

## Depleted Uranium

*Is it potentially involved in the recent upsurge of malignancies in populations exposed to war dust?*

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### ABSTRACT

لقد دخل اليورانيوم المنضب إلى عالم الصناعات الحربية حديثاً بسبب كثافته النوعية الفائقة، كما أنه يعد ملوثاً كبيراً للبيئة. وبالرغم من أن فعاليته الإشعاعية أقل من اليورانيوم الطبيعي فإنه ما يزال يحتفظ بكامل السمية الكيميائية للأصل اليورانيوم الطبيعي. كما تقل المعطيات التي تتعلق بالمخاطر طويلة الأمد لليورانيوم المنضب على الإنسان. ولكن يُظن أنه عامل سمي وماسخ جيني كبير. تظهر مراجعة الأدب الطبي ندرة المعلومات المتوفرة حتى لدى منظمة الصحة العالمية وذلك عن علاقة اليورانيوم المنضب بالسرطان، وتوثق التقارير الصادرة عن ساحات المعارك السابقة ارتفاع ثابت للسرطانات وتشوهات الأطفال بعد الحروب التي استعمل فيها كسرطانات الدم في البلقان، والتشوهات الولادية، وسرطان كابوزي في جنوب العراق. ويملك سرطان كابوزي في العراق سلوك عدواني واضح مقارنةً بكابوزي التقليدي المعروف في العراق قبل الحرب مما يشي بعلاقة هذا السرطان باليورانيوم المنضب المستعمل في الحرب، ويشي أيضاً أننا أمام نوع مختلف من كابوزي وهو سرطان كابوزي المرتبط باليورانيوم المنضب. يعد الأطفال أكثر حساسية للإشعاع من الكبار، وهذا يضاعف مسؤولية المجتمعات الطبية نحو موقف مدعم بالبراهين تجاه اليورانيوم المنضب، ويوجب إيقافه حتى يثبت العكس. إننا كهيئات طبية لنا مقاربة إنسانية بهذا الشأن، نقف مع الإنسان أن لا تُساء معاملته، ومع الأنظمة الخضراء التي تعارض كل الملوثات المشبوهة للأرض. ومن الآن وحتى إشعار آخر يجب أن يؤخذ اليورانيوم المنضب إلى المختبر للتحقق من سلامته قبل أن يذهب للقتال.

Due to its extreme density, depleted Uranium (DU) has recently entered the warfare industry and became a major pollutant to the biosphere. Although DU is less radioactive than natural Uranium, it still retains all its chemical toxicity. Limited data exists regarding the long-term hazards of DU on humans, however, it is suspected to be a major toxic and mutagenic agent. Literature review reveals the scarcity of the World Health Organization's knowledge regarding related DU-malignancies. Battlefield reports documented a steady rise of malignancies and newborn malformations after war, that is, leukemia

in the Balkans, and congenital anomalies and Kaposi sarcoma (KS) in Iraq. Kaposi sarcoma in Iraq has a quite aggressive behavior compared with the classic KS before, suggesting a potential relation with DU, and possibly a different DU related KS-type. Children are more susceptible to radiation than adults. This enlarges the responsibility of the medical communities for an evidence-based attitude towards DU, and to ban its use until proven otherwise. We, as medical bodies have a human approach - stand with man not to be mistreated, and with green norms, which veto all suspected pollutants of the planet. Until further notice, DU should be thoroughly checked for safety, before it kills.

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After the epidemic of leukemia which occurred in the Balkan region and the flare up of malignancies including Kaposi sarcoma (KS) in Iraq, in which depleted Uranium (DU) has been used as a piercing element against tank armaments, a global suspicion arised whether DU has any etiological relation with human malignancies, and does it carry any risk to the exposed population - military or civil- in and around the battle field. This issue gains currently special importance, as new outbreak of wars has just ensued in the Middle East, and drums of battle are loudly beaten all over with possible use of DU again. This review was carried out to highlight the potential hazards of DU on the battle theater, so as to urge all health-related bodies to set up the necessary scientifically sound epidemiological studies, to ascertain if DU exposure is responsible for

increased cancer rates and malformations, and finally to initiate a proper global action for that.

It is well-known that weapons containing natural uranium (NU), that is, 'nuclear weapons' are disqualified due to their radioactivity, prompt mass destructive power, and long lasting genotoxicity, which has sustained effect through generations. However, as DU has not been globally and legally well-identified and studied, and as it formed a heavy disposal task on the nuclear industry, this allowed it to leak to traditional weapon industry for deeper destructive effects instead of being buried costly in nuclear graveyards. In light of new reports tackling the disastrous outcome of DU on the health of exposed populations, a question arises, as to which extent may the weapons containing DU yet be considered conventional, and does DU still retain similarities with the "maternal" NU, regarding the toxic and carcinogenic effect, which the latter has. It is important here to be reminded of the biodata of NU and DU. On average, approximately 90 (micrograms) of uranium exists normally in the human body, this is gained from normal intakes of water, food, and air. Approximately 66% is found in the skeleton, 16% in the liver, 8% in the kidneys, and 10% in other tissues. (<http://www.who.int/mediacentre/factsheets/fs257/en>) However, DU is a nuclear exhaust born as a byproduct of Uranium impregnation in the nuclear industry, and almost completely formed from Uranium-238 (U238), which has a 60% radiation power of NU.

Physically, NU and DU consist of a mixture of 3 radioactive isotopes but in different ratios; NU contains U238 (99.27% by mass), U235 (0.72%), and U234 (0.0054%), whereas DU contains approximately 99.8% U238, 0.2% U235, and 0.001% U234 by mass. The main difference between DU and NU is that the former contains at least 3 times less U235 than the latter. Table 1 shows the half-lives and the specific activity of the 3 isotopes of NU and DU, the average energies per transformation emitted by these isotopes, and the percentages of isotopic abundance by weight and activity of NU and DU. (Data derived from URL: <http://www.who.int/mediacentre/factsheets/fs257/en>). The DU behaves chemically, physically, and toxicologically similar to NU. As it was found to still retain an extra penetrative and destructive effect, it was presently involved in the manufacture of high-powered smart bullets/missiles, and thus it entered the armory of the arsenal as an anti-tank shell agent. Uranium-238 is pyrophoric, bursting after shooting into flame with 70% of the shell aerosolize into respirable particles less than 5 microns in diameter. Most DU particles are dispersed as dust on earth, which when it rains, penetrates into the

soil to contaminate water resources, and consequently agricultural products.

Uranium-238 is an alpha radioactive emitter. On degradation, it shoots mainly alpha, and to a lesser quantity beta particles. Man, in and around the battle field, is exposed to DU hazards by radiation, inhalation, swallowing, and wound contamination. In the human body, DU is nephro-toxic, it is mostly excreted via the kidney causing acute nephritis,<sup>1</sup> however, it is also excreted in the semen, and uranyl ions infiltrate the testes, ovaries, placenta, embryo, and central nervous system.<sup>2</sup> Table 2 shows the amount of DU one would

**Table 1** - The half-lives\* and specific activity of the 3 isotopes of Uranium.

Isotope	U238	U-35	U234
Half life, million years	4510	710	0.247
Specific activity	12.4	80	231000
<i>Average energy emitted per transformation</i>			
Alpha	4.26	4.47	4.84
Beta	0.01	0.048	0.0013
Gamma	0.001	0.154	0.002
<i>Relative isotopic abundance</i>			
<i>Natural Uranium (%)</i>			
By weight	(99.28)	(0.72)	(0.0057)
By activity	(48.8)	(2.4)	(48.8)
<i>Depleted Uranium (%)</i>			
By weight	(99.8)	(0.2)	(0.001)
By activity	(83.7)	(1.1)	(15.2)

\*The half life of a radioactive isotope is the time needed to decay to half of its original radioactivity

**Table 2** - Amount of DU needed to be inhaled or ingested to lead to a kidney concentration of the chemical toxicity limit (3 µg per gram of kidney), or to a dose of 1 mSv (radiation dose limit).

Route of intake	Intake leading to a kidney concentration of 3 microgram per gram		Intake leading to a dose of 1 mSv	
	Mass, mg	Activity, Bq	Mass, mg	Activity, Bq
Inhalation of a reference 'moderately soluble' DU aerosol	230	3,400	32	480
Inhalation of a reference 'insoluble' DU aerosol	7,400	110,000	11	160
Ingestion of a reference 'moderately soluble' DU compound	400	5,900	1,500	22,000
Ingestion of a reference 'insoluble' DU compound	4,000	59,000	8,800	130,000

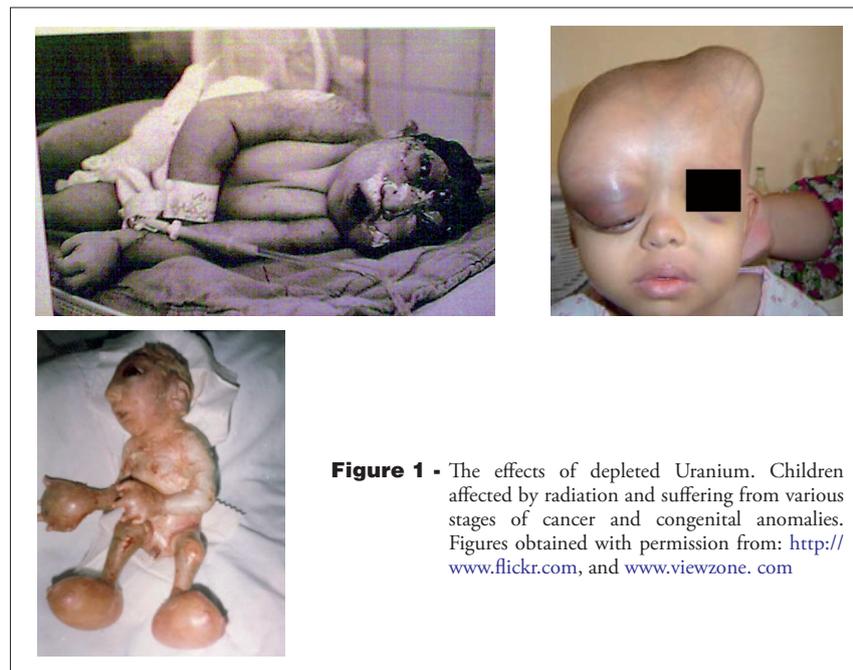
DU - depleted Uranium. The values have been calculated for 3 types of Uranium compounds: 'moderately soluble' (UO<sub>3</sub> and U<sub>3</sub>O<sub>8</sub>), and 'insoluble' (UO<sub>2</sub>). Bq - Becquerel unit of radioactivity, Sv - Sievert dose equivalent radiation, which quantitatively evaluates the biological effects of ionizing radiation

have to inhale or ingest to lead to a kidney concentration of chemical toxicity limit (3 microgram per gram of kidney) or to a dose of 1 mSv (radiation dose limit) according to the International Atomic Energy Agency (IAEA) (<http://www.iaea.org/NewsCenter/Focus/DU/finalreport.pdf>; <http://www.iaea.org/index.html>)

Naturally, children are more susceptible to radiation-induced cancers than adults. **Figure 1** shows children affected by radiation. A marked increase in childhood cancers and congenital anomalies was reported in Basra, the city which was polluted in 1991 with hundreds of tons of aerosolized U238.<sup>2</sup> Yet, chemical toxicity is more risky than the radiological hazards.

In reviewing medical literature, the Balkans and Iraq stand as a major example of the theater where DU has been profusely used. Iraq, within the past 3 decades has been subjected to 3 large wars, and to an -off and on- military episodes in between. A mainstay report published in Saudi Medical Journal in 2003 by Al-Waiz et al<sup>3</sup> from Baghdad University clearly shows that KS has recently made an upsurge in southern Iraq, and it behaved in these particular cases quite divergently compared with the well-known classic KS, which exists before sporadically in Middle Eastern people including Iraqis. The report concluded that this KS outbreak might have been provoked and/or boosted by DU fallout. The differences between the new Iraqi KS outbreak and the known classic type may be concluded in: 1. Age: the mean age of patients in these series was

54 years compared with 68 years in classic KS,<sup>3</sup> thus these patients were 14 years younger than the classic KS patients, that is, 14 years earlier presentation. 2. Advanced presentation: classic KS usually presents as macular lesions and progress very slowly to plaques or nodules,<sup>3,4</sup> but the disease in all these patients presented directly in the advanced plaque and nodular stage, none was in the macular stage. This is a major deviation from the classic KS, which suggests a rather aggressive nature, and more rapid course probably related to a new potential factor. 3. Visceral involvement: 5 KS patients (25%) had lung and liver involvement, and 10% of them had lymph node involvement within a short period of the disease course. Considering that the visceral dissemination occurs very lately and infrequently in classic KS<sup>4</sup> reflects again a comparatively more florid type of KS than the classic one. 4. High mortality rate: The mortality rate was 15%, and death was due to systemic dissemination of the tumor. Whereas, classic KS patients enjoy a rather normal life span, approximately 10-20 years in average and death is very rarely related to KS.<sup>5-7</sup> 5. The southern geographic predilection: one case of KS only came from northern Iraq, which is comparatively calm and far from the battle field, versus 15 cases came from the central Baghdad region, and 4 came from the south; this suggests some geographical polarization of KS distribution consistent with the battle field - Baghdad and south Iraq. Considering that Baghdad is relatively closer to the south increases the



**Figure 1** - The effects of depleted Uranium. Children affected by radiation and suffering from various stages of cancer and congenital anomalies. Figures obtained with permission from: <http://www.flickr.com>, and [www.viewzone.com](http://www.viewzone.com)

polarization to one case north versus 19 middle/south. This southern:northern ratio of KS cases is far bigger than that of the populace distribution. The northern people alone are approximately 8 million (Kurds and other sects living with them). From the Wikipedia almost 75% of Iraq's population lives in the flat, alluvial plain stretching southeast from Baghdad to Basra, and the Arabian Gulf. Possibly, approximately one quarter of Iraqi population lives in the north, and one KS case came only from the North, and 19 from the Midsouth. This inconsistent geographical distribution of KS cases which are not parallel with the populace distribution suggests a Southern related factor incriminated in KS epidemic, and is existed in the Middle South, that is the focus of the battle field during successive wars. 6. The epidemic occurrence: This is highlighted via a cluster of 20 KS cases diagnosed within a short (one year) period, and perhaps, this number has jumped up later.<sup>7</sup> Literature review shows that this compact episode of KS is probably the first recorded in Iraq, and in all the neighboring countries. Fortunately, there was an Iraqi study of 21 cases of classic KS 15 years before,<sup>8</sup> that is, before the Gulf war era but with a quite different clinical behavior. Thus, the current report involves almost the same number of patients but within a tenth of the period of the previous study.

Does this carry any statistical or clinical value? We think so. These marked deviations of new KS series in Iraq from the classic straightforward type suggest a more florid and aggressive type of KS, they remind of the African type<sup>9</sup> of KS but now in Asia, changing the entire continent. We think this issue is worthy of further research to point out how, and where from these series of "Africoid" KS erupted but in Asia, and what is its exact relation with the series of wars, and with the generous use of DU during these times. The timing, the epidemic occurrence, and the southern polarization all suggest a link with DU, which was the only exception of the multiple previous Middle East wars. Hence, it may be speculated that DU might have been a potential risk factor of KS, and might have intervened directly or indirectly with this KS outbreak. This link between the aggressive KS outbreak and DU is unique, and cannot be enrolled in any of the 4 known types: the classic; the epidemic-AIDS related; the endemic African; and the iatrogenic, immunosuppressive-type although it is similar to the Africoid-African like-type in its aggressiveness but differs in being in Asia, Asian for the first time. We suggest prospectively, to be identified as a separate type - the DU related KS.

Literature reveals that DU was also an etiological suspect of a leukemia outbreak in the Balkan wars where it was profusely used as well.<sup>10</sup> Reviewing the proceedings of the United Nations in Bosnia-Sarajevo after the leukemia outbreak of Balkan reveals unfortunately, the scarcity of World Health Organization's (WHO) knowledge regarding DU-malignancy relation.<sup>10</sup> This is probably due to the difficulty of carrying out research in vivo with the huge Uranium phobia surrounding it, or else and this is more likely, taking it straight to act in the battle field away from bio-medical control. Nevertheless, the present knowledge indicates that DU seriously affects human health,<sup>10</sup> and pushing it to the military field should not have happened without full knowledge and comprehensive evaluation of the total hazards. The carcinogenic effects of DU on the human blood need approximately 2-5 years exposure period, depending on the intensity and duration of exposure before the clinical presentation issues.<sup>10</sup> This period is compatible with the aforementioned upsurge of KS epidemic in Iraq, which has sustained even a longer time than the required "radioactive incubation period" for KS to ensue. This point should have acted as a breaker to slow down the uncontrolled military ambition to overkill. However, and for an unbiased view, literature review reveals debatable reports, some of which are pro, and many are against using DU in military armor and munitions, while the dispute continues and the puzzle needs to be cleared up. There exists a route for trans-generational transmission of factor(s) leading to genomic instability in F1 progeny from DU-exposed fathers according to Miller et al.<sup>11</sup> Data indicate according to Xie et al<sup>12</sup> that human bronchial cells are transformed by DU and exhibit a significant chromosome instability consistent with a neoplastic phenotype. Al-Dujaily et al<sup>13</sup> found high prevalence of human epidermal growth factor receptor 2 (HER-2/neu) over expression in female breast cancer patients among an Iraqi population exposed to DU (expression was positive in 67.8% of breast cancer patients). The HER-2/neu over expression plays an important role in the pathogenesis of breast cancer, and is associated with a worse prognosis. Hahn et al<sup>14</sup> found that DU fragments of sufficient size cause localized proliferative reactions, and soft tissue sarcomas that can be detected with radiography in the muscles of rats. Caldicott<sup>1</sup> considers the use of DU is a form of radiologic warfare, it is not just an energetic piercing agent. Briner<sup>15</sup> found that although DU is less radioactive than NU, it still retains all the chemical toxicity associated with the original element. It has been found that exposure of developing organisms to low dose DU delays the issue of milestones, and ingesting

it carries a radiologic risk.<sup>15</sup> And we know for sure that it will eventually find its way to the human body via ingestion, inhalation, or contamination. Reports from southern Iraq have documented a steep rise in the incidence of cancers since the 1990s, especially in children. According to the Cancer Treatment Centre of Basra, in the far Southern Iraq and the focus of the Gulf wars, local cancer incidence raised from 11 cancers per 100,000 in 1988 to 75 in 1998, and 116 in 2001, approximately 11 folds in 13 years, rising almost one fold each year.<sup>16</sup> In Fallujah, Busby et al<sup>17</sup> found that the results qualitatively support the existence of serious mutation-related health effects as 80 deaths per 1,000 births were reported in Fallujah compared with only 19.8 in Egypt. Caldicott<sup>1</sup> recalled the mechanisms, by which depleted uranium induces mutations and cell damage. Cells are attacked directly and indirectly by DU.

The alpha rays hit the DNA molecules resulting in direct damage to the chromosomes, although this damage is not stationary, it passes via generations posing genomic instability of the damaged cells. Additionally, indirect bystander effect occurs to the intact adjacent cells by uranyl ions, which bind avidly to DNA-clumped chromatin causing DNA damage and chemical toxicity, hence, their mutagenic capability. Hamilton<sup>18</sup> inquires why adequate measures were not taken to ensure that good scientific evidence for later use was obtained at the onset of both Gulf and Balkan conflicts. It is possible that at the time of confrontations, circumstances were not fit, there were political or military limits, which made the recurrent publication and media comments on these events decades after their occurrence just serve in dissolving the confidence of the general public.<sup>18</sup> Possible, however the lack of publication and media coverage serves also to obscure the problem rather than solving it, whereas it continues to exist inconspicuously with extra potential human sufferers. For fairness, it is worth mention that some studies showed leniency with DU and did not refuse using it in military, for instance, Patel<sup>19</sup> in his article "Health in the Middle East: No strong link between depleted uranium and cancer", and McDiarmid ("Depleted uranium and public health. Fifty years study of occupational exposure provides little evidence of cancer")<sup>20</sup> but circumstances of both are quite different. Uncontrolled occupational exposure is quite different from haphazard permanent residence of the whole society, including children and pregnant women inside the contaminated field. Yet, the authors could not deny the existence of an insidious link or evidence of malignant relation between DU and cancer, the term they used -no strong "link" - and -little "evidence" - ascertains the presence of a "link"

with, and an evidence of cancer rather than denying it. It is not the size of the "evidence" or the "link" between DU and cancer which accounts in the human affairs, but the link itself is; it is incriminated even if it kills one man only. Size can act in the field of materials not in humans. We, in the medical field feel it is part of our medical mission and educational deputation as a pioneering medical media in the region, to notify any malpractice against human health or life, share in protecting the common people from mass health disruption, and send a plea to whom it may concern, such as the WHO, United Nations, the Green Groups, and all concerned health authorities requesting them to consider research reports regarding KS<sup>3</sup> originated from the Gulf and Balkan region as workpaper, which is worthy of further investigation and follow up, that is:

1. Perform epidemiological studies with control groups, and further mass population screening for any uprise in mortality and morbidity in general, and malignancy in particular and around the battle fields, prospectively and retrospectively, to document the old cases and discover the new ones as early as possible in order to have a larger statistical database to depend on in the next steps.
2. Perform further in vitro laboratory research and animal studies -although not ideal with battle field medium- to clear any suspicion regarding DU - human health relation on radiological, toxic, and molecular basis.
3. Until final conclusion is issued, to ban the use of DU in any means until full knowledge of its safety and hazards is evident. Military experts should obtain a safety certificate of DU before taking it to the field but not after. Safety should never be proved retrospectively or provisionally, as long as man is not a laboratory rat to start with in death trials, and as long as prevention is better than cure as we always say, noticing that once DU is blasted, it will never vanish, it will finally pollute the water, agriculture, and human life in an everlasting circle.

International health authorities who care should undergo regular check up on the factories of death materials to see what is up, they should not wait and see, but should move -prophylactic wise- there to face the death engineers in the pre-manufacturing stage in order to control the obsessive killing drive in that media, and suppress the explosive fatal craving. Performing all these preventive measures is crucial -particularly at this very time with new launch of wars, in order to clear the relation between DU and uprising malignancies, and to clean this perpetual hazardous contaminant of human life. When NU is disqualified for its non-conventional mass destructive effect, DU with 60% radiation of NU, and with everlasting environmental contaminating effect is a genuine suspect, it should not at all be justified

and passed, and should not be simply considered as conventional until proven otherwise by unbiased evidence-based science. There seems to be a thick wall separating militarists and health preachers. Each is working separately and independently, one with death and the other against it, without minimal coordination and harmony. This wall should be knocked down so that they might work together like a smart surgical team when this does a legal operation. Yes, bombs are made to kill, but they should not do this randomly, they should first earn a health certificate before going to war and before killing. Materials involved in them should not be used until safety measures are confirmed, and preserved in terms of effects, adverse effects, and contra effects, exactly like poisons, and pharmaceutical materials. The side effects of these materials are as vital as the effects, In fact, they are effects on the long run. In another way, they should not kill massively beyond the range of their pre-decided legal law, and "hiddenly" through mutagenicity, which works deeply across decades and generations. In terms of DU, allow the manufacturers to first prove its conventionality and then use it, but not before. The capacity of death should be callipered precisely in extent, mass and duration so that no undesirable hidden killing would silently take place. Illegal instruments should not be used, even in killing, although the taste of death is finally alike. Instruments also should be compatible with -but not above- the morals and ethics of wars, and nothing should be there above ethics and norms.

Leaving a sustained agendum of death to act insidiously and deeply at the level of molecules and chromosomes, and ignoring it is an immoral behavior, and should not occur in the claimed era of human rights and in the current advanced health and war technology. We believe until proven otherwise, that semi-nuclear is nuclear as well, and nucleotides and genes do not read well these accumulative quantitative gradients of radiology, but we do. Scientific silence is a hypocrite act, and it is the other face of the coin of death.

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