IKV PAX CHRISTI

IN A STATE OF UNCERTAINTY

Impact and implicatons of the use of depleted uranium in Iraq

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Colophon

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Cover: IRAQ, Baghdad : An Iraqi boy swings on the gun of a destroyed Iraqi tank in Dura on the southern outskirts of Baghdad, as his friend looks on 24 June 2003. The tanks were destroyed by US forces during their invasion of Iraq which began in March. AFP PHOTO/Ramzi Haidar.

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Executive summary

The use of depleted uranium (DU) in conventional munitions has generated controversy for more than 30 years. Research increasingly supports the idea that there may be a link between its use and reports of increasing health problems in those countries where it has been deployed. Of these, Iraq is by far the most affected country, with large quantities of DU munitions used in 1991 and 2003. However, uncertainties over its impact and implications remain. This report is one of the first to attempt to provide a comprehensive overview of the use of DU in Iraq by US and UK armed forces, and the subsequent actions, or lack thereof, that have been undertaken to address the issue of DU contamination and resulting exposure to civilians. Furthermore, it will provide an overview of reported health problems that might be related to exposure to DU, and other toxic remnants of war, and will provide recommendations for next steps to be undertaken in order to minimise the risks to the civilian population.

The aim of this report is to provide greater clarity on the impact that the use of DU has had on Iraqi society; in doing so it will document the persistent uncertainty that continues to affect the daily lives of Iraqi civilians.

Summary of key findings

The lack of transparency from Coalition Forces over the use of DU: There is an absence of crucial information on firing coordinates, the quantities and types of DU munitions used; data gaps relating to the efforts undertaken to clean up contaminated sites and material are hindering efforts to assess risks and implement remediation work.

The use of DU in populated areas: aircraft and vehicles have used DU in populated areas against armoured and non-armoured targets. States that use DU defend its use on the basis of it being specifically for engaging armoured vehicles; evidence from Iraq suggests that it has been used against a far wider range of targets, and in populated areas. This is highly problematic because of the indiscriminate nature of DU dust.

The difficulty in assessing and managing DU contamination: effectively and safely managing sites or wreckage contaminated by DU requires the involvement and cooperation of a range of expertises, as demonstrated by the UN's approach, which has required the input of the UN Environment Programme, International Atomic Energy Agency and World Health Organisation. The Iraqi government, which is slowly recovering from decades of war, has faced major challenges in terms of capacity, expertise and funding in seeking to identify contaminated hotspots and implement programmes to analyse, clean-up and safely store contaminated scrap metal and debris. More than 300 contaminated sites are still in the process of being assessed and decontaminated, placing a huge financial burden on the Iraqi government.

Impact on civilian health and environment: numerous media reports and published research indicates that there is a serious increase in congenital birth deformations, with exposure to toxic remnants of war a potential risk factor. In addition to the direct physical health legacy from exposure to military-origin toxics, concern over possible exposure to DU residues is widespread and may be impacting on the psychological wellbeing of communities. This anxiety is being stoked by media reports but appears to be intrinsic to the use of radioactive materials in conventional weapons. The lack of transparency over targeting sites, distrust of the authorities, politicisation of the DU issue and the ongoing failure to comprehensively manage contamination have only served to exacerbate the situation.

As noted above, detailed and reliable data on the quantities and types of DU munitions used in Iraq, and their geographical distribution is still unavailable. Furthermore huge gaps remain over the assessment and remediation histories of sites, this is particularly true of the period from 2003-2005, under the governance of the Coalition Provisional Authority. Therefore it is difficult to judge the effectiveness of the mitigation measures that may, or may not, have been undertaken

by Coalition Forces and later, by the Iraqi authorities to protect civilians from exposure to DU.

This report aims to provide an overview of all the credible reports that have been published so far on DU use in Iraq, both from the media and research institutions. In researching the report, the author conducted three field trips to Iraq, and spoke with representatives from Iraqi ministries, NGOs, doctors, experts and civilians living in contaminated areas; this input will be used to not only illustrate the current state of affairs, but also to suggest policies and precautionary measures that need to be implemented to protect civilians and the environment. This report will also consider other environmental problems resulting from both wars and take into account these issues when drawing up a final conclusion and recommendations.

Recommendations

Based on the information and policy gaps, and obstacles identified in this report, IKV Pax Christi offers the following recommendations:

1. One of the most pressing issues is the need for full transparency over the use of DU in Iraq. All data relevant for research, such as firing coordinates, type of ammunition used and target types must be published in order to support the Iraqi government and national and international organisations engaged in assessment, research and fieldwork.

2. Use all available data to undertake a nationwide assessment of DU contamination of scrap metal sites in order to create a national strategy for reducing civilian exposure to contaminated scrap and debris.

3. Further capacity building of relevant Iraqi governmental bodies is necessary to enable the government to intervene effectively at a local and national level.

4. Implement, where necessary, international regulations regarding the safe storage of low level radioactive waste, with particular focus on the scrap metal trade: introducing stricter controls on its recycling for industrial purposes, its transport and export.

5. Comprehensive environmental assessments in civilian areas to identify other toxic remnants of war that may lead to health and environmental problems, and greater support from the international community for mitigating the risks they may pose. Existing domestic obligations and strategies from DU user states could be used as an example.

6. Set up a nationwide DU exposure prevention strategy, covering rapid assessments when discovered, population and environmental monitoring, awareness-raising and risk education and remediation.

7. International organisations with relevant expertise such as UNEP should be involved in further site assess ments on DU, especially regarding soil and groundwater contamination and the impact of other toxic remnants of war on health and the environment, which should lead to a better understanding of exposure pathways and the behaviour of DU in arid climates.

8. Health research in affected areas needs detailed research on possible risk factors for cancers and congenital birth deformations. The psycho-social impact of DU should be investigated in order to better inform assistance to affected communities. In areas of concern, increased medical support should be provided to hospitals and health centres.


TURKEY
SYRIAN ARAB REPUBLIC
ISLAMIC REPUBLIC OF IRAN
SAUDI ARABIA
KUWAIT
JORDAN
Al Qāmishlī
Hakkāri
Orūmīyeh (Umia)
Mīāndowāb
Zanjān
Sanandaj
Hamadān
Kermānshāh
Bonujerd
Khorramābād
Dehlorān
Dezfūl
Ahvāz
Ābādān
Zākhū
DAHŪK
Dahūk
'Aqrah
Al Mawşil (Mosul)
Sinjār
Tall 'Afar
NINAWÁ
Ar Raqqah
Dayr az Zawr
Al Qayyarah
Makhmūr
ARBIL
Arbīl
Küysanjaq
Rāyāt
Al Ḥaḍr
Kirkūk
AT TA'MIM
Bayjī
Tāwūq
As Sulaymānīyah
Ḥalabjah
Qaşr-e Shīrīn
Khānaqīn
Bīārm
Mehrān
Abū Kamāl
'Anah
Al Qā'im
Al Ḥadīthah
ŞALAḤ AD DĪN
Sāmarrā'
DIYĀLĀ
Ba'qūbah
Akāshāt
Al Walīd
Al Ḥabbānīyah
Ḥīt
Ar Ramādī
Baghdad
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Ali al Gharbi
KARBALĀ'
Al Ḥayy
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An Najaf
Ad Dīwānīyah
MAYSĀN
Al 'Amārah
Abū Şukhayr
AL QĀDISĪYAH
Qal'at Sukkar
Qal'at Şālih
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DHĪ QĀR
Ar'ar
AN NAJAF
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As Samāwah
As Salmān
Jalībah
Al Başrah
AL BAŞRAH
Umm Qaşr
AL MUTHANNÁ
Makhfar al Buşayyah
Al Fāw
Persian Gulf
Al Jahrah
Kuwait
Al Aḥmadī
Rafḥā'
Ḥafar al Bāţin
IRAQ · العراق
National capital
Governorate capital
Town, village
Airport
International boundary
Governorate boundary
Expressway
Main road
Secondary road
Railroad
0 50 100 150 200 150 300 km
0 50 100 150 200 mi
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IRAQ
40°
42°
44°
46°
48°
30°
32°
34°
36°
38°
28°

Map of Iraq

1. Background

Since the outbreak of the Gulf War in 1991, the Iraqi population has been struggling with a major health crisis as a result of warfare. The heavy bombardment of military and industrial targets, destruction of critical civilian infrastructure, destruction of the environment by oil fires and oil spills and the abundance of explosive remnants of war (ERW) have all contributed to a range social and health problems. The economic sanctions put in place by the United Nations during the 1990s deteriorated the situation further by restricting the importation of medicines, medical equipment, food and other vital products for maintaining functioning healthcare and agricultural systems. Soon after the war, journalists reported an increase of birth defects and cancers, meanwhile veterans from Coalition forces reported increased health problems, the so called Gulf War Syndrome[1]. This was linked to the use of depleted uranium munitions (DU) by the United States and the United Kingdom and a range of other chemical risk factors.

This stirred up debate over the legitimacy of the use of DU munitions, which subsequently generated controversy amongst activists and researchers over DU's potential effects; with some stating it was the main cause of the health problems, while others took a more cautious approach, calling for better research and a moratorium on its use. Political debates on DU's acceptability in western States ensued, mainly due to the exposure of veterans to DU and its potential health legacy. However, no international action was taken to halt the use of these munitions, largely as a result of user States claiming that no health effects had been proven and that these munitions were vital to maintain military superiority on the battlefield.

> *'Destroyed tanks were used by children as playgrounds, while scrap metal collectors dismantled contaminated tanks and armoured vehicles and sold the scrap metal,...'*

After the invasion of Iraq in 2003, DU was used again to destroy Iraqi tanks but it was also used against civilian targets in populated areas. New and alarming reports of increased cancer rates and birth malformations emerged in the years after the official ending of the hostilities in Iraq, as well as amongst veterans of Coalition forces who were present during and after the fighting; which again pointed to the use of DU as the cause of these health problems. Though some reports by the World Health Organisation (WHO) stated that the expected health effects were low (WHO, 2001), other scientific research indicated that DU was indeed a potential cause for some of the reported cancer cases and birth defects.

Indeed, concerns amongst Iraqi civilians continue to mount, they feel abandoned by their own government in providing clarity and support, while at the same time are condemned to live in the areas where DU has been used. Destroyed tanks were used by children as playgrounds, while scrap metal collectors dismantled contaminated tanks and armoured vehicles and sold the scrap metal, to be melted or re-used. Doctors in hospitals in Basrah and Fallujah report that the first question new mothers ask after birth is not *"is it a boy or a girl?"* but *"is it healthy?"*[2].

There remains huge uncertainty among civilians over the extent to which environmental contamination is impacting on their health and wellbeing. Proving causality in such cases is notoriously difficult, a task further complicated by the range of potential exposures, nevertheless it is clear that the population has genuine and justified concerns for their health due to the pollution which has resulted from the conflicts. Greater transparency over the use of DU would help resolve at least some of the uncertainties facing Iraqi society.

[1] The causes for the Gulf War syndrome are likely to be a mixture of Post-traumatic Stress Disorder, smoke from burning oil wells, vaccinations against chemical and biological weapons and exposure to other chemical toxics during combat.

[2] Neurink, J. (2003) Kanker in Irak roept vragen op. Dutch Newspaper Trouw. Accessed at http://www.trouw.nl/tr/nl/4324/Nieuws/archief/article/detail/1761859/2003/12/30/Kanker-in-Irak-roept-vragen-op.dhtml

Bedouins collecting scrap metal from tanks, Southern Iraq ©Takashi Morizumi

Depleted uranium: a short introduction

To provide a better understanding of the health risks and other problems that stem from the use of DU, this chapter will give an introduction to what DU is, its military applications and where it is known to have been used in conflicts. Natural uranium is a heavy metal that that can be found in low concentrations in our natural environment, it consists of three isotopes, U238, U235 and U234. After enrichment of natural uranium, usually for nuclear energy or nuclear weapons, a by-product, DU is left. It is called DU because it is depleted in the isotope U235. Its radioactivity is initially about 60% of that of natural uranium, increasing to around 80% a few months after it is produced; it is variously labelled as Intermediate or Low Level Radioactive Waste (LLRW). DU gets increasingly radioactive as it ages and the DU metal in weapons is a far more concentrated form of uranium than exists in nature. As such, direct comparisons to the health risks from natural uranium are difficult, although the chemical toxicity of uranium remains the same regardless of its isotopic composition.

During the 1960s, the United States army started to develop anti-armour ammunition utilising DU, this was in response to the growing threat of Soviet armoured capabilities. DU was attractive as a material for armour-piercing ammunition because of:

- Its high density: DU is 1.7 times denser than lead, which allows greater penetration
- Its pyrophoric effects: Upon impact, DU fragments burn, creating a secondary incendiary effect.
- Greater effectiveness against armoured targets than the tungsten alloys available at the time, though advances since then have narrowed this performance gap considerably.
- Its ready availability: large stockpiles of DU existed as a result of uranium enrichment, presening lower costs than tungsten[3].

DU rounds were developed for a range of different weapon systems: 20mm munitions (Phalanx Close-in Weapon System[4]), 25mm (AV98-B Harrier, Bradley Fighting Vehicle), 30mm munitions (A-10 Warthog), 105 and 120mm (M1A1/2 Abrams Tank). However, it is interesting to note that over the last couple of years the US Army has invested in research into replacing DU rounds in the A-10 with tungsten alloy based munitions[5], as well as non-DU 105 and 120mm munitions for the M1A2 Abrams tank[6], referring in their rationale for this move to DU's potential environmental impact.

[3] Joint Technical Coordination Group for Munitions Effectiveness (1974) Special Report: medical and Environmental Evaluation of Depleted Uranium. Ad Hoc Working Group for Depleted Uranium. Vol. 1. pp 1-2.

[4] 20 mm DU munitions were replaced with non-DU rounds around 2000-2001. The US Navy stated that tungsten was a good alternative 'while offering reduced probabilities of radiation exposure and environmental impact'. See http://www.gulflink.osd.mil/du_ii/du_ii_tabe.htm#TAB E_Development of DU Munitions

[5] D.Hambling (2003) Safe' alternative to depleted uranium revealed, New Scientist, 30 July.

[6] Janes International Defense Review. NATO tanks aim at wider target set with smoothbore ammunition. Posted January 19, 2012.

After the US started developing DU munitions, other states such the United Kingdom and the Soviet Union followed suit. Currently, around 20 states produce or stockpile DU weapons[7]. Current known users are the US and the UK, though it is conceivable that Russia used DU against armoured targets in Chechnya and during the ten day war in Georgia in 2008.

At present, DU is known to have been used in conflicts in the Balkans in 1994-95 (Bosnia Herzegovina) and 1999 (Kosovo, Serbia and Montenegro), where more than 12,600 kilograms of DU were fired. In Kuwait (1991) and Iraq (1991 and 2003-2004) the most conservative estimate is that more than 440,000 kilograms of DU were used by tanks, armoured vehicles and aircraft. Chapter 2 provides a more comprehensive overview of these platforms, the specific quantities fired, all the known locations in Iraq where DU has likely or is known to have been used, and reported sites where DU has been found or where DU contamination is suspected. However, this overview is limited due to the refusal by the US to provide specific data on firing locations, amounts of DU and target types.

There are indications that DU was also used in Somalia by US forces between 1992-93[8] and Afghanistan[9] in 2001-2006, but this has never been confirmed by credible sources[10,11]. Other reported instances of DU use outside conflict are on test sites and firing ranges in Japan, Puerto Rico, Kuwait, various firing ranges in the US[12] and in Scotland. It is reported that the US also used DU in training in Egypt prior to the invasion in Iraq in 1991, although this has not been confirmed. To date, Iraq has seen the largest use of DU munitions, followed by the Balkans. Even though US forces - after repeated interventions by the then UN Secretary General, provided firing coordinates in the Balkans to facilitate research undertaken by the United Nations Environment Programme (UNEP), only a couple of hundred kilograms of DU rounds could be retrieved. This left most of the DU fired in the soil, and the clean-up and storage of DU munitions were costly operations involving specific expertise and capacity from affected states. For more information on the Balkans, see UNEP reports[13] and ICBUW's report *A Question of Responsibility*[14].

In conclusion, DU remains a part of the arsenal of more than 20 states, although research into less controversial alternatives is underway. User states still argue that DU is the most effective anti-armour material available. However the increase of asymmetrical warfare, and growing international opposition to their use, means that DU munitions are likely to be less useful in many future conflicts. Moreover, during the 2011 intervention in Libya, which would have been an exemplary case of using A-10 gunships against Libyan armoured vehicles, DU munitions were not fired, likely due to their controversial nature and pressure from civil society groups. States are increasingly being held accountable for the type of weapons and munitions they deploy, this has led to more scrutiny over rules of engagement, for example with landmines and cluster munitions. However, as long as DU is in the stockpiles of user states, its future use is still likely if States conclude that its military utility overrides the public and diplomatic condemnation its use would generate.

Health effects

The potential health effects of DU have long been debated within the international community. Numerous reports and studies have been produced by institutions such as the WHO, the British Royal Society[15], the International Atomic Energy Agency (IAEA) as well as the United States Armed Forces Radiobiology Research Institute (AFRRI)[16]. These have sought to include, to a varying extent, a wide range of peer-reviewed studies[17]. Although most of these reports recognise the poten-

[7] See http://www.bandepleteduranium.org/en/users for a complete overview.

[8] The US warned Italy to test its peace keeping forces on DU, but never confirmed the use of DU. However, Italian veterans who got ill after returning from their mission were compensated by the Italian government. According to the court, their illness could be attributed to DU exposure.

[9] Apparently, Russian DU munitions were found in Taliban stockpiles, originating from the '70s but are not likely to have been used.

[10] Fahey, D. Depleted Uranium and its use in weapons.pg.19-20 In: McDonald et al. (2003) Depleted Uranium Weapons and International Law: a precautionary approach. TMC Asser Press, The Hague.

[11] According to a leaked document, DU munitions were present if Afghanistan. See http://www.bandepleteduranium.org/en/leaked-us-army-transport-letter-suggests-du-in-afg

[12] A complete list of US ranges can be found here: http://www.wise-uranium.org/dissti.html

[13] Reports can be found on the UNEP website: http://postconflict.unep.ch/publications.php?prog=du

[14] Cullen, D. (2010) *A Question of Responsibility: depleted uranium weapons in the Balkans.* ICBUW. http://www.bandepleteduranium.org/en/docs/134.pdf

[15] Royal Society (2002) The health hazards of depleted uranium munitions. Part II. Accessed at http://royalsociety.org/uploadedFiles/Royal_Society_Content/policy/publications/2002/9954.pdf

[16] Alexandra Miller, A Review of Depleted Uranium Biological Effects: In vitro studies can be found at http://www.bandepleteduranium.org/en/docs/183.pdf

tial hazards of DU, they estimate that the risks to human health are generally low, and dependent on the level of exposure. Nonetheless, all of the aforementioned organisations outline safety procedures for protection against exposure to DU, thereby recognising the potential threat and underlining the need for precaution. Pregnant women and children are regularly identified as being particularly vulnerable, as expressed by the WHO in their report Children in the New Millennium, stating that: *'Naturally, children may be particularly at risk from exposure to depleted uranium because of their curiosity and lack of knowledge about the contamination'*[18] as well as in their 2001 monograph, which concludes that: *'Young children could receive greater depleted uranium exposure when playing within a conflict zone because of hand-to-mouth activity that could result in high depleted uranium ingestion from contaminated soil. This type of exposure needs to be monitored and necessary preventative measures taken*[19]*.'*

There are typically three main routes of DU intake for civilians and military personnel: ingestion, inhalation and embedded fragments or contaminated wounds caused by the impact of DU munitions. Once inside the body, the two health hazards of DU are its chemical toxicity and radioactivity. DU primarily emits alpha particles, although beta and gamma radiation are also emitted from uranium's decay products. Inside the body, alpha radiation can disrupt cellular processes and damage DNA strands, which could lead to an increased risk of developing different types of cancer, depending on which organ is exposed. DU is also a heavy metal and therefore chemically toxic.

Reported health effects in laboratory studies.

The health risks from DU are derived from its chemical toxicity and radioactivity, with the former often viewed as its primary hazard. Although research indicates that they may act synergistically in a way that may exponentially increase their toxic effect[20]. A large number of in vivo and in vitro studies have proven the carcinogenicity of DU. Studies by AFRRI have demonstrated that DU damages DNA and can cause the formation of tumours, with damage induced by both its chemical toxicity and radioactivity. A range of novel radiation induced effects have been reported, for example the so-called *'bystander effect'*, where chromosomal damage occurs in cells next to irradiated cells, through mechanisms that are currently unclear[21]. In a recent overview, Dr Alexandra Miller from AFRRI summed up their results from *in vivo* and *in vitro* studies, reporting the following results:

Internalised chronic DU exposure *in vivo*[22]	***in vitro*[23]**
1. Causes uranium re-distribution to multiple organs.	1. DU induces neoplastic transformation, mutagenicity, and genotoxicity in vitro.
2. Is associated with mutagenicity.	2. DU is involved in uranium-induced genomic instability.
3. Induces chromosomal damage.	3. Alpha particles similar in energy and distribution to those resulting from cellular uranium exposure to DU aresufficient to transform cells.
4. Induces leukeamia development in mice.	4. Radiation bystander effects are involved in uranium-induced neoplastic transformation and genomic instability.
5. Causes preconceptional paternal exposure to induce genomic damage in unexposed offspring.	
6. Induces germ cell DNA damage.	

[17] For an overview of peer reviewed studies, please see http://www.bandepleteduranium.org/en/docs/58.pdf

[18] UNEP, UNICEF & WHO (2002) Children in the New Millennium: Environmental Impact on Health. pg.63

[19] WHO (2001) Depleted uranium: Sources, Exposure and Health Effects. Geneva.

[20] This paragraph summarises the overview of health effects from Fahey, D. Environmental and Health consequences of the use of depleted uranium weapons. In: McDonald, A. et al. (2008) Depleted Uranium Weapons and International Law: a precautionary approach. TMC Asser Press. The Hague.

[21] Morgan, W.F., Sowa, M.B. (2007) Non-targeted bystander effects induced by ionizing radiation. Mutation Research 616 (2007) 159–164.

[22] Miller, A. (2011) A Review of Depleted Uranium Biological Effects: In Vivo Studies: http://www.bandepleteduranium.org/en/docs/184.pdf

[23] Miller, A. (2011) A Review of Depleted Uranium Biological Effects: In Vitro Studies. http://www.usuhs.mil/afrrianniversary/events/DUsymp/PDFs/50thMiller_in-vitro.pdf

Literature reviews by the WHO and the Royal Society, though based on the limited data available in 2001-2002, reported other potential health effects such as lung cancer, bone cancer and leukaemia when exposed to high doses of DU over a longer period, though they note that risk from exposure to small amounts for a short period of time is low. Long-term studies on civilian populations have not yet been conducted.

Apart from cancers, DU has other reported effects. From laboratory studies DU has been shown to be a teratogen, affecting reproductive cells and the foetus, thus making it a potential risk factor for birth defects[24, 25]. DU is also able to cross the blood-brain barrier and may cause nervous system diseases; it also has the potential to affect the immune system and with long-term exposure could affect kidney function.

Even though laboratory studies are indicative, long-term epidemiological studies on an exposed population are needed to establish a clear correlation between exposure and effect. However, undertaking such studies in a post-conflict environment such as Iraq remains highly problematic. First of all, undertaking such a study requires basic security, which is often lacking because of the absence of a capable and reliable police or military force. Secondly, to be able to set up research, baseline data such as medical records for target groups are required to reveal trends in health outcomes, but in the states affected so far (Iraq, the Balkans) these types of medical records are incomplete or unavailable. Thirdly, transparency over the locations, targets and quantity of DU fired is needed to identify target areas for research and to be able to make comparisons between affected and non-affected areas. However, the continued refusal by the US to publicise these data obstructs any future attempt for serious research. Fourthly, populations in the affected areas may have been highly mobile; this further complicates the identification of suitable cohorts. Finally, after armed conflict, medical facilities prioritise primary care over research.

'...it is clear that the lack of studies on exposed civilians in affected areas currently makes it difficult to accurately determine the dynamics of exposure and health effects.'

In conclusion, we can see that it is clear that the lack of studies on exposed civilians in affected areas currently makes it difficult to accurately determine the dynamics of exposure and health effects. As a result, the scientific debate revolves around the level of exposure and the dose-effect relationship. This uncertainty is further compounded by the lack of appropriate long-term epidemiological studies on exposed civilians. In recent years therefore, a new discourse has emerged that seeks to analyse the factors influencing the risks to civilians from DU and assess the role of precaution[26]. The degree to which DU poses a risk to human health and the environment depends on a wide range of factors. Undertaking accurate civilian risk assessments for military DU use is therefore fraught with difficulties. For the purposes of this report, risk can be defined as the quantitative relationship between exposure and a given health outcome. In a paper on DU risk assessment, Dr. Keith Baverstock, a former WHO expert, outlined the problematic nature of DU with regard to risk assessment as follows:

'By its nature [a risk assessment] would depend upon assumptions about specific scenarios of exposure, not all of which could be predicted given the nature of the way in which DU is dispersed into the environment, where, for example, environmental conditions such as climate might influence the risk[27].'

As there is also insufficient experimental data to understand the dose-response relationship for all health outcomes, the relationship between dose and harm is not fully predictable. This and other uncertainties have confounded recent attempts at performing risk assessments. Therefore, every exposure to DU should be considered a risk, which needs to be managed appropriately.

[24] See Fahey, D. (2008) supra. pg.64-65.

[25] Hindin, R et al. (2005) Teratogenicity of depleted uranium aerosols: A review from an epidemiological perspective, Environmental Health, vol. 4, pg. 17.

[26] Weir, D. (2012) Precaution in Practice. Challenging the acceptability of depleted uranium weapons. ICBUW. Available at http://www.bandepleteduranium.org/en/docs/195.pdf

[27] Baverstock, K. (2011) Evaluation of the SCHER opinion on DU in 2010. Available at http://www.bandepleteduranium.org/en/docs/168.pdf

To conclude, contamination from DU creates a legacy of uncertainty and unpredictability. We do not know for certain what the safe threshold for human exposure is, nor precisely how DU behaves in the human body. Further studies have shown that DU's environmental behaviour is also enormously variable, as are the locations and quantities it is used in during conflict. Because of these uncertainties, a precautionary approach should be adopted, which would mean that each contaminated site needs to be assessed individually and remediation should be undertaken.

Contaminated tank in unprotected storage location. Al Zubayr, 2012 © Edouard Beau

2. Use of depleted uranium in Iraq

Three decades of intense conflict has left deep scars on Iraq. A country once known as the cradle of civilisation is now slowly rebuilding itself from the ruins of these wars. The Iran-Iraq War caused major destruction in the southern part of Iraq, and resulted in the loss of hundreds of thousands of lives, scattered communities and environmental degradation, After the Gulf War of 1991 and the subsequent UN sanctions system, the Iraqi population suffered more, both from the brutal Saddam regime and the lack of necessary medical support and import of food, leading to poverty, malnutrition, a breakdown of the healthcare system, as well as pollution from the burning of oil wells. The situation worsened after the US led invasion in 2003 when the system of government collapsed, resulting in high levels of unemployment, corruption and many deaths and injuries due to violent bomb attacks, fighting by insurgents and terrorist attacks. Again, the suffering of the Iraqi population continued, and suffered from a lack of basic necessities, while living in an environment polluted by the conflicts. Yet little support was forthcoming for protecting civilians from the consequences of war, despite the increasing levels of income from oil revenues.

As noted previously, access to quantitative and geographic data on DU use in Iraq would help considerably in the planning and delivery of research, clearance and remediation work, yet the current lack of transparency is hindering these efforts and obscuring the debate. This chapter attempts to give an overview of the locations where DU is known to have been used, it combines the limited data released by the US and UK governments, media reports, scientific articles from Iraqi researchers and eyewitness reports, which were collected during field trips in 2011 and 2012 as part of this study[28].

Operation Desert Storm, 1991.

'The slender, yard-long, depleted uranium dart of the sabot round crossed the killing zone in a fifth of a second. It tore through the berm and hit the T-72 with the force of a race car striking a brick wall at 200 miles per hour, but with all of its energy compressed into an area smaller than a golf ball. One millisecond later the dart broke through just above the track and a foot below the turret ring. Two milliseconds later it had gone through to the right side of the tank, then the berm again, and off into space. The dart's impact caused what ballistics scientists tactfully term a "pyrophoric effect," the result of thousands of tiny bits of dense uranium material, sheared off and turned white hot, flashing throughout the crew

[28] A full overview of all the known sites and their GPS coordinates can be accessed online at http://goo.gl/maps/VVWKs

compartment. One piece of metal torched through the combustible cardboard of the propellant charges in the autoloader. A second Iraqi tank erupted in grisly pyrotechnics[29].'

The 1991 Gulf War was the first conflict where large quantities of DU were fired by multiple platforms. After the end of the conflict in 1991, images appeared on television of highways full of burning and destroyed Iraqi tanks, armoured vehicles, personnel carriers and trucks. One of the most infamous places where the Iraqi army suffered major losses was on Highway 80, the so-called Highway of Death - the road between Kuwait City and Basrah. In the aftermath of the hostilities, the army retreated and was attacked by the US Air Force, leaving a burning trail of hundreds of tanks and abandoned vehicles. Elsewhere, in the desert and along other roads, tanks and armoured vehicles struck by DU remained where they had been destroyed for years after the conflict. Looters and scrap metal collectors used parts of the tanks for commercial and private use, while children used the wreckage as a playground.

The US deployed multiple systems capable of firing DU during the conflict, both on the ground and in the air. Most of the DU was fired by the AV-8B Harrier and A-10 Thunderbolt II (or Warthog) in the form of 25 and 30mm munitions[30]. The GAU-8 Gatling rotary cannon used on the A-10 is able to fire 3,900 rounds per minute. Each PGU/14B 30mm round contains 302 grams of DU, thus an A-10 is capable of releasing hundreds of kilograms of DU within a short period. According to conservative estimates, the A-10s were responsible for *'destroying 987 tanks, 926 artillery pieces, 501 armored personnel carriers, and 1,106 trucks. Hogs also destroyed other targets, such as Scud missile sites, Surface to Air Missile (SAM) sites, and two helicopters'*[31], 100 of those tanks are reported to have been destroyed with 30mm DU ammunition[32], while the AVB used 25mm ammunition to engage artillery, tanks, ammunition storage bunkers, convoys, logistics sites, troop locations, airfields and known anti aircraft artillery/surface-to-air missile locations. In total, 783,514 rounds of 30mm and 67,436 rounds of 25mm DU ammunition was fired by US aircraft during attacks on Iraqi targets.

More DU was used by the M1 tank, firing 105mm M900 rounds, each round containing 3.83kg of DU, and by the M1A1 tank, firing 120mm M829 and M829A1 rounds, each containing 3.94 and 4.64kg of DU respectively[33]. The UK deployed Challenger tanks, which used 120mm DU rounds, and in total fired 88 rounds, adding up to 408kg of DU. In total more than 286,000kgs of DU were fired in north-eastern Saudi Arabia, Kuwait and Iraq during the US-led operations[34].

The only geographical data on DU use released by the US is a generic map of operations where DU was used (below). Based on accounts of tank battles, it is possible to identify more specific locations where DU was likely to have been fired. On a couple of occasions during the invasion of Kuwait and Iraq, US armoured divisions faced Iraqi tank battalions, resulting in heavy fighting in the desert and in and around some towns near the Kuwaiti and Saudi Arabian border. For example, before the actual invasion of Kuwait on 15th February 1991, Iraqi forces managed to occupy the city of Khafji at the end of January for a couple of days. A coalition of Arab and US troops managed to re-take the city, resulting in the destruction of approximately 90 tanks and armoured vehicles, mostly with Maverick missiles[35].

When the Gulf War officially began on the 15th of February, Allied tank and armoured divisions crossed the Saudi border into Iraqi and Kuwaiti territory, engaging Iraqi forces. During the 73 Easting Tank Battle, US and UK tank brigades destroyed hundred of tanks, personnel carriers and trucks from the Iraqi Tawakalna tank division, 20 km west from the Kuwaiti border in Iraq. At the Battle of Norfolk, about 2km away from the 73 Easting battle, 60 tanks and 180 AFV's were destroyed. Other known tank battles were fought at Al Busayyah, leaving over 30 destroyed tanks, trucks, artillery and AFVs, and at the Medina Ridge near Basrah, where US forces engaged Iraqi armoured divisions, resulting in the loss of 186 tanks and 126 AFVs on the Iraqi side, while A-10s accounted for dozens of successful attacks in support of the US

[29] "Quote from 2nd Squadron, 2nd Armoured Cavalry Regiment, in the Battle of 73 Easting, in: General Robert H. Scales (1993) Certain Victory: the US Army in the Gulf War. US Army Command and Staff College Press, Fort Leavenworth, Kansas. pg. 4.

[30] Fahey, D. (2008) supra. "The A-10 alone is accounted for 83 % (by weight) of the total DU shot during the war". pg. 14.

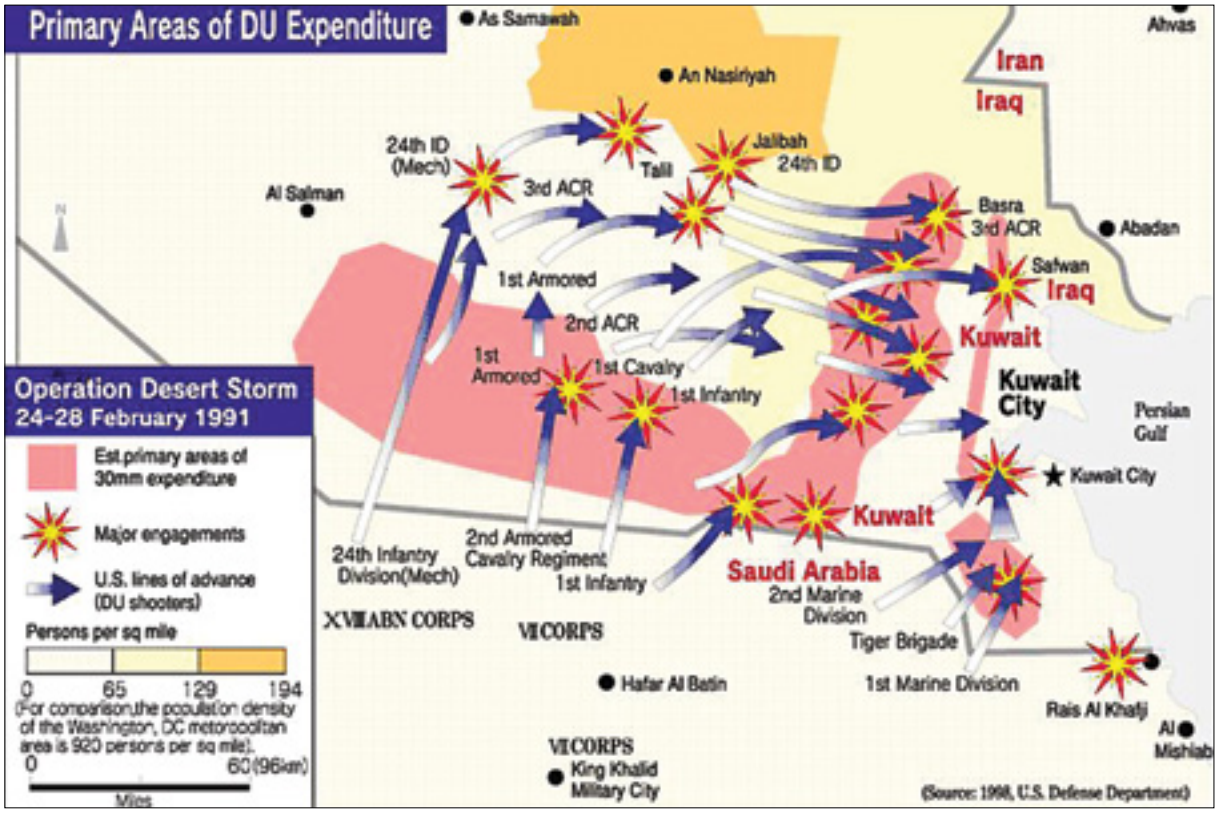
[31] Jacques, D.R., Strouble, D.D (2010) A-10 Thunderbolt II (Warthog) Systems Engineering Case Study. Air Force Center for System Engineering. Air Force Institute for Technology. Accessed at http://www.dtic.mil/dtic/tr/fulltext/u2/a530838.pdf

[32] Fahey, D. (2008) supra. pg 15.

[33] Department of Defense (2000) Environmental Exposure Report. Depleted Uranium in the Gulf (II) Accessed at http://www.gulflink.osd.mil/du_ii/du_ii_tabf.htm

[34] Fahey, D. (2008) supra, pg. 14-18

[35] Major John. F. Newell III (1998) Airpower and the Battle of Khafji: Setting the Record Straight. School of Advanced Air Power Studies. Maxwell Air Force base Alabama. pg. 58.



tanks[36]. On March 2nd, two days after the unilateral ceasefire, US troops engaged a column of retreating Iraqi forces on the road from Rumaila, destroying 187 armoured vehicles, 43 artillery systems and more than 400 trucks[37].

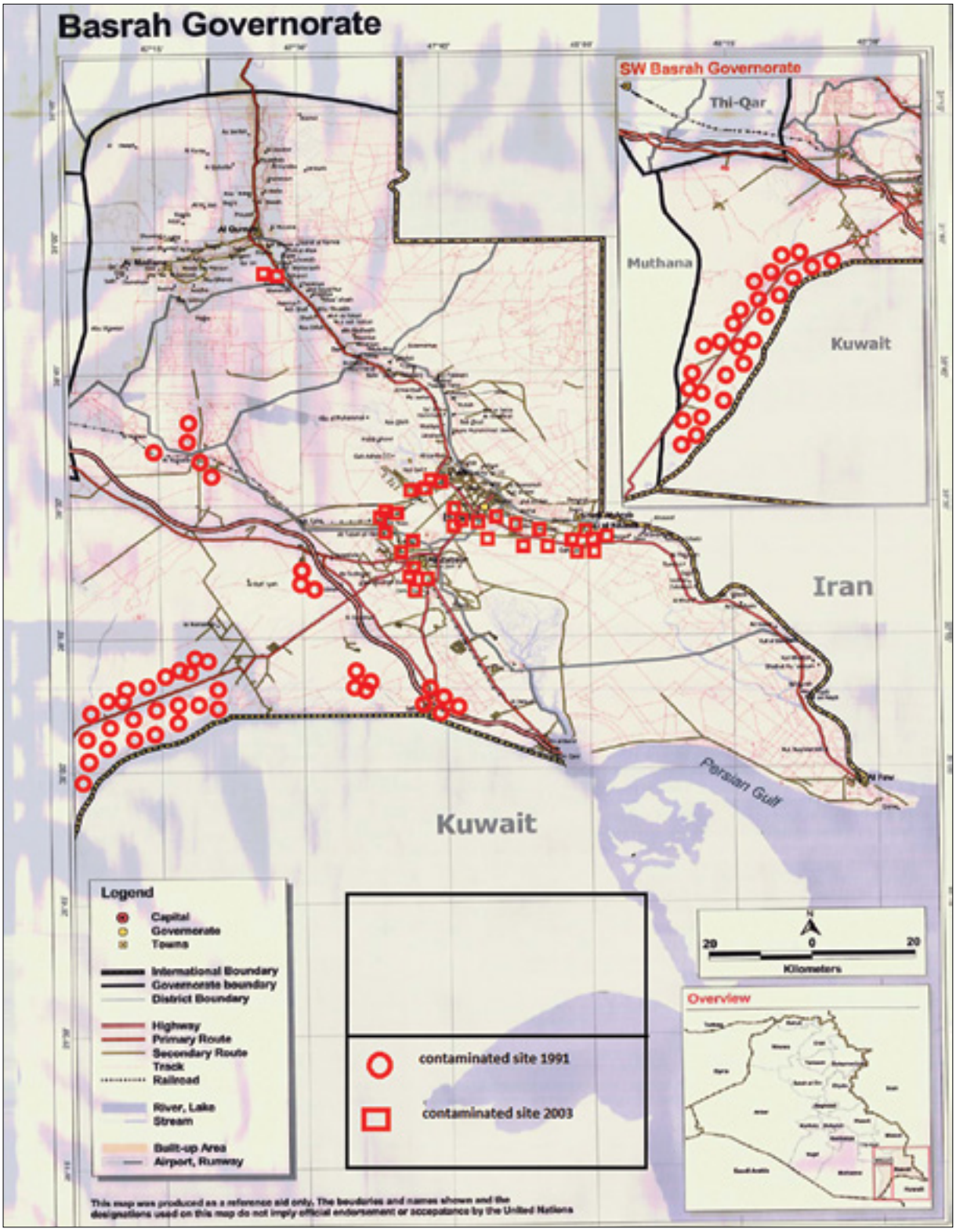
On several occasions, friendly fire incidents occurred, leading to the loss of life of US soldiers and the destruction of six tanks and 15 M2 BFVs[38]. Most of the incidents took place at the Battle of Norfolk and the battle for Jalibah Airfield, and involved M1 Abrams tanks firing 120mm DU rounds. Other reported air-to-ground incidents were caused by an A-10 mistakenly attacking US forces by strafing them during patrols near the Kuwait-Saudi border.

Overview of DU use in 1991[39]

Branch	Weapon System	Ammo size	Quantity of DU rounds	Weight of DU (kg)
US Army	M1 tank	105mm	504mm	1,930
	M1A1 tank	102mm	9048	37,293
US Air Force	A-10 jet	30mm	782,514	236,319
	A-16 jet	30mm	1,000	302
US Marine Corps	AV-8B Harrier	25mm	67,436	9,981
	M60A3, M1A1	105, 120mm	Unknown	Unknown
US Navy	Phalanx Gun	20mm	Unknown	Unknown
UK Army	Challenger tank	120mm	88	408
Totals			Tanks - 9,640 Jets - 850,950	Tanks - 39,631 Jets - 246,602 Total - 286,233

Even where the general locations of battles are known, establishing the precise locations of strikes is impossible without more detailed coordinates. Thus, the only accurate data on contaminated sites is that derived from research undertaken by Iraqi researchers after 1991, and the Iraq War in 2003.

Soon after the end of the invasion in 2003, the Iraqi Ministry of Environment (MoE) was slowly rebuilding its capacity, and established the Radiation Protection Centre (RPC). Its main objective was monitoring and safeguarding nuclear materials.



Overview of found DU contamination by Dr.Vartanian

One of the RPC's experts, Dr. Khajak Vartanian, wrote his PhD thesis[40] in 2006 on DU contamination in southern Iraq. He based his findings on research conducted on 44 sites with tanks, armoured vehicles or anti-aircraft guns destroyed with DU, taking over a hundred samples of debris and soil. This thesis is a valid source of information and data on the locations of these vehicles and will be used in this chapter. Other available resources that mention DU contamination from that period are grey literature medical reports from the University of Baghdad. During the mid 1990s, a small team of researchers measured radiation levels in areas where DU was suspected to have been used. However, it is not clear what the researchers based their information on, thus the reliability of those reports cannot be guaranteed. Sites where samples were taken included the Northern and Southern Rumaila Oil fields, Al Zubayr, Basrah City, Safwan and Jabal Sanam[41].

The map above clearly shows contamination on the road to Basrah from the Southern Rumaila oil fields, and in and around the town of Safwan on the Kuwaiti border. Little information is available on clean-up operations after the end of hostilities in 1991, but it seems that most of the wreckage was left on the battlefield. Tanks, AFVs and trucks that were destroyed on the road or in populated areas are likely to have been collected and moved to scrap metal yards.

In sum, due to a lack of transparency over precise firing locations and targets, a clear picture of the scale of contamination, especially in urban and populated areas is lacking. A small number of these locations were investigated by Iraqi researchers, but these are just a fraction of the total number of contaminated sites. Considering the tremendous amount of DU fired, more than 286,000kgs, it is to be expected that a substantial number of people, both military and civilian, are likely to have been exposed to DU, be it in combat or while handling damaged vehicles and ammunition. Repeated requests to the US government to publicise firing data were turned down, stating that the US had not recorded the data, but this remains disputed considering the level of technology used in their weapon systems and the fact that is common practice to store this data for subsequent evaluation and training purposes.

Operation Iraqi Freedom 2003

"It is a superior weapon, superior armor. It is a munition that we will continue to use, if the need is there to attack armor." Dr. Michael Kilpatrick, US Department of Defense[42].

Although the US and the UK drew heavy criticism from campaigners and veterans after the use of DU in the 1991 Gulf War and the Balkans, they did not hesitate to use it again during the invasion of Iraq in 2003. Combat operations started on March 20th with American, British, Polish and Australian forces moving in from Kuwait, while the US Air Force provided air support and attacked critical military infrastructure.

The US and the UK once again deployed several platforms with DU munitions such as the M1 and M1A1 Abrams tanks, Challenger II tanks and the A-10 Thunderbolt II and AV-8B Harrier aircraft. To these were added the Bradley AFVs, armoured fighting vehicles that would play a significant role in urban operations and which could fire M919 25mm DU rounds. Apart from engaging armoured vehicles, Iraqi soldiers, trucks and buildings were attacked using DU. The latter is best illustrated by the well documented and notorious attack on the Iraqi Ministry of Planning in Baghdad by an A-10, resulting in significant contamination of the building and surrounds.

Again, there is no transparency over specific firing locations and targets, but looking at some of the major battles that took place during the operations in Najaf, Basrah, Al Samawa, Karbala and Nasiriyah, involving platforms armed with DU, we can establish with certainty that DU was used in populated areas and against armoured and non-armoured targets.

[36] Houlahan, T. (1999). Gulf War: the complete history. Schrenker Military Publishing.

[37] Richard S. Lowry (2003) The Gulf War Chronicles: A Military History of the First War With Iraq. iUniverse, Lincoln.

[38] Department of Defense (2000) Environmental Exposure Report. Depleted Uranium in the Gulf (II) Accessed at http://www.gulflink.osd.mil/du_ii/du_ii_tabg.htm#TAB G_DU Exposures in the Gulf War

[39] Data taken from Fahey, D. (2008) supra.

[40] Vartanian, K., 2006; Study of radiation pollution by depleted uranium for Basrah environment. A thesis submitted to the College of Education, University of Basrah, Iraq, for the Degree of Master of Science in Physics Supervised by Prof. Kassim A.R. Khazal, May 2006.

[41] Al-Azzawi, S., and Al-Saji, M., 1998, Effects of radioactive on surface and ground water in selected regions in southern Iraq. Journal of Arabic Universities Association, vol. 6, no. 1, Baghdad,1999.

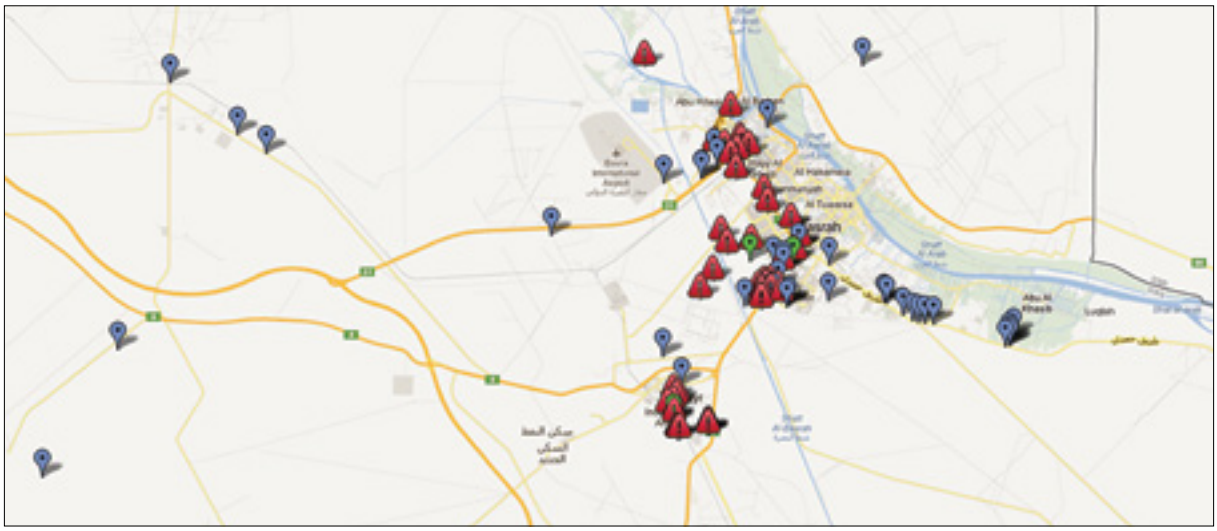
[42] Department of Defense (2003) Briefing on Depleted Uranium. March 14, 2003. Accessed at http://www.defense.gov/transcripts/transcript.aspx?transcriptid=2058

Amount of DU fired during the 2003 invasion[43]			
Branch	**Weapons system**	**Type of DU**	**Amount of DU fired**
US Air Force	A-10	30mm	93.400kg
US Army	M2/M1A1/M1A2	25/105/120mm	21.800kg
US Marine Corps	M1A1/M1A2/AV-8B	25mm	Unknown
UK	Challenger II	120mm	870kg

Use of DU in Basrah Province

The bulk of data currently available covers mainly the southern part of Iraq. Thanks to Freedom of Information requests, research by UNEP, the IAEA and local researchers, it is possible to get a fuller picture of contaminated locations and objects.

The UK Ministry of Defence provided more specific data over the locations where DU was fired after a request from UNEP, and this was later shared with the public. According to the MoD, DU was fired on 51 occasions in the Basrah region, and they later published the information in response to a Freedom of Information request by UK campaigners. Together with other available public information, the following overview of DU in Basrah province is made:



The red icons represent the information provided by the UK, the blue and green icons, data collected by Iraqi researchers. According to the map, a substantial quantity of DU appears to have been fired in populated areas in Basrah and Al Zubayr. The data only provided firing points; it therefore does not give any detail of the type of targets and their locations. Interestingly, and considering the number of firing points (51), and type of munitions fired (120mm, each containing 4.5kg of DU) this accounts for only 229.5kg of the 870kg reported fired.

UNEP undertook field research in 2006/7using the UK MoD's data, but were not able to locate specific contaminated tanks and found little or no DU ammunition. After the end of the conflict, Coalition forces and the Iraqi government undertook some remediation programmes, but the extent and outcome of these have not been made public. According to the

[43] Fahey, D. (2008) supra pg.136-137.

director of the MoE in Basrah, Mr. Taha al-Quraishi, most of the tanks were shipped to a tank graveyard in an undisclosed location in the desert, while other wreckage was stored in scrap metal sites in and around Basrah. Hence, most of the tanks have been moved outside populated areas, but it is unclear how many of the tanks and armoured vehicles were destroyed with DU. UNEP research, based on the UK and Iraqi RPC data, also used local accounts, satellite images and media reports of the fighting to determine research locations, and took samples at the following sites[44].

1. Al Samawah (bridge, main road where tanks were positioned, cement factory, scrap yards, waste piles and train station).
2. An Nasariya (tank defence positions at main road, railway, Iraqi army warehouse, munitions storehouse, former Coalition military camp, various roadways, commercial and industrial properties over town, one tank and scrap yards).
3. Al Basrah (main roads, industrial, commercial and residential areas over different parts of town).
4. Al Zubayr[45] (industrial, commercial and residential areas, roads and several tank parts).

The samples taken at a majority of the locations were found to contain DU, although the radiation levels were lower (less than 100µSv/a) than standard recommended radiation dose limits (1mSv/a). As mentioned earlier, no safe thresholds for internal exposure to DU have been established, thus all exposure should be avoided. Considering the fact that most of the smear samples contained DU, it is clear that DU dust was spread over the area after impact. Other reports by researchers provided more specific locations for research. Vartanian (2005) took samples from destroyed tanks, armoured vehicles, bridges and fortified strongholds found in a range of locations in southern Iraq, with the bulk near Basrah and Az Zubayr. The main locations were:

Basrah city	Basrah Airport	Abu Khasib district	Al Zubyar town
Saad square	Road to the airport	Hamdan Industrial Area	No location specified
Qibla area	Airport Gate	Wetlands	
Al Zubay Bridge	Runway and train station	Awja district	
Road to Anas Ibn Malik Mosque			

The locations where destroyed tanks and vehicles were found, and samples taken, indicate the presence of contamination, both from the wreckage, and likely in the soil due to the strafing of targets by A-10 aircraft. A10s from the 190th Fighter Squadron are known to have provided air support for British ground forces. On one well known occasion, this led to a friendly fire incident 25km north of Basrah, where two A10s strafed two British armoured vehicles, resulting in the deaths of British soldiers. Other known friendly fire incidents with likely use of DU were reported to have occurred in the southern Basrah area.

Over the course of the years after the ceasefire in 2003, multiple systems capable of firing DU were used to fight the Iraqi insurgency in combat operations, but there is no data available on the quantities of DU fired.

Other areas where DU is known or suspected to be used

The Coalition strategy behind the invasion was less of a ‘shock and awe’ campaign but focused instead on a swift move into Iraq, bypassing Iraqi strongholds and moving quickly to Baghdad to decapitate the regime. This resulted in heavy fighting between Iraqi troops and Coalition forces in and around Nasiriyah, Samawa, Najaf and Karbala, leaving hundreds

[44] GPS coordinates can be found in link in footnote 28.

[45] The UTM coordinates provided in the UNEP report for Al Zubayr are incorrect, thus no specific location could be indicated on the map.

of destroyed armoured vehicles, tanks, trucks and artillery pieces in the cities and along roadsides. Data on the use of DU in these locations is limited but the reports in the following section provide evidence of DU use in these cities, both against armoured and non-armoured targets, such as buildings. Furthermore, on some occasions, Coalition forces suffered losses of M1 Abrams tanks (which have DU armour) and Bradley AFVs, due to 'friendly fire' incidents, in and around Nasiriyah, Karbala and Najaf, which could also have caused contamination due to burning DU armour or ammunition.

Nasiriyah

The US forces' ground advance was halted at Nasiriyah, where heavy battles took place to conquer the bridges into the city. These failed at first and US forces ended up besieging the city for over a week. Fighting continued inside urban areas, where Iraqi forces put up fierce resistance, with mainly RPGs and small arms, and a small number of dug in tanks. US tanks, AFVs, attack helicopters and fighter planes were called in to support ground operations. According to news sources[46], A10s, AV-8s, M1 Abrams tanks and Bradley AFVs, all platforms that can use DU, were deployed and involved in fighting against armoured and non-armoured targets, such as buildings and strongholds. One report from an embedded journalist near Nasiriyah describes the following scenario, in which 25mm DU munitions from a Bradley were used against a pick-up truck:

'One of the most horrific images that I've seen here in the war was the results of 25-millimeter depleted-uranium ammunition fired at a Nissan pickup truck with six Iraqi regular-army soldiers that were driving it straight at a U.S. position. These Iraqi regular-army soldiers had RPGs and fired two of these rocket-propelled grenades at the U.S. positions, when a U.S. Bradley troop carrier using this depleted-uranium ammunition opened fire on it from about 30 to 35 meters away. If you can imagine what a human being looks like melting when being hit by this ammunition, there wasn't much left of these people other than the charred remains of their skeletons. And the people that took the brunt of the attack, even their skeletons had multiple fractures all over them. One Iraqi soldier who was out of the vehicle at the time about 15 meters back from the vehicle was killed just from the concussion of the blast[47].'

Again, specific information on the type of targets and quantities of ammunition used is unavailable but, based on reports from secondary sources it is possible to get an indication of where DU was used. Both UNEP and Dr.Vartanian located vehicles and hotspots in Nasiriyah, identifying 14 sites where DU had been used in battles, mainly in the southern part of the city[48]. The samples taken by UNEP were mainly soil samples, and some samples taken from the surface of tanks and other military equipment. DU residue was also found in scrap yards. Researchers from the University of Thi-Qar also collected samples from 20 locations in the Khamasiya region and the Thi-Qar Governorate, with the bulk of the samples taken from munitions depots that were attacked, and some samples from destroyed armoured vehicles[49]. Other research from Baghdad and Al-Nahrain University also found traces of DU in two locations in and around Nasiryah, and one in Amara, north east of Nasiriyah[50]. Unfortunately, specific information on the locations was not provided.

In conclusion, DU use in Nasiriyah can be confirmed, as well as along the roads leading up to Nasiriyah from Basrah and the roads towards Baghdad and Al Samawah. The deployment of platforms that are likely to have fired DU against armoured and non-armoured targets has been acknowledged by the US Army, embedded journalists, UNEP and Iraqi researchers, who found traces of DU in scrap yards and in the soil. As A-10s and AV-8s were deployed in several support operations, it is to be expected that fairly widespread contamination by 20 and 30mm DU ammunition may be found at the target locations. Large scale use of 120mm DU munitions is less likely, considering the small number of Iraqi tanks that were involved in the battles, so it is to be expected that High Explosive (HE) tank ammunition would have been the weapon of choice.

[46] Connetta, C. (2003) The Wages of War: Iraqi Combatant and Noncombatant Fatalities inthe 2003 Conflict Project on Defense Alternatives Research Monograph # 8. Accessed at http://www.comw.org/pda/0310rm8ap1.html#3.%20Nasiriyah

[47] Radio Free Europe (2003) Iraq: Desert Dispatch – The View Near Karbala. Accessed at http://web.archive.org/web/20040627032246/http://www.rferl.org/features/2003/04/02042003150647.asp

[48] See link in footnote 28 for specific locations.

[49] M.Al-malky, S. R.Al-Bahrani, M (2006) Environment Radiological Pollution from the Use of Depleted Uranium Weaponry Against Thi Qar Governorate during 2003 War. Journal of the University of Thi-Qar. No.2 Volume 2.

[50] Ahmed A. Mohammed, Ali Sh. M. Hussien, Nada F. Tawfiq (2008) Assessment of depleted uranium contamination in selective Iraqi soils. Journal of Al-Nahrain University Vol.11(1), April, 2008, pg.74-81

Al Samawah

The road north west from Nasiriyah leads to Al Samawah, the last city before the Shiite holy city of Najaf. US forces encountered resistance from Iraqi forces, and took several days to besiege the city and locate and eliminate Iraqi resistance fighters. During press briefings by US Central Command, it was stated that DU was used during the fighting in the area: *"There's a very small portion of our munitions that use depleted uranium[51]"*, said General Brooks during a Q&A with reporters, but failed to provide any more details. Other reports of DU use in the area came from embedded journalists, who reported several accounts of US soldiers mentioning the use of DU during operations in Al-Muthanna and Najaf, for example by Sergeant First Class Cooper who noted that: *"[weapons systems] are performing well, especially the 25mm DU and 7.62[52]"*. Other accounts also mention DU use in urban areas against non-armoured targets, for example by embedded journalist Chris Tomlinson in the 3rd Battalion, 7th Infantry regiment:

"[Sergeant Bryce] Ivings spotted a man moving furtively around a commercial building, about a thousand meters away. American tanks opened fire. In support, Ivings fired his 25mm cannon, equipped with high explosive, depleted uranium shells. 'Wow, look at that' Ivings said, as two basketball-sized holes open up in the building. He fired again, knocking down the wall. 'Whoa, that was awesome'[53]."

Therefore, widespread use of DU in the areas of operation, both against armoured and non-armoured targets seems likely. However, specific data on the firing locations and targets is still absent, hindering any useful assessment of the scale, impact and exposure risk from DU in these urban environments.

Research by UNEP identified four locations, including two tanks, finding DU in smear samples taken at all four. Additional smear samples were taken at the train station at Al-Khafora, a scrap yard near the cement factory, and from piles of waste and debris that were found in the area. DU was found in all of the samples taken from artillery pieces and tanks. An employee from the local Radiation Protection Centre who was interviewed by the author, confirmed that they regularly find new contaminated hotspots, ranging from debris to destroyed armoured vehicles. However, he admitted that they lack the funding to set up clearance and decontamination operations, stating that an average clean-up effort would cost US$25,000, and would require sophisticated equipment, which they do not possess[54].

After the end of hostilities, Dutch and Japanese armed forces were also based in Al-Muthanna, holding Al Samawah as the main city. According to a Dutch Ministry of Defence spokesman, specific information was given by the US Army to the Dutch troops about sites with contamination, and Dutch soldiers were given instructions on precautionary measures to take if they came across DU during the course of their operations[55]. This represents further confirmation that DU was used in and around Al Samawah, and that specific contamination hotspots and/or firing coordinates are known to US forces.

In sum, no specific firing data is publicly available, but the wide scale deployment of platforms that use DU has been reported in Al-Samawah and confirmed by traces of DU found in samples taken at different sites in this area; therefore civilian and military DU exposures were likely in the area.

Najaf

The rapid US advance towards Najaf slowed after it met with considerable resistance at the city, particularly at Najaf airport. The 2nd Brigade of the 3rd Infantry Division, consisting of M1A1s and Bradley AFVs, engaged in heavy fighting with militiamen, with close air support from A10s[56]. The US armoured vehicles deployed in the area had DU in their standard combat loads, and were deployed against light armoured vehicles and pick up trucks, this report from a Time journalist is telling:

[52] Dispatches From Iraq (2003) Field Message from SFC Cooper Accessed at http://web.archive.org/web/20040130232417/http://www.phoenix158.org/iraq/cooper.cfm

[53] Chris Tomlinson (embedded with 3rd Battalion, 7th Infantry, 3rd Infantry Division) and Michael Luo, Associated Press, as published in the Athens Banner-Herald on Wednesday, March 26, 2003. See: http://www.onlineathens.com/stories/032603/war_20030326057.shtml

[54] Interview with RPC employee, Najaf, 19 April 2012.

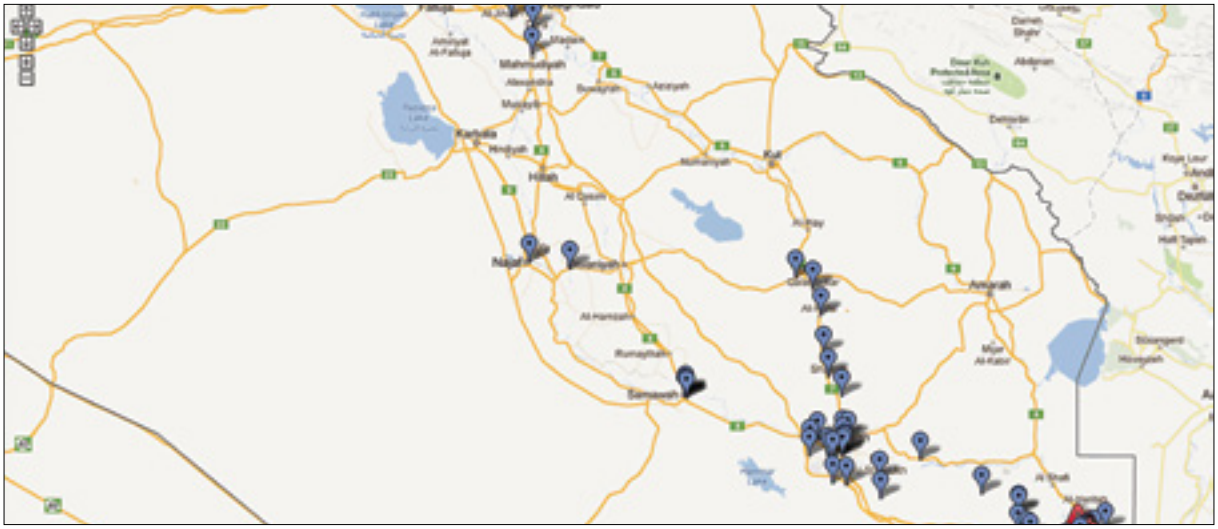
[55] Communication with author, November 14th 2012.

[56] Colonel Gregory Fontenot, Lieutenant Colonel E.J. Degen, Lieutenant Colonel David Tohn (2004) On Point: *The United States Army in Operation Iraqi Freedom.* Combat Studies 57 Institute Press Fort Leavenworth, Kansas

"For hours, the Iraqis continued this furious drag race—floor it and fire—whipping down the road from Najaf into the waiting guns of the 2nd Brigade's M1 Abrams tanks. The M1s obliterated them. Says Perkins: "I didn't expect this many of them, but all that meant was we used up more ammo. And I have plenty of that, especially if it means not fighting these guys in Baghdad"[57].

The only reported use of DU in Najaf found by the author can be found in a footnote of *On Point*, a US army account of the war in Iraq. The author describes an attack by Iraqi troops on a Bradley fighting vehicle and, in the course of the fighting, 305 25mm DU rounds were fired on trucks, buildings and Iraqi soldiers[58].

Reports from both journalists and the Pentagon suggest that hundreds of Iraqis were killed and dozens of vehicles destroyed during the intense fighting[59]. Only one media outlet reported the use of DU by A10s, stating that: *"suspected Fedayeen positions were being hit with 30mm depleted uranium rounds - "tank killer" weapons that are capable of blasting through walls"*[60]. The use of DU against non-armoured targets in Najaf and the surrounding areas seems likely. As with other cities, no detailed data on firing locations, targets or the quantity of DU fired around Najaf has been made public. The map below shows all the information available based on UNEP and Iraqi research.



The road to Baghdad

After a small pause, mainly used for resupplying troops and assessing Iraqi weaknesses, US forces began their march to Baghdad, moving into the city from Karbala in the south, and Al-Kut in the south east. The city had already been subjected to an intense bombing campaign, and multiple defensive positions with armoured vehicles in and around the city had been targeted. US forces on the road to Baghdad encountered Iraqi armour near to, and inside Karbala, south of Baghdad, and in Al-Kut, south-east of Baghdad, destroying tanks and armoured vehicles. Newspaper articles later confirmed the use of DU in Al-Kut from samples taken by journalists and analysed in the US[61]. In the so-called Karbala Gap, dozens of Iraqi armoured vehicles were destroyed by M1s and Bradley AFVs from the 3rd Infantry Division, battles which probably involved DU. One Iraqi eyewitness described the attack of an A10 in an urban area in Al Mahmouhidiya, south of Baghdad, where three tanks near the market tried to flee the city, and were strafed and destroyed with DU rounds. The tanks

[57] Jim Lacey, April 4 2003. On the road to death at Najaf. Time Magazine. Accessed at http://www.time.com/time/world/article/0,8599,438872,00.html

[58] On Point, pg. 140.

[59] For an overview of the reports, see http://www.comw.org/pda/0310rm8ap1.html#6.

[60] ABC news, April 2, 2003. US troops attack Fedayeen in Najaf. Found at http://www.abc.net.au/news/2003-04-02/us-troops-attack-fedayeen-in-najaf/1828880

[61] Larry Johnson (2003) Use of depleted uranium weapons lingers as health concern. Seattle Post Intelligencer. "To get additional evidence that DU was used on these tanks, the P-I used swabs of cloth to gather samples of residue from the blackened bullet holes on two tanks on the outskirts of Baghdad, and from the black ash on a tank in Kut." Accessed http://www.seattlepi.com/news/article/Use-of-depleted-uranium-weapons-lingers-as-health-1120909.php#photo-633802

remained there for months before they were transported to a scrap metal site[62].

On Highway 8, towards Baghdad, the Marine Corps engaged in fighting with Iraqi armoured forces, resulting in the destruction of 33 T-72 tanks, two T-62 tanks, 19 T-55 tanks, 12 MTLB armoured vehicles, 50 artillery pieces, six BM-21 rockets launchers and 127 trucks[63]. Over the course of several days, numerous other attacks against armoured vehicles and tanks were reported[64] along Highways 1 and 8, leading up to Baghdad, and it is to be expected that DU was deployed there as well.

Near Baghdad, a fierce battle took place for Baghdad Airport, which was defended by the Republican Guard. It was reported that *"The 3rd Infantry came under shellfire.... From the skies, A-10 Thunderbolt 'Tankbusters' fired on Iraqi tanks, reducing many of them to burning wrecks"*[65]. Further confirmation of DU use came from the current commander of the Iraqi 14th Division, General Hamid, who was based in Baghdad during the attacks and stated that: *"DU was used a lot by the US on Baghdad airport,"* he added that after the ceasefire there was a large scale clean-up of wrecked tanks and other military scrap by the US military, which he linked to its likely contamination by DU[66].

Inside Baghdad

The US learned from British tactics in the south, realising that attracting enemy fire by deploying tanks and armoured vehicles was an effective method of pinpointing the locations of Iraqi troops. These so called *'thunder runs',* moving an armoured convoy into the area, became a favoured tactic in Baghdad, and had been used in Najaf and Nasiriyah as well. The first thunder run into Baghdad consisted of almost a hundred M1 tanks, Bradleys and other wheeled vehicles[67]. The 3rd Battalion fought their way through Baghdad to reach US forces at Baghdad Airport, meeting heavy resistance from Iraqi forces. This armoured raid was followed by similar operations in the following days. Intense fighting took place inside Baghdad, where pockets of resistance remained, often with close air support from A-10 aircraft against armoured and non-armoured targets.

A10 firing DU at the Ministry of Planning, April 4, 2003 ©Reuters

[62] Interview with author in Baghdad, October 7 2012.

[64] John B. Tisserand (2006) Network Centric Warfare U.S. V Corps and 3rd D Infantry Division(Mechanized) During Operation Iraqi Freedom Combat Operations (Mar-Apr 2003) Volume III: Network Centric Warfare Insights. Center for Strategic Leadership, United States Army War College. pg. 117.

[64] bid. pg. 118.

[65] Andrew Gumbel and Donald Macintyre, "Amid Wrecked Jets and Hangars, the Greatest Prize; Airport Seized and Re-named," The Independent (London), 5 April 2003, pg.4.

[66] Interview with General Hamid, Basrah, 4 October 2012.

During these operations, the use of DU was reported on numerous occasions. The best documented occasion was the attack of an A-10 against the Iraqi Ministry of Planning, which was filmed by a TV crew (see photo). The aircraft conducted two strafing runs on the building, firing hundreds of rounds of DU. A Japanese journalist was near the strike site, and entered it afterwards with a Geiger counter, and saw the streets littered with DU bullets[68]. In the years that followed, the Iraqi Ministry of Science and Technology was able to undertake limited assessments on several sites in Baghdad, and found DU and contaminated debris in a building with communication devices. They also found DU in a Turkish restaurant near Al Jumariyah bridge. Reports were made about these assessments, but were never made public[69]. Based on these accounts and the deployment of platforms capable of firing DU, it is safe to assume that, apart from the A-10 attacks, DU would have been used as well during the intense fighting in the city. However the extent of this remains unclear, but this claim can be substantiated by the fact that DU contaminated scrap metal and tanks were found at the Ouraij scrap metal site in the outskirts of Baghdad.

Fallujah

From 2009 onwards, credible media reports[70] from the city of Fallujah brought reports of high rates of congenital birth defects in the city to the world's attention. Fallujah had been the scene of intense urban warfare in 2004, after the US, together with Iraqi combat units and supported by UK forces had moved to crush opposition forces in the city. The second such operation 'Phantom Fury', in November and December 2004, sparked considerable international controversy and was the most intense operation since the official end of major combat operations in 2003.

In response to a Freedom of Information Act request in 2011, the US military denied that DU munitions had been used in operation Phantom Fury, although they claimed that no records had been kept prior to July 2004[71]. Few sites have been formally identified by the Iraqi authorities as being contaminated by DU, but in 2005 two contaminated tanks were found, which were probably destroyed by A-10s in the 2003 war[72]. At least two platforms that utilise DU munitions were employed in Phantom Fury, the Abrams tank and the Bradley AFV. The use of the 120mm APFSDS rounds by Abrams tanks would have been of questionable utility in street fighting against irregular forces, however as noted elsewhere, the 25mm M919 rounds fired by the Bradley were shown to be useful for defeating targets behind concrete walls elsewhere in Iraq.

Conclusion

The alleged effectiveness of DU remained an overriding argument for the US Army in justifying its continued use after the Gulf War in 1991, despite international criticism over its potential health and environmental impact. As a result, at least 440,000kg have been used in Iraq, although based on satellite imagery at the end of the 2003 war, UNEP estimated that the total amount was somewhere around 1000 and 2000 metric tons[73]. This chapter provided information based on the most reliable sources available to give an initial understanding of the widespread use of DU. Though contamination is typically localised, it is safe to say that there is widespread localised contamination. Moreover, transparency over the firing locations, target types, and quantities of DU fired is essential for reaching a better understanding of the scale of contamination; and the risks that it poses. The continued refusal by the US to release this data is an obvious obstruction for meaningful site assessment and research on exposure, which is necessary to build a full understanding of the effect and impact of DU on human health and environment.

This section began with a quote from the US spokesman on DU, who claimed that DU was developed and is used solely as an anti-armour weapon – a common refrain, often repeated. However, and as this report makes clear, DU has been used in populated urban and rural areas against non-armoured targets such as light vehicles, buildings and other civilian

[67] On Point, pg. 342.

[68] Toyoda Naomi (2003) Iraq – A Nuclear Polluted Land. Found at http://www.japanfocus.org/-toyoda-naomi/2000

[69] Interview with expert from Ministry of Science and Technology, October 7, 2012.

[70] Chulov, M. (2009) Huge rise in birth defects in Falluja. Iraqi former battle zone sees abnormal clusters of infant tumours and deformities. Accessed at http://www.guardian.co.uk/world/2009/nov/13/falluja-cancer-children-birth-defects; Holland, L. (2009) The Truth Of Iraq's City Of Deformed Babies. Accessed at http://news.sky.com/skynews/Home/World-News/Sky-News-Returns-To-Fallujah-Lisa-Holland-Revisits-The-Children-Born-With-Deformities/Article/200908415371946; Simpson, J. (2010) Disturbing story of Falluja's birth defects. Accessed at http://news.bbc.co.uk/1/hi/8548961.stm

[71] http://www.bandepleteduranium.org/en/us-claims-no-depleted-uranium-used-in-second-fallu

[72] Interview with expert from Ministry of Science and Technology, 7 October 2012, Baghdad.

[73] Interview with Dr. Mario Burger, UNEP, Spiez, September 23, 2012.

infrastructure. Given what is known about the potential risks from DU, and taking into account the repeated assurances of users, the use of DU in populated areas is alarming; particular when considering the indiscriminate nature of the DU dust generated during impacts and the implications for civilian exposure.

'The use of DU in populated areas against non-armoured targets raises profound questions about both the acceptability of these weapons, and the credibility of the military's claims.'

The claim that DU is solely used against armoured targets becomes increasingly tenuous when you consider that A-10 pilots cannot choose between DU or non-DU ammunition once airborne. And while gunners in Abram tanks and Bradley AFVs do have the ability to pick specific ammunition types, Bradley ammunition still appears to have been used against a range of non-armoured targets. The use of DU in populated areas against non-armoured targets raises profound questions about both the acceptability of these weapons, and the credibility of the military's claims.

The exposure risks to civilians from the use of DU in populated areas have been compounded by the US's persistent refusal to release the data that could have helped facilitate effective assessment and clearance work, providing that the Iraqi government had the capacity and finances to undertake it. Taken as a whole, these issues cast serious doubts over the legitimacy of the use of DU.

3. The aftermath: clearance and decontamination efforts

Soon after the end of the conflict, US forces recognised the need to protect their own troops against DU exposure. Major clean-up programmes were undertaken to clear army bases and remove contaminated military scrap metal from these sites, to storage areas in and around Baghdad and Basrah. Later, Iraqi governmental bodies responsible for nuclear affairs such as the Radiation Protection Centre and the Ministry of Science and Technology, started to do limited assessment work on sites where concerns were raised by the local population. This chapter aims to provide more information on clearance efforts by Coalition forces, the Iraqi government and UNEP, and will suggest the next steps needed for further research and decontamination efforts.

Major combat operations might have ended in 2003, but the US would remain in Iraq for at least eight years, ensuring that they would need to build military bases. In addition to the necessary security measures, US forces were also facing the challenge with providing a clean environment for their troops to live in. Numerous Iraqi military bases had been subjected to intense fighting involving DU, leaving contaminated tanks and soils on site. This posed a health hazard to US forces, and therefore decontamination efforts were set in motion, as described below by a journalist from the *Christian Science Monitor*:

"There is a warning now at the Doura intersection on the southern outskirts of Baghdad. In the days before the capital fell, four US supply trucks clustered near an array of highway off-ramps caught fire, cooking off a number of DU tank rounds. American troops wearing facemasks for protection arrived a few days later and bulldozed the topsoil around the site to limit the contamination[...] The troops taped handwritten warning signs in Arabic to the burned vehicles, which read: 'Danger - Get away from this area.' These were the only warnings seen by this reporter among dozens of destroyed Iraqi armored vehicles littering the city... despite the troops' bulldozing of contaminated earth away from the burnt vehicles, black piles of pure DU ash and particles are still present at the site[74]".

Unfortunately, the US government's clearance efforts remain classified. It also remains unclear as to what the Iraqi government knows about these efforts. The RPC stated that they did not receive any information from the US, but the former Iraqi Minister of the Environment noted that information was given by the US to the Iraqi government's presidential council, but an agreement was made not to share or publicise the information, even between ministries[75]. However, several employees working for demining agencies in the period between 2003 and 2005 recalled that some clean-up efforts took place; as do Iraqi citizens and government officials who were involved in the work.

Attempts to obtain data on the activities conducted by the CPA has not resulted in any new information becoming available, which is likely the result of a lack of will to collect all the data on DU use, and a refusal to share or publicise this data with relevant authorities and international organisations. A plausible explanation might be that the US and UK fear that if this should lead to the conclusion that contamination needs to be handled in a proper way, they would be held accountable for the costs involved in clean up; potentially followed by claims from veterans and Iraqi civilians exposed to DU and suffering ill health.

The WHO did draw up a plan after the end of major combat operations in 2003, highlighting areas where intervention was required and seeking support and funding[76]. In the report, they argued that the use of DU should be investigated immediately, stating that:

[74] Peterson, Scott (2003) Remains of toxic bullets litter Iraq: The Monitor finds high levels of radiation left by US armor-piercing shells. The Christian Science Monitor, 15 May 2003.

[75] Internal notes from Roundtable discussion on Depleted Uranium. Amman, Jordan June 8, 2011. Available on request.

25mm bullets found by deminer in Baghdad, 2003. Source known to author

'There are reports of increased rates of cancers, congenital malformations and renal diseases among the population of Iraq. The Iraqi government has attributed this increase to exposure to depleted uranium (DU). Epidemiological studies are needed to investigate such increases and explore all possible causal factors. Iraqi health officials and scientists, working with WHO, have developed plans for the surveillance of cancers, congenital malformations and renal diseases, for investigating the health effects of environmental risk factors including depleted uranium, and for improved cancer control.'

Unfortunately, this plan was never implemented, due to a lack of funding and likely opposition by the US. In a follow-up meeting in June 2003, the WHO engaged with local Iraqi authorities to discuss outstanding environmental issues, and was made aware by Iraqi researchers about the contamination in Basrah resulting from the intense fighting that took place both in 1991 and 2003.

'Since 1991, the area of Basra Governorate is full of remnants of destroyed tanks and military equipment which are all around the area. The department has been measuring the radioactivity both in the battle fields and in Basra city[77]'.

Although Iraqis had been working on prevention and remediation efforts prior to the start of the war, these activities were stopped in 2003 when the war started. The renewed use of DU led to a greater need for the assessment and marking of contaminated sites; to be followed by remediation work and awareness-raising among local populations.

After the fall of the Iraqi regime in April 2003, UNEP published a desk study on the environment in Iraq, which provided an overview of key environmental issues caused, or exacerbated by, the recent conflict[78]. Along with other environmental problems such as contaminated industrial sites, oil spills and the lack of effective waste management, DU was mentioned as a concern. In October 2003, UNEP published a follow-up report on the environment in Iraq, highlighting 'priority areas for action'. Based on further research and fieldwork, this report again mentioned DU as an area of concern that required transparency over targeting data and remediation work. UNEP received the UK's firing coordinates for DU used in Basrah Governorate, together with an assurance from the MoD that: *'most of the heavy military equipment has been moved, mainly by troops, from the battleground to scrap areas'*[79]. The UK carried out some initial assessments on tanks that were found, and analysis found low levels of radioactivity. However, in their conclusion the researchers stated that: *"it must be recognised that the data is not of the quality needed for robust generalised statements about DU contamination or any possible health consequences*[80]*".*

[76] WHO (2003) Potential impact of conflict on health in Iraq. Briefing note. Accessed at http://www.who.int/features/2003/iraq_briefing_note/en/index2.html

[77] WHO (2003) WHO/IRAQ Area Office For The Lower South Basrah. Site report Nr. 27. July 6. Accessed at http://www.who.int/disasters/repo/10338.pdf

[78] UNEP (2003) Desk Study on the Environment in Iraq, April 2003.

[79] UNEP (2003) Environment in Iraq: UNEP Progress Report.

UNEP also requested data from the US, but did not receive any targeting data or information on environmental assessment or remediation of DU contamination in Iraq: *"They concluded that 'based on the available information, much of the DU expenditure used during the 2003 conflict appears to be in or near urban areas, where people live, work, draw water and grow food (...) People generally are clearly unaware of the risks of exposure to DU*[81]*".* UNEP provided recommendations to identify and assess sites, and carry out testing and monitoring of the local population. They suggested that urgent steps needed to be taken to raise awareness on the potential risks and to introduce protection measures, including warning signs and restricting access to contaminated locations and storage sites. However, the Iraqi authorities lacked the capacity, expertise and funding to implement these measures and the poor security situation in Iraq prevented UNEP from carrying out their own assessments.

The 2003 suicide bomb attack on the UN's headquarters had played a significant role in constraining the activities of UN agencies in Iraq. UNEP therefore focused on capacity-building and training with the Iraqi MoE, with support from the WHO and the IAEA, UNEP held workshops in Amman and Geneva. In 2007, the security situation had improved and equipment, as well as capacity-building workshops were delivered to Iraqi personnel. Together with UNEP, the RPC conducted initial limited contamination assessments on more than five locations where UK Challenger 2 tanks fired with 120 mm rounds[82], collecting dozens of smear and soil samples. The sampling locations were based on UK firing data, RPC data, satellite images and media reports. DU was found in the majority of the locations where samples were taken. Despite their rigorous efforts to get a better understanding of the scale of the contamination, the lack of cooperation from the US hindered further assessments of possible DU contaminated sites by the RPC. For example, in all the assessed locations, contaminated tanks had been removed, making it difficult to do a realistic in-situ assessment of the levels of contamination around the vehicles[83].

UNEP provided recommendations for the clean-up of contaminated sites, monitoring and awareness raising:

> **1**. The Iraqi Ministry of Environment should continue to receive support from the international community to maintain staff expertise and morale;
> **2.** All tanks, armoured personnel carriers, and other military equipment hit by DU ammunition should be identified and isolated to prevent access by the general population;
> **3.** All metal scrap yards that have received scrap related to the conflict(s) should be assessed or the potential presence of DU;
> **4.** Health and safety precautions in scrap yards and scrap processing plants should be improved to minimize long-term health impacts on people working there. With respect to human health, the radio toxicity or radiological effects of DU should be considered secondary to its chemical toxicity;
> **5.** Education and awareness-raising efforts on DU-related issues should be scaled up throughout the country to avoid the population being accidentally exposed to DU residues and DU-impacted scraps; and
> **6.** The issue of the storage and disposal of DU contaminated scrap metal should be taken into account as part of national efforts to decommission and store radioactive sources[84].

The extent to which these recommendations have been followed-up remains unclear, since the RPC shifted its focus to other priorities after 2007. This was partly because of a lack of funding[85], but also because of pressure from the IAEA and the US to shift focus to yellowcake uranium oxide from Saddam-era nuclear facilities[86]. However, the RPC has kept

[80] Smith, D. Brown, R. (2003) Radiological Assessment of Depleted Uranium Impact Locations in Iraq. TA6 - Radiation Protection of the Public and the Environment. Accessed at http://www.colloquium.fr/06IRPA/CDROM/docs/P-210.pdf

[81] UNEP (2003) Environment in Iraq: UNEP Progress Report. October 2003.

[82] Regarding site contamination, less soil contamination is to be expected due to the calibre and limited quantity of the ammunition fired , and therefore these assessments are not representative for every site contamination and can not be extrapolated.

[83] Interview with Dr Mario Burger, UNEP. 23 September 2012.

[84] UNEP (2007) Technical Report on Capacity-building for the Assessment of Depleted Uranium in Iraq.

[85] Interview Ahmed Bushra, Radiation Protection Centre, October 8, 2012.

[86] Interview with Dr Mario Burger, 23 September 2012.

track of contaminated sites and, according to their data, in 2006 there were between 300 and 365 contaminated sites, which they are now in the process of cleaning, and 30-35 sites which still need to be cleaned-up. The majority of these identified sites are located in the Basrah region[87]. The level of contamination at these sites varies from one single tank or contaminated soil to many tanks and more widespread contamination. According to a local RPC employee in Al Muthanna province, new sites are still found each year, with varying levels of radiation. In some cases this is secondary contamination resulting from poor management during clearance, for example contamination left on tracks at a railway station after the shipment of tanks. It was reported that children were playing on the tanks, without any warning signs in place or efforts made to restrict public access[88].

Remarkably enough, UNEP and the RPC did not find any intact DU penetrators during their fieldwork. Other sources consulted for this research however, did come across DU penetrators and were given specific instructions by US and UK forces on how to deal with them. In 2003, a local Iraqi deminer was working for a UK-based demining organisation, at an old Iraqi army base in Al Mehmonah, Missan province, north of Basrah, which had come under heavy attack by Coalition forces. According to his account, he collected more than 200 30mm DU rounds and was instructed by the UK Army to wear gloves and a dust mask, and received guidelines on how to deal with the penetrators. They were told that DU was dangerous and if they blew them up (which was standard procedure with explosive remnants of war), the DU would result in health problems. The recovered penetrators had to be put in buckets filled with water, sealed off and delivered to the British Army base. He had no information on how the UK disposed of them. They instructed the local population to not enter the area, but specific information on exposure scenarios was not given[89]. Another deminer, working for Handicap International in Baghdad in 2003, recalled that they found large numbers of DU penetrators, mainly 30mm, in the centre of Baghdad during battlefield area clearance (BAC). Impact sites were marked and GPS data stored, but removal was done by the Coalition forces[90]. This supports the idea that specific information on DU sites was known by Coalition forces.

DU penetrators were also found by journalists in and around US strike sites, notably the Ministry of Planning where a reporter wrote down the following:

"A visit to site yields dozens of spent radioactive DU rounds, and distinctive aluminium casings with two white bands, that drilled into the tile and concrete rear of the building. DU residue at impact clicked on the Geiger counter at a relatively low level, just 12 times background radiation levels. But the finger-sized bullets themselves - littering the ground where looters and former staff are often walking - were the "hottest" items the [Christian Science] Monitor measured in Iraq, at nearly 1,900 times background level[91]".

The US and UK armed forces have policies[92] in place concerning how to deal with DU and to avoid DU exposure in and after armed conflict that are applicable to their own personnel, but apparently the fate of civilians in a war crippled country is of less concern.

Scrap metal

"As Explosive Ordnance Disposal (EOD), ground combat units, and the civil populations of Saudi Arabia, Kuwait, and Iraq come increasingly into contact with DU ordnance, we must prepare to deal with the potential problems. Toxic war souvenirs, political furor, and post conflict clean-up (host nation agreement) are only some of the issues that must be addressed[93]."

For those not working in the oil industry, southern Iraq offers little opportunity for other sources of income. The abundance of scrap metal, containing a wide variety of valuable metals which can be sold, make it an attractive business for those liv-

[87] Interview with Ahmed Bushra, RPC, October 8 2012 stating that there were 300 sites, though Narmin Othman provided the number 365 during the roundtable discussion on DU in Amman, Jordan, June 2011.

[88] Interview with RPC employee , Najaf, April 2012.

[89] Interview with Mohammed from Danish Deming group, October 4 2012.

[90] Correspondence with Handicap International deminer, December 2, 2012.

[91] Peterson, Scott (2003) Remains of toxic bullets litter Iraq: The Monitor finds high levels of radiation left by US armor-piercing shells. The Christian Science Monitor, 15 May 2003.

[92] Zwijnenburg, W. (2012) Hazard Aware: Lessons learned from military field manuals on depleted uranium and how to move forward for civilian protection norms. IKV Pax Christi.

[93] Depleted Uranium (DU) Ammunition. Lt. Col. Gregory Lyle; Defense Nuclear Agency memo; March, 1991.

ing near these sites. However, this is not a risk-free job. Apart from valuable components, scrap, and in particularly military scrap, also contains toxic substances like Polychlorinated Biphenyls (PCBs), asbestos, chlorofluorocarbons (CFCs), fuels and DU dust. Prolonged exposure for those living and working near or on the sites increases the risk of health problems, particularly for children and pregnant women.

In order to get a better understanding of the current storage conditions, and safety measures in place, several scrap sites in Basrah Province were visited as part of this study. The scrap site south of Al Zubayr mainly held civilian or industrial scrap, but according to a local police officer who was interviewed, all the military scrap had been moved to other locations. At this site, civilians, including children, were seen removing parts and components from the vehicles. At other scrap sites, similar scenarios were witnessed: adults and children working on scrap. At one particular site, which was fenced off but still accessible, a local guard stated that children were playing on the scrap sites all the time, and that they had not received any specific information about the dangers of scrap metal. Even more tellingly, he mentioned that an international organisation came in with equipment and white suits, and told them it was very dangerous *"and quickly ran off"*, adding: *"If we complain about the dangers, we don't get our money"*. Local residents and workers were afraid to talk about the problems at the sites, fearing that the government would evict them from their homes and land. A few kilometres away from that site, another scrap metal site was found where contaminated vehicles were stored. Despite the recommendations made by UNEP, little had been done to prevent people from accessing this site, apart from a single rusty barbed wire fence. No warning signs were visible and local scrap metal collectors who made use of the site again said that had not received any information about the hazards.

The concerns about the hazards of working and living near to scrap metal sites are also well documented in Iraqi papers and magazines, which mention the problems of accessible contaminated scrap sites and the risk of exposure to civilians[94]. One source referred to research done in different Iraqi provinces and claimed that 16 contaminated scrap metal sites were found in Diyala province, 20 sites in Babylon, 11 locations in Wasit province, 14 locations in Missan province, 22 locations in Basrah and 20 locations in Nasiriyah; while in Baghdad itself, 40 contaminated sites were identified, with a total of 143 sites contaminated with DU[95]. However, the methodology and background of this research remains unclear and, according to the paper, the data could not be made public due to pressure from the Iraqi government on the research team.

According to news reports and sources consulted for this research, most of the military scrap metal was moved from urban areas to scrap metal sites; some directly after the conflict by US and UK armed forces, but much of it years later. As noted by Dr. Bushra from the RPC: *"There are more than 200 square kilometres of land south of Basra containing war debris, some of which is contaminated with depleted uranium[96]"*. The total number of sites contaminated with DU however, remains unclear. This is largely due to the lack of capacity to undertake assessments of sites and the lack of information on locations where DU was deployed.

An Iraqi journalist stated that 5000 tons of scrap was moved from the city to storage sites in the desert[97], while Dr. Vartanian, who worked for the RPC in Basrah at that time, mentioned the figure of 150 tons of scrap metal[98], which is a relatively small quantity, considering the weight of one T55 tank, which is around 36 tons. Although these numbers cannot be verified, considering the heavy tank battles that took place in both 1991 and 2003, a large number of military vehicles must have been transported from areas of combat to scrap sites.

An investigative report by the Iraqi journalist Ammar Al Salh reports that 200 tons of scrap metal were removed from the centre of Basrah in 2009. When the issue of contaminated sites was raised with the US Army, the concerns about the health impact of DU were downplayed, but after Iraqi experts provided them with maps and their own research, the US

[94] Al-Muqdadi, K.(2010) Radioactive contamination and the repercussions in Iraq: Reality and Updates, Althakafa aljadida, V. 335, March (in Arabic); Al-Muqdadi, K.(2008) Inheritance of radioactive pollution in Iraq, Al-Bia Wal-Tanmia,V.129, Dec.(in Arabic). Al-Muqdadi, K.,(2008) Appeal to clean up the Iraq war remains, Al-Bia Wal- Tanmia, V.135, May.(in Arabic). Al-Muqdadi, K.(2006) Beware of iron scrap remnants of war, Al-Bia Wal-Hayat, V. 8, September (in Arabic).

[95] Al-Sarai, Dh.T, (2010) Depleted Uranium sites in Iraq. Modern Discussion, 3106, August 26. Article received in Arabic.

[96] Suadad al-Salhy (2009) Iraq sees alarming rise in cancers, deformed babies. Reuters May 1, 2009.

[97] Interview with Ammar Al-Salh, April 2012, Basrah.

[98] Interview with Khajak Vartanian, Basrah, June 14 2011.

DU contaminated scrap metal site near a steel factory in Al Zubayr. Photo taken by author.

position changed and they began to work on removing scrap and identifying sites for toxic waste landfills. This project was funded by the US Army corps, and operated under supervision by the Iraqi MoE and the Ministry of Science and Technology. However, according to Dr. Vartanian, the project had some major flaws and obstacles: the storage locations were not sealed off, and scrap was stolen; there was a lack of monitoring of storage sites and landfills with contaminated metal and soil; local workers who were contracted for the work were not given instructions about the health hazards, which could have led to exposure to the detriment of their health, as well as further contamination during removal operations. Furthermore, allegations were made that local officials had ties with the owners of some scrap metal storage sites, who delayed the clean-up efforts in order to increase profits. Soon after, the US Army retracted its support for the project, both because of the indecisiveness of the local government and the withdrawal of their own troops from Iraq.

However, according to the US Army, they removed over 6,000 tons of scrap from Basrah[99] and in total conducted 18 of these operations. With regard to radiological contamination, a spokesperson for the US Army stated that: *"Both the Iraqis and my soldiers did independent radiological tests before, during and after the removal of this, to ensure that there was nothing that would hurt any of the workers or the local population as they removed the scrap metal,"* Bullimore said. *"They found nothing harmful, but all the precautions were taken".* The cost of the whole project, including removal of 3,000 tons of material at Hyyaniah, Al- Abbas, the Hamden Industrial Park and in the Abu al Qaseeb area was more than US$1.6m, and should have cleaned up over 50,000 tons of scrap metal[100].

The director of the regional office of the MoE in Basrah, Taha al-Quraishi, considers the whole clean-up project to be completed, since all the scrap metal has been removed, but not everyone agrees with his conclusion. Dr. Vartanian's assertion is that the current situation with pollution in Basrah still demands urgency regarding clean-up, and an effective long-term strategy on how to deal with landfills for contaminated waste. He argues that this should be based on a nationwide approach, instead of merely a local operation, stating that only 20% of the contaminated sites in Basrah were surveyed, based on the scarce information available. Another problem he came across was a new law that was imposed in 2004, which allowed citizens and entrepreneurs to collect scrap and reuse,sell, or export it, without having to provide information on its eventual destination. This led to an increase in citizens stripping military vehicles for useable metal components. It was a lucrative business for some[101], though concerns were raised by Iraqi researchers on scrap metal contamination[102].

[99] USDS Public Affairs (2010) Scrap project beautifies Basra. Accessed at http://www.army.mil/article/37224/Scrap_project_beautifies_Basra/

[100] US Embassy Baghdad (2010) PRT Basrah Supports Governor's Request to Help Clean-up Basrah. Provincial Reconstruction Teams News. Accessed at http://iraq-prt.usembassy.gov/prt-basra-051310.html

Naturally, the average Iraqi does not posses any knowledge of possible hazardous components such as DU, PCBs or other toxics in military vehicles, thereby increasing the risk of exposure.

In other areas, such as Baghdad, large scale operations have been undertaken by the Iraqi government to clean up thousands of tons of scrap metal, while assessing the contamination present at those sites. According to Sabah Mohammad Lateef, director general of the awareness office at the Iraqi MoE, concerns over contamination were taken notice of: *"If the teams discover that these metal scraps are contaminated with radiation, especially the vehicles and other items that are leftovers of wars and explosions, they are quarantined and specific processes are conducted to de-contaminate them"*[103]. Be that as it may, previous statements by other sources mentioned in this report have noted several shortcomings in these policies, most notably the absence of sufficient capacity and equipment to conduct rigorous assessments. Nonetheless, these efforts are indeed an important first step in removing scrap and assessing the contamination, though there remains a lack of clarity regarding responsibilities, capacity and oversight. For example, significant quantities of military scrap were exported to Jordan after the war, including tank parts. During border checks, staff from the IAEA picked up elevated levels of radiation from the scrap metal, raising concerns among government officials in Jordan[104]. This kind of practice raises serious concerns over the dispersal of contamination and export controls elsewhere following the use of DU.

In addition, Dr. Vartanian noticed that that the quick removal of scrap from the sites made it difficult to obtain a complete picture of contamination[105]. This is indeed a problem when it comes to cleaning-up armoured vehicles or infrastructure attacked by Bradley vehicles or A-10 gunships. These systems have rapid firing cannons. While strafing a target, several hundreds of rounds can be spread around over an area of 500m^2, depending on the flight path of the plane[106]. Similar problems were also encountered by UNEP, while trying to do in-situ site assessments, making it difficult to get a clear picture of soil contamination[107].

At one of the scrap sites visited near Al-Zubayr, hundreds of tanks and armoured vehicles were seen stored near a steel recycling plant, with minimal safety measures in place to limit access to the sites, nor any warning signs to prevent people from accessing the area. More of these locations can be found in the desert near the Kuwaiti border and near Baghdad. At another location south of the city of Al Zubayr, adjacent to a densely populated residential area, military scrap metal was moved away two weeks prior to the arrival of the author, hence it had been stored there for nearly a decade without any special warning signs or security measures to prevent people accessing the site. Children were seen playing on the sites or helping adults collecting scrap.

Inside urban areas, the RPC has identified nine places contaminated with DU, based on the information they have at the moment, which is still limited. In Baghdad, one of the scrap metal sites at Ouireej was mentioned by UNEP as an area of concern in their *Environmental Hotspots* in *Iraq* report, not only because of DU but also other toxics and UXOs. Specific warnings of contamination with DU with regard to scrap were given, namely:

If DU is included in tanks taken away for scrap metal recovery, its fate can vary according to its form and the type of processing:

- DU and uranium oxide dust and fragments will be distributed on the ground surface around the original combat area and the scrap yard storage and processing areas;
- Whole DU rounds or pieces may stay intact and be exported with other scrap;
- The uranium may be smelted with the steel scrap and be incorporated in the ingots;
- Some of the uranium may burn during smelting, releasing uranium oxide dust[108].

[101] Shiskin, Phillip (2007) With Much of Iraq Turned Into Scrap, A Market Heats Up. Washington Post, November 23, 2007.

[102] Al Muqdadi (2006) Beware of Scrap Metal. Environment and Life Magazine, Issue 8. pg 46 (in Arabic) Available on request.

[103] Mahmood al-Mulhim (2011) Iraqi government starts collecting scrap metal. Accessed on http://mawtani.al-shorfa.com/en_GB/articles/iii/features/iraqtoday/2011/04/25/feature-04

[104] Glanz, James (2004) The Struggle for Iraq, the new looting; In Jordan's Scrapyards, Signs of a Looted Iraq. New York Times, May 28, 2004.

[105] Al-Salh, A. (2012) Cancers spread in Southern Iraq, and the government is incapable of addressing depleted uranium. Al-Ghad newspaper, April 5, 2012. In Arabic.

[106] Cullen, D. (2011) A Question of Responsibility; depleted uranium weapons in the Balkans. pg. 11. ICBUW.

[107] Interview with Dr Mario Burger, UNEP, September 23, 2012. Spiez, Switzerland.

[108] UNEP (2005) Assessment of Environmental 'hotspots' in Iraq'. pg. 115.

Hence, scrap metal is a major source of possible exposure for civilians and workers and therefore remediation efforts are recommended.

Similar recommendations were issued by the IAEA in both of their reports on radiological conditions in Kuwait[109] and southern Iraq[110] as well as in a 2010 report to the UN General Assembly[111]. The conclusions underline the need for precaution against exposure to DU for individuals who are in direct contact with the materials, and call for the identification of, and for restricted access to, contaminated sites where DU fragments, DU munitions or affected war equipment are found or stored. Though both reports consider the radiological hazards low, precautionary measures and clean-up efforts are advised. If contaminated tanks are to be found, burial is considered a cost-effective option, as well as occasional monitoring of food and informing local residents and workers about the possible hazards. In the 2010 IAEA report on Iraq, it is also strongly advised not to use military vehicles for reprocessing as scrap, but to dispose of them as low level radioactive waste (LLRW).

Concluding, establishing the precise number of contaminated sites and the locations of scrap metal storage and other affected areas remains problematic. This is mainly due to the lack of sufficient monitoring and control efforts for scrap metal, the lack of information on firing locations and on efforts undertaken by Coalition forces to remove military scrap between 2003 and 2005. From the end of hostilities, contaminated vehicles should have been marked and strict procedures should have been applied in removing these vehicles from the locations where they had been attacked. On some occasions, US and/or UK forces marked contaminated vehicles with spray paint, but the majority of DU destroyed vehicles were not marked. All of those who worked on contaminated vehicles, i.e. military personnel, civilians stripping scrap metal or children using them as a playground, may have been left at risk of exposure of DU.

'All of those who worked on contaminated vehicles, i.e. military personnel, civilians stripping scrap metal or children using them as a playground, may have been left at risk of exposure of DU.'

Furthermore, the lack of information on contaminated vehicles has resulted in an unknown number of polluted scrap sites across the country. Establishing the total scale of contaminated sites would currently entail assessing every site with military scrap, which would be a difficult or even impossible task, considering the financial and capacity constraints it would place on the Iraqi government. Hence, specific geographic and target data is a prerequisite for effectively managing contaminated scrap and waste; this includes implementing precautionary measures for limiting the exposure of civilians to DU.

Procedures

After the end of major hostilities, and the launch of the De-Baathification process, which stripped much of the civil service of its expertise, the Iraqi government started to recover slowly with the support of the Provisional Authorities, rebuilding expertise and its organisational structures. Aside from security, healthcare and critical infrastructure problems, Iraq faced major problems with environmental pollution. In order to address these issues, the Iraqi government, together with UN agencies, investigated the magnitude of these problems and invested in rebuilding governmental capacity to resolve them. As for DU, clear standards, procedures, responsibilities and expertise were needed to get a full picture of contaminated sites. The current procedure for the Iraqi government is that the MoE is alerted when suspected material is found, and undertakes the initial assessment and, if required, arranges local storage. If contamination is found, the RPC draws up a working plan for how to deal with the waste and what specific kind of regulation is needed for decontamination and the storage of soil and residues. The next step is handing over the information to the Ministry of Science and Technology

[109] IAEA (2003) Radiological Conditions in Selected Areas of Kuwait with Residues of Depleted Uranium. Report by an international group of experts. Radiological Assessment Reports Series. Vienna.

[110] IAEA (2010) Radiological Conditions in Selected Areas of Southern Iraq with Residues of Depleted Uranium. Report by an international group of experts. Radiological Assessment Reports Series. Vienna.

[111] UNGA (2012) Effects of the use of armaments and ammunitions containing depleted uranium Report of the Secretary-General. A/67/177.

An Iraqi man salvages parts, for domestic use, from a rusting Russian-made army tank at a scrap yard in a Baghdad suburb December 29, 2003. ©Reuters

(MoST) which is responsible for the treatment of contaminated sites, based on guidelines by the IAEA[112]. The RPC continues to monitor the contaminated sites after the clean-up and the Ministry of Defence is responsible for guarding the sites.

The MoST undertook some assessment work of DU contaminated sites when concerns were raised by local authorities, for example at a hospital in Al Zubayr and the aforementioned locations in Baghdad. At the steel factory in Al-Zubayr, measurements were taken and high levels of radiation were found in scrap metal. The MoST recommended that the facility should stop reprocessing that scrap metal[113], but this advice was ignored and reprocessing continued.

According to Dr. Bushra of the RPC, on some occasions the contaminated debris and soil was put in small containers and transported to storage sites; but it appears this was only done on some sites. This was partly due to lack of funding and capacity, but apparently also because of institutional disputes over responsibilities and budgets between different Iraqi ministries, which hindered the effective and timely intervention at contaminated sites. Other sources however, claim that private contractors were hired by the MoE to undertake clean-up at some sites in order to lower the costs. Those contractors did not receive any specialised hazard awareness training and it was reported that the workers did not wear basic protective clothing, such as dust mask and gloves. On one occasion, contaminated debris was reportedly dumped in an undisclosed location[114].

One of the major problems with clearing contaminated sites is the cost involved in conducting assessments, clean-up, the safe storage of contaminated soil and scrap and monitoring of sites. The amount of work depends on the level of contamination, but according to Dr. Bushra, the cost for cleaning-up one site is somewhere between US$100-150,000[115]. During his own field work, Dr. Vartanian estimated that the cost of doing a single assessment was around US$6,000, which involved outdated equipment to analyse soil and smear samples. A rigorous assessment of samples would preferably make use of a lab with an expensive Inductively Coupled Plasma Mass Spectrometry (ICP-MS) meter, but that was not at his disposal at the time. Taking into account that there are over 300 known contaminated sites, between US$30 and US$45million would be needed to clean them.

[112] Interview with Dr. Bushra. Baghdad, October 8, 2012.

[113] Interview with expert from MoST, 7 October 2012.

[114] The source was involved in this operation, but wishes to remain anonymous.

In comparison, when the Serbian authorities remediated DU contaminated sites, the total cost for cleaning up the 3000 PGU/14B 30mm rounds that were fired (with only a few hundred retrieved), contaminated soil and transport to a storage facility was around US$1.479m, and took 41,000 working person hours[116]. Some experts claim that the total cost for cleaning up all the contaminated sites in Iraq, including the safe storage of toxic waste and soil, would come with a 'multi-billion price tag'. Hence the reason why DU user states refuse to be held accountable for the contamination in Iraq, or to be transparent over firing coordinates and clean-up efforts, and refute evidence that there is a likely correlation between exposure and health effects[117].

US clean-up of contaminated soil in Kuwait

Despite the efforts by the US government to downplay the health hazards related to DU exposure, major clean-up operations of contaminated vehicles and soil took place in Kuwait in 2004. An explosion and fire at an ammunition depot in Camp Doha, Kuwait on July 11 1991, resulted in 56 wounded US and UK soldiers[118]. Large stockpiles of DU munitions were also stored on the base and ignited during the blast, contaminating a large part of the area with DU ammunition fragments and dust. In 2003, US forces also used Kuwaiti firing ranges to practise firing with DU rounds, resulting in high levels of DU oxide in the soil and concerns from the Kuwaiti government.

After pressure from the Kuwaiti government[119],the American government provided a contract to US firm MKM Engineering to clean up the hazardous site. Over 22 tons of DU munitions, contaminated scrap and 6,700 tons of contaminated soil were shipped back to the US, along with 25 tanks and Bradley vehicles that were decontaminated in the US. Other tanks were too contaminated, and the cost-benefits were too low for remediation efforts, and thus were wrapped in plastic and buried in a remote Kuwaiti desert. MKM Engineers were paid US$6.2m for cleanup of this site, but the problems did not end there. US citizens living near the waste disposal site in Idaho were concerned about the storage of contaminated soil and filed complaints against the dumping of hazardous materials in their town[120]. It should be noted that in the majority of US DoD papers on DU, the need for clean-up and remediation efforts is strongly recommended and is common practise for DU test sites in the US[121].

Several researchers have come up with ideas for dealing with contaminated soil and designing safe storage facilities. For example, researchers from Luleå University in Sweden have drawn up a range of plans for site selection, storage facilities and the isolation of radioactive military waste. In their papers, practical solutions for landfills with storage of hazardous waste are offered, and which provide options for future projects by governmental entities and private contractors to deal with the problem[122].

To sum up, locating, assessing and managing contaminated and hazardous sites requires a range of specific interventions by various governmental bodies. Considering the financial and bureaucratic constraints, not to mention the time it would take to implement these policies, for a government that is still struggling with basic capacity and equipment shortages, managing DU contamination is proving highly problematic. It is to be expected that governments who are crippled by conflict would generally not have the means to implement and execute recommended procedures; the result being prolonged and unnecessary civilian exposure. Comparisons with states such as the US or Serbia that do have those capacities, expertise and the financial means, show how costly and time-consuming remediation is.

[116] Cullen, D. (2011) A Question of Responsibility; depleted uranium weapons in the Balkans. pg 13. ICBUW

[117] William, T.D (2004) Weapons Dust Worries Iraqis. Provisional Government Seeks Cleanup; U.S. Downplays Risks. Hartford Courant, November 1, 2004.

[118] See http://www.gulflink.osd.mil/du_ii/du_ii_s04.htm for more information.

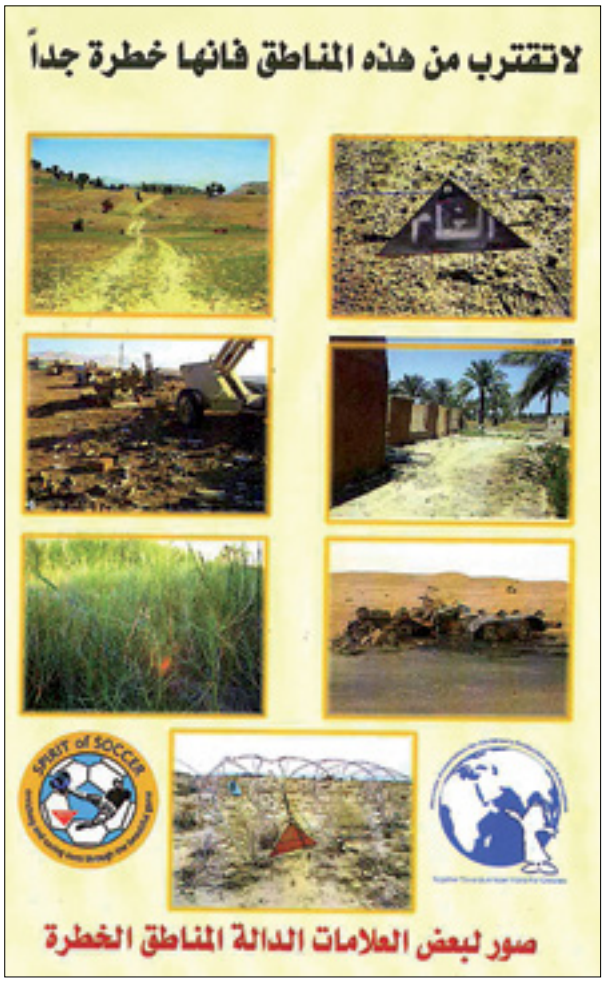
[119] See Wikileaks Cable from US embassy in Kuwait: http://wikileaks.org/cable/2009/03/09KUWAIT180.html

[120] A full overview of local news reports can be found here: http://www.ufppc.org/local-news-mainmenu-34/7434-local-news-depleted-uranium-contaminated-sand-shipping-on-nw-rails.html

[121] For example, see: Daneal, M. (1990). Kinetic Energy Penetrator Long Term Strategy Study. Army Armament Munitions and Chemcial Command, Rock Island.

[122] Pusch, R., Knutsson, S.,Al-Taie, L.& Shahrestanakizadeh, M. (2012) Isolation of hazardous soil contaminated by DU (depleted uranium) from groundwater. In: Waste Management and the Environment VI . Popov, V., Itoh, H. & Brebbia, C. A. (red.). WIT Press , s. 297-308.12 s. (WIT Transactions on Ecology and the Environment; Nr 163); Al-Taie, L., Al-Ansari, N., Pusch, R. & Knutsson, S.(2012) Proposed site selection criteria for hazardous waste disposal facilities in Iraq. In: Waste Management and the Environment VI . Popov, V., Itoh, H. & Brebbia, C. A. (red.). WIT Press, s. 309-319.11 s. (WIT Transactions on Ecology and the Environment; Nr 163).

Iraq's experience has demonstrated that the effective management of DU contamination requires the close cooperation of a range of governmental bodies with diverse expertise – the MoE, RPC, MoST and MoD. It is clear therefore, that post-conflict DU management places a particularly problematic bureaucratic burden on states. During a period of post-war recovery, where resources for environmental and health protection are limited, DU management is an unwelcome and long-lasting problem with implications for civilian protection.



Left: Awareness-raising poster on DU produced by the Radiation Protection Centre. Right: Leaflet distributed amongst children in southern Iraq warning them not to use tanks as playgrounds.

Awareness raising

When it has been established that a specific site is contaminated, the location sealed off and the level of risk assessed, the logical next step is to inform civilians. In previous situations, for example in the Balkans where DU was used, UNEP distributed a leaflet among UN personnel to inform them about DU and provide basic precautionary steps on how to avoid exposure. Most armed forces have similar guidelines in place for their own troops, and have specific instructions for transportation, storage and incidents involving DU[123]. Other organisations, such as the International Committee of the Red Cross (ICRC) have issued specific instructions to their staff, for example in Kosovo:

"Personnel working in areas where depleted uranium munitions may have been used are briefed about depleted uranium, both orally and in writing. A briefing paper advises staff to avoid sites where depleted uranium munitions may have been used and to refrain from collecting any form of military debris. Staff are also encouraged to share these instructions with others, including the resident population...as part of its programme to warn the population about the dangers of unexplod-

[123] Zwijnenburg, W. (2012) Hazard Aware: Lessons learned from military field manuals on depleted uranium and how to move forward for civilian protection norms. IKV Pax Christi

ed ordnance and landmines left in Kosovo, ICRC instructors have also been advised on how to respond to questions about depleted uranium during public sessions[124]".

One group for whom contact with DU remnants is likely are mine clearance agencies. Iraq is littered with UXOs, and explosive remnants of war such as landmines and cluster munitions. During the fieldwork undertaken for this study, several demining organisations active in Iraq were interviewed. Danish Demining Group, Norwegian People's Aid, the ICRC and the Regional Mine Action Centre (RMAC) were all familiar with DU. Meanwhile experts working for Handicap International and Mine Tech cleared DU in the course of their work between 2003 and 2005, although most of them did not come across it in their regular clearance and survey operations. Mine clearance organisations have specific Technical Notes and Standards on how to deal with certain ammunition. In the Technical note for Clearance of Depleted Uranium Hazards a basic overview and precautionary measures are given[125], but according to staff, not everybody is well informed about the precise information on how to recognise and handle DU. One expert from the United Nations Development Programme (UNDP) which funds the RMAC, recalled an incident in 2003 when US forces blew up a stockpile of DU munitions, increasing the risk of DU dust dispersal; he had to quickly intervene to stop this practice[126].

The Iraqi government initiated some awareness-raising measures for civilians living in known contaminated areas. According to Dr. Bushra and Dr. Vartanian, media outreach had been undertaken in several cities such as Basrah, Safwan, Al Zubayr and Baghdad. The RPC provided educational materials such as posters that warned people not to approach destroyed tanks and ammunition, to wash their vegetables and alert the authorities when they found suspicious materials such as ammunition. Local organisations working on mine awareness and risk education related to UXOs also included warnings in their materials to stay away from destroyed tanks, but did not provide specific information on DU exposure and precautionary measures in the course of their work[127].

Other toxic remnants of war

Apart from DU, toxic pollution is rife in Iraq, according to reports by UNEP, NGOs and other scientific studies. The sources of pollution are disparate, varying from contamination as a result of the multiple wars to the environmental mismanagement of Iraq's burgeoning oil and other industrial activities. The alarmingly high rates of birth defects and other ailments associated with pollution are presented in chapter 4. Different types of contamination found in the Iraqi environment and their sources that can be linked to the reported health effects are presented below.

Contaminants detected in the Iraqi environment and their sources

One of the most extensive surveys to be conducted of the Iraqi environment since the 2003 war was that undertaken by UNEP in 2004[128]. The report identified cases of industrial sites that had been impacted in some way as a result of the war (bombed or looted) and one scrap yard for military waste. The table below summarises the substances detected by UNEP on the respective sites and the extent to which they formed an environmental and health hazard. It was found that the majority of these environmental hotspots only formed a hazard on the site itself, whereas the risk of contaminant migration away from the sites was deemed low by UNEP's environmental assessors. Most of the sites were also fenced and guarded, which reduced the risk. However, the Oureij site was of most concern as it was slowly being subsumed into residential housing, thus posing a grave risk to residents, particularly children, from the contaminated land.

Beyond the UNEP report, interviews with Iraqi environmental experts show a degree of mismanagement of the remaining toxic remnants, such as anecdotal evidence of remediation contractors simply burying barrels of cyanide instead of adequately cleaning them up at Qadisiyah. Also, the stalled clean-up of 10 barrels of rocket propellant found at Al-Kut, with the site still accessible to the public[129].

[124] ICRC (2001) Depleted Uranium Munitions. International Review of the Red Cross, No. 842. Found at http://www.icrc.org/eng/resources/documents/misc/57jqxp.htm

[125] Geneva Centre for Humanitarian Disarmament (2002) Clearance of Depleted Uranium Hazards. Technical Note 09.30/02 Version 2.0. Technical Notes for Mine Action.

[126] Interview with Kent Paulluson, Senior Mine Advisor UNDP Iraq, October 13, 2010 New York.

[127] Interview with head of Bustan Association for Children's Protection and Education, October 4, 2012, Basrah.

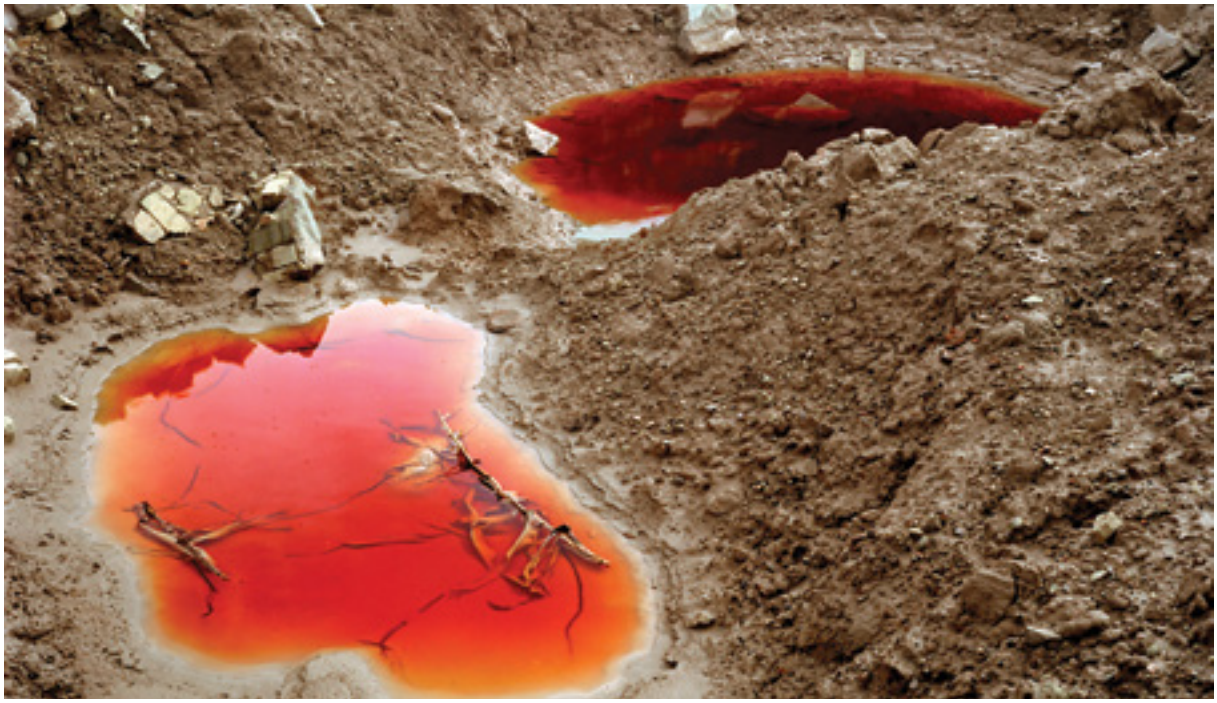
[128] UNEP (2005) Assessment of Environmental 'hotspot' in Iraq. Geneva.

[129] Interview with expert from MoST, October 8, 2012, Baghdad.

Site	Contaminants detected	Risk on site	Risk off site	Damage to site
Qadissiyah	Sodium cyanide, PCB, heavy metals, hydrocarbons.	Yes	No	Bombed and looted
Suwaira	Organo-chlorine pesticides, mercury, copper, hydrocarbons.	No	No	Looted
Khan Dari	Lead, furfural.	Yes (moderate)	No	Looted
Al-Mishraq	Sulfuric acid.	Yes (moderate)	No	Arson attack
Ouireeij	PCB, DU and other heavy metals, hydrocarbons.	Yes	No	Undamaged

Contamination and exposure in urban areas from military activities

Emissions from munitions and military activities are harder to measure and are not well documented, but there have been several studies noting apparent rises in birth defects and cancers in areas that experienced intense or prolonged fighting, such as Fallujah and Basrah. Based on what is known of the composition of weapons and munitions, and also what could happen when certain facilities (e.g. power stations, refineries) are bombed, it is expected that military activity in a given area will leave a legacy of contamination that will either be transient or long-lived, depending on the type of substance deposited or emitted. War activities and munitions are known to cause the release of such contaminants as outlined in the previous section; munitions use may release lead, mercury, toxic explosive materials, tungsten and other materials into the environment.



Unburnt trinitrotolluine (TNT). Iraqi Army ammunition storage depot, Missan Governorate, south eastern Iraq, 2004. Courtesy of the photographer - ©Jonathan Olley

The following table provides an overview of some of the common contaminants that may be found in the Iraqi environment and the reasons that they are of concern from a toxicological and environmental perspective.

Substance	Overview	Toxicity	Exposure
Organic energetic materials(explosives) benzene	Carbon and hydrogen atoms form the basis of organic compounds; these are often arranged in ring like structures (e.g. benzene). Organic explosives are based on benzene rings occasionally interspersed with nitrogen (N) atoms with nitro (NO2) functional groups attached. These functional groups are an important basis of the explosive nature of these compounds, and also a contributing factor to their toxicity.		
RDX: Research Department Explosive	RDX is a commonly used explosive developed in the 1930s.	Possible carcinogen and genotoxin. Acute exposure causes seizures. The effects of long term exposure are unknown.	Contaminated soil, water or air.
TNT: Trinitrotoluene:	Trinitrotoluene is another widely used explosive.	Possible human carcinogen and genotoxin. Long term exposure leads to anaemia and abnormal liver function.	Contaminated soil, water or air.
Organochlorine compounds	The term organochlorine (OC) denotes organic compounds containing chlorine; these are often polychlorinated meaning they have variable numbers of chlorine atoms attached. Some of the most toxic organochlorine compounds are those based upon multiple benzene rings. The generic structures shown for dioxins and PCBs are marked with numbers to indicate the possible location of chlorine atoms. Variations in chlorine attachment results in a large number of possible compounds of varying toxicity. Each individual compound is known as a 'congener'.		
PCBs:polychlorinated biphenyls	209 individual congeners. Used as hydraulic fluid in old army tanks and also as an electrical insulator in power transformers.	The toxicity of PCBs varies depending on the individual congener. PCBs are teratogens and probable carcinogens.	Contaminated food, water, soil.
Organochlorine insecticides: e.g. DDT	Organochlorine insecticides are still used in many countries including Iraq for their ease of production, although they are banned in Europe and the US. DDT is one example. There are five classes of OC insecticides characterised by environmental persistence and moderate toxicity.	Similarly to PCBs, the toxicity of OC varies depending on the type and class of chemical. Generally OC are known to affect the central nervous system.	Contaminated food, water, soil.
TCE: Trichloroethylene	Industrial degreaser with widespread applications in logistical support military activities.	Carcinogen.	Contaminated water.

Other organic pollutants			
PAH:polycyclic aromatic hydrocarbons benzo(a)pyrene	PAHs are the products of incomplete combustion of coal, gas, solid waste and motor vehicle exhausts. Also from cooking. Polycyclic refers to the way PAH are composed of multiple benzene rings (cycles) attached to one another in different ways. Benzo[a]pyrene, shown here (left) is one of the most toxic.	Carcinogens.	Breathing contaminated air or ingesting contaminated food.
Propellants			
Hydrazine (N2H4)	Hydrazine and its variants (mono methyl hydrazine and unsymmetrical dimethyl hydrazine) have been used as rocket propellants since WW2. Its high toxicity means the aerospace industry is attempting to find replacements.	Toxic effects on the kidneys, lungs and nervous system and mucous membrane.	Inhalation, ingestion and dermal contact are all possible routes of exposure.
Toxic and heavy metals			
Depleted uranium (DU)	DU is used in kinetic energy penetrator rounds used mainly for armour piercing purposes. DU is the by product of the enrichment process for producing nuclear fuel. Its radioactivity is less than natural uranium, but it is just as toxic.	Carcingogen, teratogen and Genotoxin. Also known to affect kidney function.	Inhalation of DU particles, ingestion of contaminated soil, shrapnel fragments embedded in body are all possible routes of exposure.
Lead	Lead is a commonly used constituent of bullets.	Neurotoxin that impairs brain development and IQ. Can also cause anaemia and other problems. Ingestion or inhalation of particles.	Ingestion or inhalation of particles.
Mercury can occur in a variety of forms	Mercury fulminate (Hg(CNO)2)) is used in the fuses of older weapons systems. Mercuric oxide batteries are used for some missile systems. Methyl mercury was used as a grain treatment and is associated with a mass poisoning in the 1970s.	Toxicity varies depending on whether the mercury is part of an organic compound or in its elemental form. But, toxic effects from mercury compounds include brain damage, kidney and lung problems.	Inhalation, ingestion of contaminated food.

4. Reported health problems

The direct impact of the Gulf War and the sanctions imposed by the UN on the Iraqi regime had a devastating effect on Iraqi society. According to MedAct: *"An estimated 110,000 Iraqi civilians died in 1991 from the health effects of the war, bringing the total number of Iraqis who died as a direct consequence of the Gulf War to around 205,000".* Further problems resulted from the collapse of the healthcare system, malnutrition, UXOs and contamination of agricultural land and communities by toxic substances. There was a sharp increase in mortality rates amongst newborns and children due to the Oil for Food Programme and sanctions, which resulted in a shortage of medicines and insufficient healthcare. The environment was heavily polluted by air pollution due to oil fires, release of toxics in the environment by bombardments on chemical factories and the dispersal of DU. Apart from the physical impact, Iraqis suffer from post-traumatic stress and long-term mental health problems, which have been associated with increased risk of heart disease and immune system problems[130].

The situation deteriorated further after the US-led invasion in 2003, due the heavy bombardment of critical infrastructure, the collapse of healthcare systems, the use of cluster munitions and resultant ERW contamination and environmental pollution due to oil fires/spills. Again, Iraqi civilians paid the price, with a range of negative health outcomes documented:

'Short and long-term physical health effects include disability, infectious diseases, stillbirths, underweight newborns, diseases of malnutrition, possibly more cancers. Short and long-term mental health effects include posttraumatic stress reaction, psychiatric illness, behavioural disturbance and developmental delays in children[131]'.

The debate on health problems associated with the use of DU began after the 1991 Gulf War when both veterans from Allied forces and Iraqi civilians reported an increase of various types of cancers and birth defects. The use of DU again in Operation Iraqi Freedom intensified the debate and highlighted concerns about civilian and military protection against exposure. This led to investigations by US, UK and Canadian government organisations into the exposure of veterans from both conflicts. In the US, a total of 341 veterans were tested using urine samples, and 29 of those had detectable levels of DU. The UK tested 437 veterans, with only one person found positive for DU. After Operation Iraqi Freedom, more than 2,100 US and 350 UK veterans were tested, with only a few positive indications of DU found, but those results were contested on the basis of methodology[132].

From a civilian perspective, there are many reports from the media and grey literature and unpublished studies. This chapter will summarise the most reliable sources and studies, and include some of the statements made by government officials, as well as documenting concerns by NGOs and civilians over the impact of DU on their lives and communities.

The debate about DU became distorted with unreliable information after the first Gulf War in 1991. There are several explanations and aggravating factors for this process. First of all, the US government's refusal to provide information and their flat denial of any potential health consequences clouded the discussion and spurred rumours and allegations. The Iraqi regime at that time took advantage of this and accused the US government of deliberately contaminating Iraq. The discourse in the West was also prone to sensationalism, such as the claim: *'the release of DU in Iraq is equivalent to 100 Chernobyl accidents', or 'an act of genocide'*[133] and attributed all kinds of health problems in Iraq to DU; typically without any scientific basis. Nonetheless, the concerns of Iraqi civilians were real and were documented by journalists and researchers[134]. The absence of robust epidemiological evidence should not be seen as evidence of absence of any

[130] Salvage, J. (2002) Collateral Damage: the health and environmental costs of war on Iraq. MedAct, London. pg3.

[131] Farooq, S., Guitard, I., McCoy, D., Piachaud, J.(2003) Continuing collateral damage. The health and environmental costs of war on Iraq. MedAct, London. pg.10.

[132] A full overview of results and the debate on methodology can be found in Fahey, D. Environmental and Health consequences of the use of depleted uranium weapons. In: McDonald, A. et al. (2003) Depleted Uranium Weapons and International Law: a precautionary approach. TMC Asser Press. The Hague.

[133] Fahey, D (2003) Science or Science fiction: Facts, Myths and Propaganda In the Debate Over Depleted Uranium Weapons. Found at http://www.wise-uranium.org/pdf/dumyths.pdf

health effects, especially when considering the toxic nature of DU. However, US denials and Iraqi propaganda resulted in a strongly polarised debate, with little room for nuance.

Cancers

To date, no long-term and wide scale epidemiological studies have been conducted in known contaminated areas. Media reports, based on statements from Iraqi doctors and other scientists, suggest an increase of birth defects and cancers due to the use of DU in southern Iraq and Fallujah[135]. Since 2005, the WHO invested in improving the cancer registry systems in the whole of Iraq, thereby creating better baseline data on cancer rates. Furthermore, 25 doctors and environmental experts in Basrah set up their own study, the Basrah Cancer Research Group (BCRG), to collect, analyse and monitor data on increases of cancers. The outcome of this research[136] was that there had been an increase of various types of cancers, which they accounted for by several explanations.

Cancer	1995	2005-2008	% Change
Breast	4.0	11.9	+ 197.5
Urinary bladder	2.5	6.0	+ 140.0
Lymphoma (NHL &HL)	2.2	5.0	+ 127.3
Lung & Bronchus	2.1	4.5	+ 114.3
Leukemia	2.3	3.6	+ 56.5
Skin	2.4	3.1	+ 29.2
Colorecta	1.7	2.8	+ 64.7
Stomach	1.2	2.5	+ 108.3
Brain & CNS	0.9	2.6	+ 188.9
Larynx	1.4	1.8	+ 28.6

Comparison between cancer specific incidence rate for the years 1995 and 2005-2008 (BCRG).

First of all, there is better diagnosis and improved collection and reporting systems for cancers. Secondly, economic progress and the related changes in diet, smoking and other lifestyle factors has been a major contributor to the increase of welfare related cancers such as lung, bladder and breast cancers. And thirdly, exposure to environmental pollutants has increased over the years. Though no specifics were given, exposure to toxics in everyday life such as the burning of plastics, contaminated water and air pollutants may also have contributed. Another urgent problem was mentioned by another expert, namely the unregulated import of food from various countries, which could also expose people to toxic substances due to a lack of monitoring or enforcement, or, as he put it: *"We import everything from everywhere and we*

[134] Fisk, R. (2001) Depleted Uranium's Fallout Comes Home Iraqi kids suffer 'Gulf War Syndrome' . The Independent, January 11, 2001; Birchard, K. (1998). Does Iraq's depleted uranium pose a health risk? The Lancet - 28 February 1998 (Vol. 351, Issue 9103, Page 657).

[135] Peterson, S. (1999) DU's fallout in Iraq and Kuwait: a rise in illness? The Christian Science Monitor http://www.csmonitor.com/1999/0429/p14s1.html; Chulov, M (2010) Research links rise in Falluja birth defects and cancers to US assault. The Guardian. Accessed at http://www.guardian.co.uk/world/2010/dec/30/faulluja-birth-defects-iraq; Simpson, J. (2010) Falluja doctors report rise in birth defects. BBC. Accessed at http://news.bbc.co.uk/2/hi/8548707.stm.

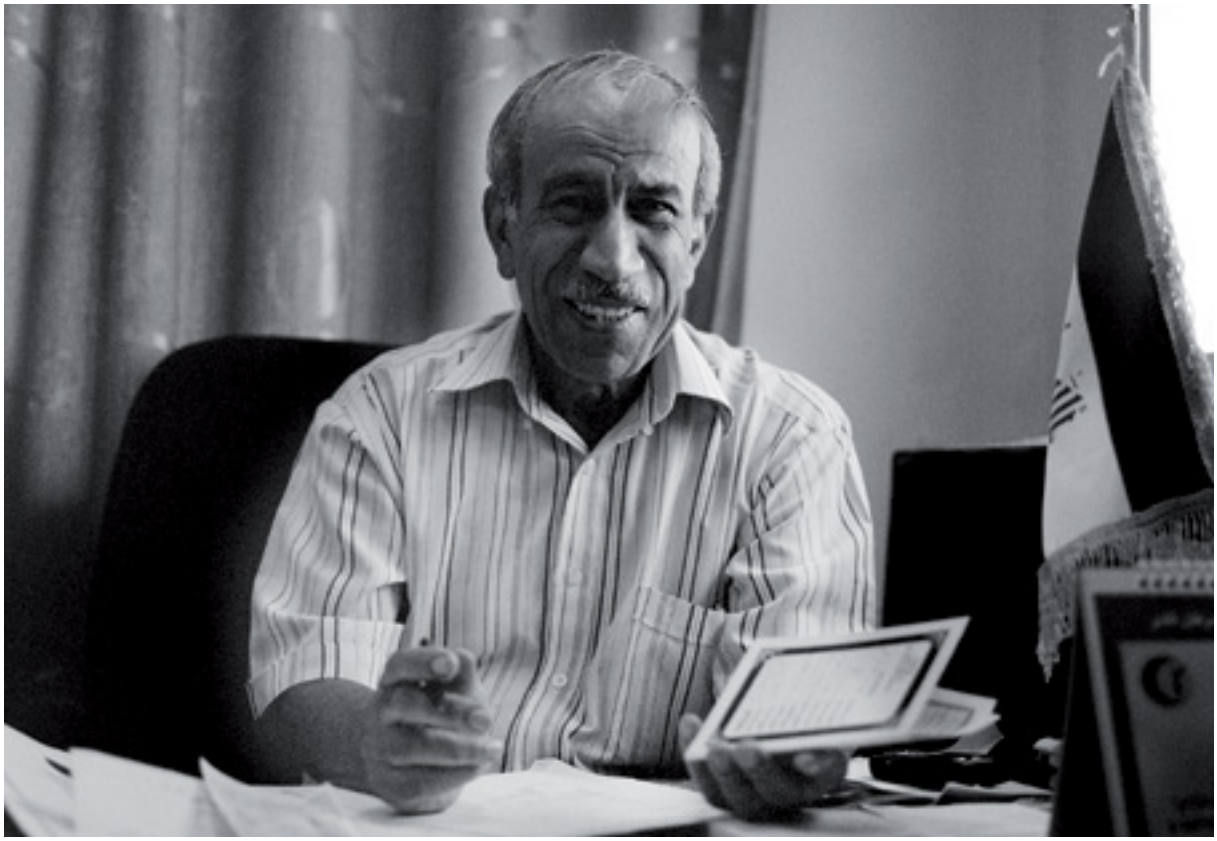
[136] Omran S H, Al-Ali J K, Al-Wiswasi M K, et al. (2007) Cancer Registration in Basrah 2005; Preliminary Results. Asian Pacific Journal of Cancer Prevention., 8:187-190; Basrah Cancer Research Group (2009). Cancer in Basrah 2005- 2008. Basrah: Dar Alkutub for Press & Publication, University of Basrah.

check nothing[137]*".* Nonetheless, the total number of registered cancers was still below average compared with neighbouring countries, despite the sharp increase, but the increase is alarming and specific causes should be explored and follow-up preventive action is needed, according to the BCRG:

"...the variation in incidence rates of all-sites and the particular type of cancer between the neighbour regions could be attributed to environmental factors, human behaviour, habits and lifestyle. Therefore, the local variables in Basrah need to be investigated thoroughly to address the possible etiological factors[138]*".*

The possible connection with exposure to DU is difficult to make, according to some of the doctors involved in the research. They acknowledged the concerns about DU and related health problems amongst their patients and stated that DU is indeed a risk factor, but stressed that follow-up research would be needed to make any useful scientific statements about the link. They considered the south of Iraq contaminated and therefore see the increase of leukaemia and lymphoma as an area of interest for further research on exposure scenarios, contamination and resultant health problems. Apart from these studies, several Iraqi doctors and researchers have published articles[139] on DU exposure and related illnesses, and although they might be helpful for raising awareness on the mounting concerns amongst Iraqi citizens, the absence of a peer-review process and the possible influence of political propaganda from the Iraqi regime on articles

'The absence of robust epidemiological evidence should not be seen as evidence of absence of any health effects, especially when considering the toxic nature of DU.'



Oncologist Dr. Jawad Al-Ali, Basrah 2012 ©Edouard Beau

[137] Interview with expert from Ministry of Science and Technology, October 7, 2012, Baghdad. Examples given were contaminated milk from China with melamine and pesticides in imported meat from India.

[138] Khalaaf, A. (2012) Incidence of Cancer in Basrah/ Iraq: Update Review. Basra Cancer Register Group. Unpublished.

published pre-2003 hinders the effective use of the data in providing a clear image of the results of impact and effects of DU on health and environment.

Improved baseline data is certainly a major step forward in understanding and analysing the current trends in cancers. However, the lack of transparency on firing locations, targets and amount of DU and historical data on remediation activities makes it difficult to set up specific research which compares health outcomes between groups living in contaminated and non-contaminated areas.

Birth defects

Recent studies[140] have suggested that there has been an increase of congenital birth defects in Fallujah and Basrah. Reports coming from Fallujah in particular have gained significant media attention in the last two years[141]. Researchers assessing the possible link between war remnants and health problems report that rates at Fallujah General Hospital have reached 15% of all births, with particularly high rates of heart defects and neural tube defects. It is likely that problems caused by environmental risk factors in the city are being exacerbated by a lack of funding for neonatal and obstetric care, nevertheless there is an urgent need for the comprehensive assessment of risk factors and rates of health problems. Should a clear link be made between war remnants and the health problems, it may have significant implications for the use of weapons that leave toxic residues within civilian areas. The lack of a complete birth registry, full US transparency on the range of weapons used and, crucially, a detailed environmental assessment within the city, have ensured that there is still considerable debate over the cause of the problems.

Other researchers are more cautious about making a direct link between environmental exposure and increasing birth defects. In a review of the limited studies that have been undertaken in Iraq, Al-Hadithi et al[142] look at a variety of environmental exposure routes such as DU, white phosphorous, heavy metals, chemical weapons and maternal factors that could be responsible for congenital birth defects. They confirmed that there had been an increase of birth defects in the hospitals selected for the study, but that the numbers are still below the average rates for neighbouring countries. Their conclusion states that the lack of data prior to 1991 makes it difficult to provide a *'clear indication of a possible environmental exposure'* but acknowledge that the Iraqi population is facing environmental challenges.

As a result of the alarming media reports, and research undertaken by the Iraqi Ministry of Health (MoH), the WHO began designing to a nationwide survey on birth malformations in 2011, explaining that: *" [T]here is a need for a comprehensive programme to better understand the distribution, trends and the magnitude of birth defects in Iraq."* In cooperation with the MoH, the WHO initiated a two-step programme, starting with conducting a survey in the following areas: Baghdad Karkh, Baghdad Rasafa, Diyala, Anbar (which includes Fallujah), Sulaminaiyah, Babel, Basrah, Mosul and Thi-Qar; the results are expected early in 2013. The next step would be conducting *"observational and analytical epidemiological and laboratory investigations to understand underlying risk factors"* in order to assess the burden that this problem could place on the Iraqi health systems, medical services and communities[143]. The WHO/MoH project is an important first step in assessing the current trends and prevalence of birth defects and providing follow-up actions to address the concerns and needs of Iraqi civilians. Though the WHO states that the survey is not looking into the relationship between DU exposure and birth defects, it states that: *"Since the issue of associating congenital birth defects with exposure to depleted uranium has not been included in the scope of this particular study, establishing a link between the congenital birth defects prevalence and exposure to depleted uranium would require further research[144]".*

While waiting for any future studies, uncertainties will remain among Iraqi families, and the absence of any effective assessment of probable causes, and activities to reduce them, where necessary, will prolong exposure to hazardous toxic materials in populated areas.

[139] For an overview of some of the studies, see the footnotes of this article: http://www.brusselstribunal.org/DU-Azzawi.htm

[140] Abdulghani et al, Perinatal and neonatal mortality in Fallujah General Hospital, Fallujah City, Anbar Province, west of Iraq. http://www.scirp.org/journal/health Vol.4, No.9, 597-600 (2012); Alaani et al, Four Polygamous Families with Congenital Birth Defects from Fallujah, Iraq. Int. J. Environ. Res. Public Health 2011, 8, 89-96.

[141] See footnote 135.

[142] Al-Hadithi, T. Al-Diwan, J. Saleh, A, Shabila, N. (2012) Birth Defects and the Plausibility of Environmental Exposure: A review. Conflict and Health, 6:3.

[143] UNDP (2012) Pilot Assessment of Congenital Birth Defects in Iraq in Six Governorates, project description. Accessed on http://mdtf.undp.org/document/download/6499

[144] WHO (2012) Congenital birth defect study in Iraq: frequently asked questions. Accessed on http://www.emro.who.int/irq/iraq-infocus/faq-congenital-birth-defect-study.html

Other voices of concern

Notwithstanding the lack of hard scientific data on the rates and causes of health problems, Iraqi society is rife with anecdotal stories about health concerns that are related to exposure to environmental contaminants such as DU. Accounts from both international and national NGOs, as well as human rights activists confirm the worries and anxiety amongst Iraqi civilians. In their report Environmental Contaminants from War Remnants in Iraq[145], the NGO Coordination Committee Iraq, an umbrella organisation that works on advocacy and coordination on humanitarian efforts in Iraq, highlights the current problems with DU and the absence of immediate action to protect Iraqi civilians, urging that clean-up operations be conducted. A similar sense of disquiet can be found in a policy brief published by 17 humanitarian aid organisations, which voices the concerns raised by local doctors over the increase of cancers and birth defects, and the possible exposure to radiation sources, chemicals and pesticides[146]. The need for clean-up and protection of civilians was also raised by UN agencies such as the UNDP and UNICEF in Iraq, regarding clean up of landmines and cluster munitions, stating that:

"Landmines, UXOs and depleted uranium are a major threat to the Iraqi people's "right to life, liberty and security of person" enshrined in the UN Universal Declaration of Human Rights and the UN Convention on the Rights of the Child, and inhibit Iraq's economic development[147]."

The ICRC has been active in Iraq for more than 20 years, contributing to improving Iraq's water sanitation and access to health care. During the course of their work in southern Iraq, they received alarming reports on increases of cancers from tribal leaders in Basrah, urging them to address the issue of DU or mobilise other actors to help them. Specific requests were made to build medical facilities and decontaminate affected areas. According to the tribal leaders *'this need exceeded any other humanitarian needs'*. The ICRC has also been approached by several researchers and regional and local political leaders to support clean-up efforts and carry out research in contaminated areas. However, the local staff could only forward the information to their headquarters, since they neither had a mandate, nor the capacity to work on the matter, but felt the need that those concerns should be addressed in an appropriate manner by the responsible government agencies and international organisations[148]. An ICRC expert on demining recalled that in his line of work he came across contaminated tanks in the Basrah area that were suspected to be contaminated with DU. Local employees did not want to go near the tanks, afraid of being exposed to DU dust.

'Specific requests were made to build medical facilities and decontaminate affected areas. According to the tribal leaders 'this need exceeded any other humanitarian needs'.

Other local groups were consulted as part of this research. In Najaf, a group of doctors are currently assessing the increasing health problems in their region, which they associated with possible environmental contaminants[149], while a human rights lawyer in Nasariyah reported that several villages in the southern province of Thi Qar were targeted during the 2003 invasion and villagers had noted the growing number of cancers in that area. The military base in Al Khamisiya especially, between Nasiriyah and Basrah - a known storage location of missiles and chemical weapons which were destroyed by the US army[150], would probably have seen the release of toxics into the environment that could have led to exposure and resultant health problems.

Psycho-social impact

It is established that DU is a potential risk factor for health problems, as are many of the environmental contaminants that

[145] NCCI (2011) Environmental Contaminants from War Remnants in Iraq. Accessed at http://www.ncciraq.org/images/stories/NCCIDB/NCCIPublications/NCCIStudies/NCCIBrief-DUMunitionsHumanHealthinIraq.pdf

[146] Mercy Corps (2010) Fallen off the agenda? More and Better Aid Needed for Iraq Recovery. Accessed at http://www.mercycorps.org.uk/sites/default/files/More_and_Better_Aid_Needed_for_Iraq_Recovery_-Brief.pdf

[147] IAU Iraq (2011) Landmines and Unexploded Ordnance Factsheet. Inter-Agency Information and Analysis Unit, April 2011. Accessed at http://www.iauiraq.org/documents/1333/Landmine%20Factsheet.pdf

[148] Email exchange with head of ICRC Basrah, June 2012.

[149] Meeting with local NGO representative of Al Amal, March 28, 2012.

were released during Iraq's recent conflicts. In addition, and as noted in the previous paragraph, establishing a clear link to a specific substance and specific health outcome is challenging, even in benign environments with adequate resources.

However, in addition to the potential risks to physical health, it seems to be the case that DU has had, and continues to have, a significant psychological and psycho-social impact on civilians in Iraq. This is based on anecdotal evidence from Iraq and is well documented from previous incidents involving the accidental or deliberate release of radiation. This section will set out some background information on those incidents, anecdotes and the resultant psycho-social impact on communities and individuals.

According to the latest scientific insights into the psychological effects of exposure to radiation, it has become clear that due to the invisible nature of the exposure, radiological events can lead to a psychological climate of prolonged fear and uncertainty. Studies show that individuals exposed to radiological events endure high levels of sustained anxiety, which requires active intervention to avoid negative health outcomes and chronic psycho-social disruption. Studies conducted on the psychosocial impact of exposure to radiation from previous incidents, such as the meltdown of the nuclear power plant on Three Mile Island in 1979, Chernobyl in 1986 and Fukushima in 2011 have shown that there is an impact on psycho-social wellbeing[151]. The uncertainty that accompanies the knowledge of being exposed gives individuals a sense of lack of control, which can lead to chronic stress responses. With regard to the impact on communities, the individuals that are exposed may be stigmatised as contaminated and contagious, which can lead to expulsion from communities or loss of social contacts. Disruption of social networks can lead to exclusion or loss of social capital.

The psychological impact of radiation has also been studied by the US government, which publicised a report on *Potential Radiation Exposure in Military Operations: Protecting the Soldier Before, During, and After.* The authors highlighted the psychological effects that can occur in situations where there are real or perceived radiation exposures. Radiation is known to be associated with cancer and the fact that exposure is non-voluntary increases concerns. Media coverage might amplify the psychological effects, since this would increase knowledge of the presence of radiation, even though

'Aside from DU's potential impact on physical health it is highly likely that its use and presence in Iraq has led to heightened fear and anxiety, which in turn may have created a measureable psycho-social impact.'

it remains invisible. The authors further stressed that delayed or incomplete transfer of information from responsible authorities to potentially exposed persons could be a major cause of stress in many radiation exposure situations. The recommendations given by the authors focus on giving people a *'sense of control'*, for example by the implementation of specific remedial procedures, food controls and diffusion of knowledge, in order to change risk perception and alleviate stress. The report confirms that social stigmatisation of exposed persons could lead to social contact and communication being cut off[152]. Other strategies for risk communication have been set up by the US military after concerns were raised by US veterans in Iraq, who suspected that they had been exposed to uranium and DU. The US deployed teams in Iraq to undertake analyses of the local situation and exposure scenarios, and based on their findings, provided briefings for concerned soldiers[153].

It therefore follows that the knowledge that one might have been exposed to DU, combined with increased rates of visible or reported health problems within a community, can lead to a psycho-social impact on community members. Aside from

[150] Depart of Defense News Release (2002) DOD Releases two reports on Khamisiyah demolition operations. Accessed at http://www.defense.gov/releases/release.aspx?release-id=3322

[151] For example, see Cwikel, J. (1997) Comments on the Psychosocial Aspects of the International Conference on Radiation and Health). In: Environmental Health Perspectives. Vol.105, Supplement 6. December 1997; LeDoux, J. (1996). The emotional brain: The mysterious underpinnings of emotional life.New York: Simon & Schuster; Institute for Disaster Mental Health (2010) Disaster Mental Health: Assisting People Exposed to Radiation. Instructors manual. New York State Department of Health.

[152] National Research Council. (1999) Potential Radiation Exposure in Military Operations: Protecting the Soldier Before, During, and After. Washington, DC: The National Academies Press.

DU's potential impact on physical health, it is highly likely that its use and presence in Iraq has led to heightened fear and anxiety, which in turn may have created a measureable psycho-social impact.

This appears to be supported by anecdotal reports but has yet to be measured directly. The situation has been confirmed by the IAEA in their 2010 report to the UN General Assembly, which concluded that, although in their opinion physical health impacts from radiation exposure were unlikely: *"...it was also observed that in a post-conflict environment, the presence of depleted uranium residues further increases the anxiety of local populations[154]".*

Indeed, similar concerns were also voiced by Iraqi doctors and government officials. According to the director of the RPC, the increased cancer awareness is linked by people to exposure to DU. The media especially had a role to play in this after the war, when they showed scrap metal sites on television, along with pictures of deformed babies, stating that they were all contaminated with DU. In the opinion of the director, a lack of sufficient education results in people being more prone to thinking that health problems were caused by DU[155]. This is a situation that is exacerbated by distrust in the authorities, which is a recurrent factor in post-conflict societies. Dr. Al-Ali from the Basrah Teaching Hospital suggested that, when combined with experience of worsening health problems in their own families, a lack of scientific knowledge was a major factor driving fear of cancer[156]. When asked about their views on DU, the deminers working for the Danish Demining Group (DDG) stated that the main problem with DU is perception. With mines there is a direct impact and people know what they are up against, since they have knowledge about areas with mines and can see them or locate them if needed. With DU, there is long-term impact because of its invisibility, and the resulting uncertainty of being exposed[157].

The release of DU into the environment, when combined with awareness among civilians about its presence, and their direct experience of increased health problems within families and communities, has ensured that widespread fear has developed over possible exposure, contamination and ill health. Some of the awareness of DU as a toxic, radioactive substance was the result of propaganda by the Saddam regime and subsequent political rivalries after 2003. Similarly direct links were made by media outlets between scrap metal sites and health problems, which increased anxiety amongst civilians. Nonetheless, given the chemically toxic and radioactive nature of DU, and the current absence of a safe threshold dose, those concerns must be taken seriously, as DU is clearly a health hazard. States that are sceptical of the need for action should reflect on what approach their government would take if widespread DU contamination was affecting their towns and cities.

In Iraq, known or suspected DU contamination has demonstrated that it has the ability to induce high levels of stress, lead to the exclusion of individuals from communities and heighten the distrust between those communities and the authorities – with logical implications for peace-building and reconciliation. Governments may wish to dismiss these problems as a result of ignorance among civilians, which can be easily remedied by better risk education, but where trust and resources are in short supply, and a lack of transparency creates and sustains an atmosphere of uncertainty, is this not an entirely predictable outcome of the dispersal of radiological materials during warfare? If that is the case, it has serious implications for the acceptability of DU munitions.

[153] Melanson MA, Geckle LS, Davidson BA (2012) Risky Business: Challenges and Successes in Military Radiation Risk Communication. US Army Medical Department Journal. 2012 Jul-Sep:82-7.

[154] UNGA (2012) Effects of the use of armaments and ammunitions containing depleted uranium. Report of the Secretary-General. A/67/177.

[155] Interview Dr. Bushra, October 8, 2012, Baghdad.

[156] Interview Dr. Al-Ali, October 3, 2012, Basrah.

[157] Interview DDG, October 2, 2012, Al Zubayr.

5. Conclusion

The widespread release of DU into the Iraqi environment during the 1991 and 2003 wars has left civilians in a state of uncertainty over the nature and distribution of the risk it poses. At least 440,000kg of DU has been used in Iraq, some ending up as DU dust, some as corroding penetrators and leaving a still unknown number of sites with contaminated vehicles, buildings and soils. Requests by Iraqi ministries and international organisations for the release of quantitative and geographic usage data, and information on historic remediation and harm reduction measures have been met with silence by the US, and only limited data from the UK government. As a result, the true picture of the extent and seriousness of DU contamination is still incomplete. By gathering fragmentary information on the location of fighting, attempts at remediation and the storage of scrap metal, this report has sought to provide a foundation for further research and data gathering. The report has also tried to document the complexity of managing DU contamination in a post-conflict environment and the burden this complexity places on states recovering from conflict.

Reports of increasing rates of cancer and congenital birth malformations have become a feature of everyday life in Iraq, in turn generating significant concern among the population. From the Iran-Iraq War onwards, they have suffered widespread environmental damage, a collapse in basic healthcare and increased malnutrition. On top of these problems, they have also had to contend with the environmental and public health legacy of a variety of toxic remnants of war, including, but not limited to, DU.

In addition to the physical health legacy of these toxic contaminants, the visibility of health problems such as cancers and birth malformations in communities, and the ongoing uncertainty over the extent and seriousness of DU contamination, has created a climate of anxiety among communities and individuals.

This study has identified four key findings:

1. Need for transparency

There is an ongoing and increasing need for full transparency from the US over where DU has been used, in what quantities and the nature of the targets. Without this, attempts to catalogue and manage the extent of contamination – with the ultimate aim of reducing civilian harm - will be impossible. Also of importance is the full release of information over management and remediation activities undertaken during the period from 2003-2005 under the governance of the Coalition Provisional Authority. Efforts by Iraqi researchers and UNEP have only managed to identify a fraction of the total number of contaminated sites. Around 300 sites have been identified and require costly management but the true extent of contamination, and the risk it poses to civilians, remains unclear.

2. Use of depleted uranium in populated areas

The use of DU is commonly defended through claims that it is solely an anti-armour weapon and militarily necessary to defeat modern armour designs. This claim has appeared consistently in reviews of the weapons' legality and in press briefings and public relations efforts by user states. However, data from Iraq challenges this orthodoxy in two ways.

DU munitions were developed in the Cold War for scenarios far removed from those likely to be encountered today. While in some cases DU munitions were used against armoured targets, in 2003 those armoured targets were overwhelmingly located in populated areas. In other cases, DU munitions were used against civilian infrastructure, such as buildings, and non-armoured targets. When DU dust can travel several hundred metres from the target site, the implications for civilian exposure to DU residues in these cases is all too clear. Therefore, while it is often portrayed as a precision weapon, the circumstances of DU's use are the ultimate controlling factor on whether it is capable of discriminating between civilian and military objectives or not. In the case of Iraq, where contamination has remained for more than a decade, the inability of DU to distinguish between civilians and combatants is clear. Full transparency from the US over its 2003 targeting data is crucial in efforts to understand whether DU is capable of being used discriminately.

3. Difficulty in assessing and managing DU contamination

As a radioactive and chemically toxic heavy metal, which may be dispersed as fragments or dusts in, or on military equipment, buildings, vehicles and soils, DU contamination presents considerable assessment and management challenges. The UN's efforts to understand DU required the input of the IAEA, WHO and UNEP, specialists from several countries and access to well-equipped analytical laboratories.

For states seeking to reduce the potential civilian harm from DU, effective management requires a multi-agency approach and the availability of a wide range of expertise, equipment and infrastructure such as functioning radioactive waste storage facilities.

These requirements created major challenges for the Iraqi government, who were initially dependent on international assistance to build capacity and provide equipment; this was welcome, but limited by the generosity and interest of State donors. Interventions at contaminated sites were slowed by bureaucracy and political infighting between Iraqi ministries, much to the detriment of civilian protection, but the greatest impediment continues to be the lack of US targeting data. As with many sites in the Balkans, UNEP's recommendations have not been implemented in full and it is likely that a considerable volume of contaminated scrap metal has made its way into the open market. The lack of effective regulation of scrap metal sites in particular continues to put Iraqi civilians at risk of unnecessary exposure to DU and range of other military-origin pollutants.

4. Impact on health and environment

While non-exhaustive, the weight of research in Iraq suggests that there have been notable shifts in the incidence rates of congenital birth defects and of diseases such as cancer during the last two decades. Demonstrating causality between environmental risk factors and specific health outcomes is notoriously difficult, particularly in post-conflict scenarios, nevertheless it is clear that the conflicts in Iraq have introduced a range of toxic materials into the environment, many of which are tightly regulated during peacetime because they are known or suspected to be hazardous to human health.

Assessments by UNEP and the Iraqi government have identified some sites of particular concern and have sought to intervene in the worst cases. International concern over the reported rise in birth defects in Fallujah and elsewhere has prompted the WHO and Iraqi Ministry of Health to act and it is hoped that their joint study will be sufficiently robust to identify whether rates are increasing or not. However it will only cover incidence rates; further studies will be required to analyse causes. Meanwhile Iraqis will continue to suffer the health legacy from their contaminated environment.

The failure to adequately manage DU contamination continues to sustain an atmosphere of uncertainty that is fuelling anxiety and may be having a measurable psychological health impact on Iraqi communities. It is important that the international community offer its support for clearance and management efforts, coupled with risk education and harm reduction measures.

While DU is the most notorious toxic military contaminant present in Iraq, it is by no means the only one. The lessons from Iraq should trigger a wider debate about the extent of state responsibility for reducing the use of military toxics and for ensuring that their legacy after conflict is more coherently managed.

To conclude, just as oversimplified arguments in favour of DU munitions do little to convey the realities of their use in conflicts, so the complexities of having to manage their legacy are often ignored. States recovering from conflict are rarely in a position to implement even the basic precautionary measures suggested by international agencies, meanwhile user states refuse to take responsibility for their actions leaving civilians at risk and in a state of uncertainty. Given the humanitarian and socio-economic consequences, IKV Pax Christi concludes that DU has no place in conventional weapons and actively supports a ban on their use.

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