 1. Sites tested for depleted uranium contamination, 2006–2007

Source: Based on United Nations Cartographic Section map no. 3835 Rev. 4, January 2004.

Local expert DU site assessments

Having completed the training, national staff then collected environmental samples at selected sites in southern Iraq during sampling campaigns conducted in 2006–2007. The sampling campaigns were part of the final module of the capacity-building process. Trained Iraqi RCP staff utilized specialized

documentation prepared by UNEP, known as *Local Expert DU Site Assessment Packages I and II*. A total of 520 samples of soil, water and vegetation were collected as well as smear samples at four areas in southern Iraq, As Samawah, An Nasiriyah, Al Basrah, and Az Zubayr, as indicated on Map 1.

Due to the limited analytical infrastructures available to the Iraqi RPC and in order to ensure a better scientific reliability, the collected samples were sent to UNEP Geneva for analysis by Spiez Laboratory for their content of various uranium isotopes (U-238, U-236, U-235 and U-234) using high-resolution inductively coupled plasma mass spectrometry.

The following exposure pathways were considered in the radiation dose assessments: inhalation of DU-contaminated soil resuspended by the action of wind or human activity; inhalation of resuspended DU dust inside military vehicles hit by DU munitions; ingestion of DU-contaminated soil; ingestion of DU-contaminated vegetables and drinking water; direct contact with DU penetrators or DU fragments; and ingestion of DU-contaminated dust from flat surfaces (metal, concrete, walls). In addition, consideration was given to the risk of inhalation of DU dust during the scrapping of military vehicles hit by DU munitions and the re-melting of the scrap metal.

The radioanalytical results were shared between UNEP and the IAEA for an estimation of the radiation doses and corresponding risks to which the Iraqi population living at the four investigated locations could become exposed. The radiation doses were calculated as committed equivalent doses corresponding to one year's intake of DU. The estimation was done in a very conservative way, generally utilizing, of all the data provided by Spiez Laboratory, only that which showed the highest DU contamination (the so-called "worst cases") and assuming habit data for the local population that in most cases corresponded to (usually unrealistically) high DU intakes.

On the basis of the measurements carried out and the committed doses calculated it was concluded that DU residues in the environment did not pose a radiological hazard to the population at the four studied locations, as long as minimum precautionary measures were implemented, such as not entering vehicles hit by DU munitions, not undertaking long-lasting activities around objects hit by DU, not collecting penetrators or shrapnel that could contain residues of DU, and not recycling or processing objects hit by DU. Taking these precautionary steps, the estimated annual radiation doses that could arise from exposure to DU would be low (less than 90μSv)—below the annual doses received by the population of Iraq from natural sources of radiation in the environment and therefore of little radiological concern. The doses were also far below the action level of 10mSv suggested by the International Commission on Radiological Protection as a criterion to establish whether remedial action is necessary.

It must be emphasized that from the strictly scientific point of view these conclusions cannot be extrapolated to other locations in Iraq where DU ammunition was used as they strongly depend on many factors, including the amount of DU munitions fired, the specific geographical and meteorological conditions, the land characteristics and uses, the population habits and, last but not least, the intrinsic limitations of any assessment of the presence of DU residues from ammunition in the environment, which rarely extends more than a few metres away from the DU source. However, it is unlikely that these findings would be significantly different at other locations in Iraq where DU has been used.

Concerning the handling of DU penetrators and penetrator fragments, it was concluded that the dose received could become significant only if a person were in contact with them for a considerable period of time. A higher potential radiological risk was found to exist where vehicles hit by DU ammunition were present and people were entering them. Of particular concern were the scrapyards where destroyed military equipment was stored and scrap operations were apparently being conducted. An estimation of the potential doses received by workers involved in the re-melting of DU contaminated scrap metal was difficult to perform, however, in the absence of relevant experimental data.

Final recommendations

On the basis of the findings of the assessment work detailed above, a number of detailed recommendations were developed to ensure that risks emanating from the use of depleted uranium munitions during the conflict in Iraq are addressed and mitigated. These are valid for any location potentially contaminated with DU. In zones where DU munitions have been used, UNEP recommends that:

- a campaign is conducted to educate people, in particular children, about the importance of avoiding being in close contact with war-related equipment;
- steps are taken to prevent anyone from entering military vehicles hit by DU munitions;
- metal scrapping of DU-contaminated military equipment and its re-melting are avoided;
- secure areas for storing DU-contaminated equipment are identified;
- all war-related equipment is assessed for the possible presence of DU and, when positively identified, is moved to secure locations;
- access to these secure locations is restricted, as well as to all scrapyards where war-related equipment contaminated by DU is stored;
- DU-contaminated equipment is not decontaminated, as this may imply radiation hazards and the management problems associated with the radioactive waste generated would represent an additional problem;
- contaminated equipment is diposed of without further treatment by appropriate burial (this represents the most cost-effective option);
- DU residue (DU penetrators, penetrator fragments and their corrosion products) is safely removed from surfaces at targeted zones by authorized personnel and following appropriate storage practices; and
- the local residents and workers are informed of the possible hazards associated with the remnants of DU weapons, and advised, in case of clear necessity (e.g. when authorized personnel are not available), to minimize handling and use protective gloves.

UNEP hopes that the body of knowledge gathered through its assessment and capacity-building activities since 1999 will help countries to address the potential risks related to the contamination of air, soil, water and vegetation from the use of depleted uranium in times of conflict, and stands ready to provide further assistance upon request.

Notes

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2. UNEP, 2001, *Depleted Uranium in Kosovo: Post-conflict Environmental Assessment,* Geneva, at <postconflict.unep.ch/publications/uranium.pdf>.
3. UNEP, 2002, *Depleted Uranium in Serbia and Montenegro: Post-conflict Environmental Assessment in the Federal Republic of Yugoslavia,* Geneva, at <postconflict.unep.ch/publications/duserbiamont.pdf>.
4. UNEP, 2003, *Depleted Uranium in Bosnia and Herzegovina: Post-conflict Environmental Assessment,* Geneva, at <postconflict.unep.ch/publications/BiH_DU_report.pdf>.
5. Also called the Third Persian Gulf War.
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9. United Nations, 2004, *A Strategy for Assistance to Iraq: A Work-in-progress Document,* presented at the International Reconstruction Fund Facility for Iraq meeting in Abu Dhabi, 28 February 2004, at <siteresources.worldbank.org/IRFFI/Resources/UN_Strategic_Plan_Draft4.doc>.
10. UNEP, 2007, *Technical Report on Capacity-building for the Assessment of Depleted Uranium in Iraq,* Geneva, at <postconflict.unep.ch/publications/Iraq_DU.pdf>.