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SOME FACTS ON DEPLETED URANIUM (DU),

ITS USE IN THE BALKANS AND ITS EFFECTS ON THE HEALTH OF SOLDIERS AND CIVILIAN POPULATION.

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SOME FACTS ON DEPLETED URANIUM, ITS USE IN THE BALKANS, ITS EFFECTS ON THE HEALTH OF SOLDIERS AND CIVILIAN POPULATION.

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Abstract

This paper discusses four main theses concerning the use of depleted uranium (DU) weapons in Yugoslavia by NATO in the Nineties. The first thesis is that DU is harmful and dangerous, not only as a chemically toxic agent, but also from the radiological viewpoint. The second thesis is that Italian political and military authorities could not be uninformed of the dangers of DU and of its use in wars of the last decade; it is incorrect to say that DU weapons are not forbidden at the international level. The third thesis, based on an estimate of the cases expected to occur in the general population as well as in the armed forces, states that we can reasonably expect Italian soldiers to develop tumours caused by DU. The fourth thesis shows that the presence of DU is difficult to determine experimentally by field research. In addition, we focus on two points that broaden the perspective of the "DU problem in the Balkans". We note that DU is only the tip of an iceberg as regards the consequences of what amounts to a chemical, radiological and environmentally destructive war conducted by NATO against Yugoslavia and against the entire environmental system in the Balkans. In the end, we discuss epidemiological data on the Yugoslavian civilian population to demonstrate that chemical and radioactive pollution, as well as the living conditions of Yugoslavian civilians, have already caused thousands of after-war cancer fatalities and birth defects.

Premise:

This paper aims at demonstrating four main theses, stated below:

1) DANGERS OF DU. **Thesis**: DU is dangerous and harmful, not only as a chemically toxic agent, but also from the radiological viewpoint, when ingested or inhaled.

2) DU HAS NOTORIOUSLY BEEN USED IN WARS FOR TEN YEARS, DESPITE INTERNATIONAL REGULATIONS PROHIBITING ITS USE. **Thesis**: Italian political and military authorities could not be uninformed of the dangers of DU and of its use in wars of the last decade. It is incorrect to say that DU weapons are not forbidden at the international level.

3) DU RISKS IN THE BALKANS. **Thesis**: we can reasonably expect Italian soldiers and the civilian population to develop cancer caused by DU.

4) ASSESSMENT OF DU POLLUTION. **Thesis**: the presence of DU is difficult to determine experimentally.

We apologise for being obliged to adopt technical terminology on several occasions: however, such jargon is necessary for the demonstrations offered here.

1) DANGERS OF DU

Thesis: DU is dangerous and harmful, not only as a chemically toxic agent, but also from the radiological viewpoint, when ingested or inhaled.

It is widely held that the weak radioactivity of DU – lower than natural Uranium – makes its dangers slight. However, this is not the case. DU (Depleted Uranium) radiation is indeed "feeble" (i.e. low specific radioactivity, radiation with scant penetration capacity) as compared to several other sources, but its biological effects cannot be neglected.

The biological damage produced by radiation cannot be explained by radioactivity alone, nor by information concerning the amount of energy of the emitted particles. In fact, the source itself produces a wide range of damages (quantifiable by order of magnitude, rather than by a particular factor), depending on the type of tissues involved, on the duration of exposure, on whether the source of exposure is internal or external, etc.

As regards DU, the issue is relatively simple: DU is a radionuclide which becomes dangerous if inhaled or ingested, as it irradiates the human body from the inside. Secondary but not negligible sources of contamination include contamination through mucous membranes (mouth, nasal cavity etc.) or skin lesions, which are frequent among manual workers.

In dosimetry, the standard unit of biological dose (Sievert, the standard unit used for measuring Effective Dose Equivalent, EDE) is equal to the physical dose (Gray being the standard unit in this case) multiplied by different factors, e.g. Relative Biological Effectiveness (RBE). In short, these factors reflect the fact that an equal number of ergs/gr (i.e. a dose, defined as the amount of absorbed energy by units of mass in a given time), produces different results if administered to different tissues. The results differ by orders of magnitude, and the diversity of exposure conditions produces even more differences.

Data on DU composition[1] show that specific radioactivity is low for DU (e.g. about 10 million times lower than that of a gram of Radium 226), but under the circumstances that concern us here, this is in no way negligible, for the following reasons:

a) DU would have a weak or non-existent biological effect if contact with human subjects were external or transient. Matter cannot be penetrated by DU alpha radioactivity from the outside: a sheet of paper or a layer of dead skin is enough to reduce it substantially. The problem that concern us here is connected with inhalation and ingestion of DU which can be absorbed by humans through environmental or biological contamination of air, water, soil, plants, animals, foodstuffs etc. Following bombings with DU weapons, DU catches fire, burns at high temperatures (5,000 °C), is nebulised and subsequently dispersed throughout the environment and absorbed by humans. Once inhaled or ingested, DU causes cell death and chromosome damage: inhalation triggers complex chemical/ biological reactions within the human body. The alpha radiation DU emits is indeed curbed by one or two millimetres of dead skin, which is why DU is considered to be a negligible source of external contamination. However, DU remains a formidable source of cell death and chromosome damage if radiation is emitted from inside the human body.

b) DU takes the form of UO_2 and UO_3 particles, i.e. tetravalent and hexavalent uranium oxide, ranging from 0.5 to 5 microns: therefore, conditions are favourable for over 99% of its mass to remain in suspension in pulmonary mucous membranes fluids. This is because of the diameter of bronchioles (the terminal part of bronchi, where oxygen is first introduced into the blood), which is around 2-2.5 microns: the relatively large dimension of bronchus surface, ranging from 70 to 80 m², also contributes. Part of this uranium oxide is swallowed – together with bronchial mucus in the allergic reaction following inhalation of metal dust – and subsequently combines with hydrochloric acid in the stomach: the product – uranium chloride – is partially soluble, and reaches the intestine. Uranium oxide easily combines with tissues and hence migrates to the bones, whereas part of it stops in the kidneys (and in other organs, but in smaller percentages).

c) Lung cells and haematopoietic cells are extremely vulnerable to radiation-induced damage, by virtue of their high cell proliferation rate.

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[1] DU (conventionally) consists of 99.8% U^{238} and 0.2% U^{235} (in addition to negligible quantities of U^{234}). Uranium is naturally made up of 99.3% U^{238} and 0.7% U^{235}. In this paper, we consider only alpha radioactivity emitted by DU, which is by far the most hazardous to health inside the human body. U^{238} emits alpha particles (He4 nuclei) with an energy of about 4.2 MeV, and half life (tau) around 4.5×10^9 y. U^{235} emits alpha particles with an energy of 4.5 MeV, and tau ~ 1.1×10^6 y. This means that U^{235} has a decay rate and specific radioactivity about 4,000 times higher than U^{238}. The data shown here indicate that the specific radioactivity of 1 gram of DU with a "conventional" composition is about 1.07×10^5 Bq (Bequerel = disintegrations per second). DU also contains traces of ^{234}Th, ^{234}Pa and ^{231}Th (which derives from the decay of U^{235}). For this reason, DU specific activity is higher than theoretic activity, and it amounts to approximately 3.9×10^5 Bq/gram.

For these and other reasons, the Relative Biological Effectiveness factor (or QF, quality factor) of DU-emitted alpha particles is especially high (on certain conditions, thirty times higher than X rays).

Let us move on to the practical situation where inhalation occurs, bearing in mind that our calculation aims solely at establishing the order of magnitude of doses. The impact of DU rounds produces a cloud of debris of various dimensions, following a violent process of combustion at a temperature of approximately 5,000 °C. As noted, radioactive dust consists of particles whose dimension ranges from 0.5 to 5 microns. Between 300 and 1,000 metres from the impact, clouds of a density ranging from 200 to 10^4 particles per cm^3 can be breathed. The mass of such particles ranges from approximately 0.6 to approximately 5 nanograms (6-50 $x10^{-10}$ grams). Within an hour, about 1.7 grams of radioactive dust can be breathed (with winds ☞ $\leq$ 10 knots). If different explosions occur in the surrounding area (at a distance of 3-400 metres) and there is no wind, 9-10 grams of DU can be breathed. Considering physical elimination of waste (via the kidneys etc.) an hour of inhalation entails absorption of a source whose activity ranges from [1.3 – 7.6] x 10^5 Bq. Absorption may even be four times greater, if we consider the effective specific radioactivity of DU and of its daughter elements in a state of equilibrium. If we transform this datum into a “biological” human dose (EDE), whose RBE factor equals 20 multiplied by the alpha particles, other factors should be added, depending on whether calculation is being made for testing the spinal marrow, the lungs etc: the result is a dose ranging from 1.50 to 14 milliSieverts per year, without considering the most massive dust particles (which are approximately 18 times larger)[2].

It should be noted that the dose limit for a population is 1 mSv per year. Apart from numerical considerations, which we will dealt with in more detail by calculation codes, DU can in no way be considered to be a harmless nuclide.

Undoubtedly, if the exposed subjects were breathing the same quantity of Cesium or Iodium or other radionuclides with a shorter half life, the dose would be higher, but there is no point in compiling a “hit parade” of danger from radioactive substances – in such a list, DU would indeed rank among the last. The point is to clarify whether DU exposure is potentially risky, but this has already been ascertained. Therefore, it is incorrect to refer solely to half life and energy/ particle types: for

[2] The human body absorption figures just described refer to subjects who have breathed uranium oxide clouds at the time of bombing, when dust density was greater. However, it is easy to calculate accumulation due to the duration of exposure for people who live or work in bombing sites: these people should have inhaled DU dust distributed over large portions of soil for long periods of time. In such cases, immediate inhalation is obviously less significant than during the bombing, but long-lasting exposure occurs if subjects live or work in areas with large quantities of dust. Consequently, the effects of inhalation accumulate as rapidly as in 3-4 months, with winds ranging between 5 and 10 knots. Obviously, accumulation in the body increases if dampness and rainfall are low. These factors are important to consider, not only for assessing the level of uranium absorption by Italian soldiers, but also for the whole Yugoslavian population, particularly children, who often play with the debris of bombings, or on uneven dust-rich ground.

biological effects to be made clear, it is necessary to consider other (chemical and biological) parameters and processes. Environmental aspects concerning fallout of DU dust and unburnt/ inexploded waste should also be taken into account. In particular, fallout tends to move around as a result of washout, wind and absorption by living beings, especially within the food net[3].

Another important issue concerns "characterisation" of DU, i.e. determination of its effective radioactivity, where a significant contribution is made by small quantities of other radioactive nuclides, such as Actinides. This aspect is important in order to establish the concentration of Plutonium (a highly dangerous nuclide) into DU, in the form of impurity. An ANPA (Italian National Agency for Environmental Protection) report in February 2000 suggested that part of the dose is represented by Plutonium impurities: according to sources from the US Department of Energy (DoE), this part amounts to 14%. However, if we double-check the data on Plutonium (Pu) concentration that the document puts forward, we will find that the estimate is lower by at least one order of magnitude: there must therefore be some contradiction in the data, which can be explained by inferring that the actual Pu concentration must be higher than what is claimed by DoE. DoE had also committed itself to releasing a report on DU characterisation by June 2000, but sources indicate that this report has not yet been published at the time of writing.

It remains unclear whether DU concentration in Yugoslavia is high enough to represent a hazard. We return to this issue when we present an approximate estimate of the numbers of casualties expected from DU use in Yugoslavia.

To support our statements on the dangers of DU, here follows a list of reports issued by prestigious institutes, institutions and organisations, some of which can in no way be accused of being "opposition-based", such as[4]

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[3] All this is obviously referred only to radioactivity damages, but the chemical toxicity of UO_2 and UO_3 is another serious problem to be taken into account. Following the impact, DU becomes oxidised and, by virtue of its being a heavy metal, like lead, it becomes a direct carcinogen.

[4] References to these reports can be found in public documents available at the following Internet addresses:
http://www.ucsusa.org/
http://www.iacenter.org/
http://www.ippnw.org/
http://www.ccnr.org/
http://www.nrc.gov/NRC/
http://www.nrc.gov/NRC/EDUCATE/REACTOR/09/index.html
http://www.triumf.ca/safety/rpt/rpt_4/node1.html
http://www.va.gov/pubaff/gulfvets.htm
http://www.defenselink.mil/news/fact_sheets/f941221_clineval.html
http://www.orcbs.msu.edu/
http://www.orcbs.msu.edu/chemical/chp/toc-2.html
http://www.orcbs.msu.edu/radiation/radmanual.html/radman96toc.html

- Several institutes based in the Department of Defense and the US Army.
- International Physicians for the Prevention of Nuclear War (Cambridge, USA)
- International Action Center (San Francisco, Cal.)
- Union of Concerned Scientists (Cambridge, USA)
- Canadian Coalition for Nuclear Responsibility
- Sources from: Office of Radiation, Chemical & Biological Safety, Michigan State University, USA
- Gulf War Veterans

2) DU HAS NOTORIOUSLY BEEN USED IN WARS FOR TEN YEARS, DESPITE INTERNATIONAL REGULATIONS PROHIBITING ITS USE.

Thesis: Italian political and military authorities could not be uninformed of the dangers of DU and of its use in wars of the last decade. It is incorrect to say that DU weapons are not forbidden at the international level.

Let us start from the latter point: the problem of depleted uranium weapons has been discussed by the UN[5]. During its 48th session held on August 8, 1996, the Sub-Commission on Prevention of Discrimination and Protection of Minorities adopted a Resolution stating that: "the production, sale and use of such weapons are incompatible with international human rights and humanitarian law" and that there is a "need for their complete elimination". "All States [should] be guided in their national policies by the need to curb the production and the spread of weapons of mass destruction or with indiscriminate effect, in particular nuclear weapons, chemical weapons, fuel-air bombs, napalm, cluster bombs, biological weaponry and weaponry containing depleted uranium".

Evidence of DU dangers has been available to the public and to the armed forces for over 20 years: following are some quotations from several US and military sources.

In a 1979 report, the US Army Mobility Equipment Research & Development Command stated that the use of depleted uranium rounds was dangerous "not only to people in the immediate vicinity, but also to people living downwind ... Particles ... are quickly deposited in pulmonary tissues exposing the host to an increasingly toxic dose of alpha radiation, capable of provoking cancer and other lethal illnesses". Needless to say, this source does not come from advocates of a ban on DU ammunitions.

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[5] UN Press Release HR/CN/755, September, 4 1996. Available at: http://www.unhchr.ch/Huridocda/Huridoca.nsf/0811fcbd0b9f6bd58025667300306dea/887c730868a70a758025665700548a00

US governmental sources concerning precautions to be adopted in the event of DU impact are far from scanty. Another report by Los Alamos National Laboratories[6] states that "the Yuma and Aberdeen launching sites where DU bombs [were] tested" – between the 70s and the 80s – "will not be suitable for human dwelling without previous decontamination" (at this point, it seems reasonable to ask what justification may be offered for letting soldiers stay in DU-contaminated sites for long periods of time, not to mention the fate of civilians living in those areas).

The Bethesda (Maryland) Armed Forces Radiobiology Research Institute published a study entitled "Health Effects of Depleted Uranium"[7] whose conclusions highlight DU carcinogenicity/ mutagenicity and call for more studies in this respect.

In 1987, the US Army published instructions for handling DU weapons and contaminated vehicles. In July 1990, a US "Science Application International Corporation" report compiled for the Army stated that long-term effects of low-dose DU exposure included cancer, kidney disorders and congenital defects. As of 1990, the US army has published a bulletin (*Department of the US Army Technical Bulletin - Guidelines for safe response to handling, storage and transportation accidents involving army tank munitions or armour which contain depleted uranium*) informing military personnel of the dangers they run when they handle DU.

During the 1991 Gulf War, use of DU weapons was so well-known and massive that there is no need to review the record. After insurgence of the Gulf Syndrome, the Gulf War Veterans association has requested and obtained investigations on DU, such as a 1995-1996 "Presidential Advisory Committee on Gulf War Veterans' Illnesses Final Report" written by a US Presidential Committee. We return to the Gulf Syndrome and Balkans Syndrome.

Use of DU weapons during the UN/ NATO bombing of Bosnia in 1995 is also well-known and publicly recognised by US Department of Defense (DoD) in a recent interview[8]. The Italian soldiers who have got leukaemia served in Bosnia, where bombings took place between the end of August and the beginning of September 1995. More than 10,000 DU rounds were fired by A-10 fighters.

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[6] M. H. Ebinger et al. "Long-Term Fate Of Depleted Uranium At Aberdeen And Yuma Proving Grounds Final Report, Phase I: Geochemical Transport And Modeling", LA-117 90-MS, DE90 012660 (1990), Los Alamos National Laboratory, New Mexico 87545, USA

[7] http://www.ngwrc.org/dulink/afrri_briefing.htm

[8] http://www.defenselink.mil/newsjan2001/t01042001_t0104asd.html

Regarding Bosnia, it should be highlighted that military authorities have not yet admitted to the use and presence of DU in Tomahawk cruise missiles. It does not seems excessive to infer that significant quantities of DU should be present in these ordnances, both to increase shock power, and to stabilise the cruise. Estimates of DU levels in Tomahawks range between 20 and 100 kgs of DU: if confirmed, these figures will determine a dramatic increase in the currently available counts of the DU rounds launched in Bosnia[9].

Unsurprisingly, in press conferences, official spokespeople from DoD or other institutions deny things that are actually implicit in their own institutions' official reports on DU dangers. An illustration is offered by an AEPI (Army Environmental Policy Institute) report commissioned by the US Congress. The report states that DU risks are chemical as well as biological[10].

There are large quantities of documents on DU use and dangers: we deliberately skip non-US and non-military documents, not because we consider them unfounded, but because we intend to dispel the idea that data might be biased. Non-specialist books denouncing DU include *The Metal of Dishonor* (by Helen Aldicott, International Action Centre), published in New York and now widely available in Italian as well.

At this point, it would be rather curious to discover that the Italian army and government were uninformed of the use of DU weapons and of its dangers.

Moreover, US radiation protection legislation is not tolerant of the use of uranium and production of these weapons: in 1980, the National Lead Industries, in the State of New York, folded because their releases exceeded the limits imposed by law and caused excessive air contamination. The emission amounted to just 5.5 MBq per month, i.e. 375 grams of DU: transferred to the warfare arena, this figure equals just about one of the 31,000 rounds that NATO admittedly fired in Kosovo.

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[9] Regarding cruise missiles, NATO-supplied "maps" (which include only Kosovo and the surrounding areas attacked by A-10 fighters) withdraw information whether and to what extent cruise missiles have been used against Serbia. This, together with NATO's admission to having "lost count", cast a shadow of doubt over NATO's admission to having fired 31,000 rounds.

[10] "Medical And Environmental Consequences Of Depleted Uranium Use In The U.S. Army: Technical Report", U.S. Army Environmental Policy Institute, June 1995, available at: http://www.fas.org/man/dod-101/sys/land/docs/tecreport.html. An analysis of this report is offered by D.Bernstein's article, "Pentagon Document scores risks of DU used in Gulf War and Bosnia", Pacific News Service, http://flashpoints.net/pentagondocjinn.html.

Italian legislation[11] also mentions DU as a radioactive nuclide, despite its “weak radiotoxicity”. It is now commonly recognised that the relevant parameters are quantity, concentration, mode and duration of exposure. In particular, Italian legislation specifies that presence of U^{238} is subject to the law (i.e. cannot be ignored) when its total radioactivity exceeds 10^4 Bq and its specific activity exceeds 1 Bq/ gram. Given that DU specific activity is 3.9 x 10^5 Bq/ gr, a fraction of a gram of DU is enough to fall within the scope of the Italian radiation protection law. A tiny chip of a single DU round would therefore be enough.

3) DU RISKS IN THE BALKANS.

Thesis: we can reasonably expect Italian soldiers and the civilian population to develop tumours caused by DU.

In the 90s, about 90,000 cases of Gulf Syndrome have been reported by US servicemen. 60.000 have been taken into consideration by the US government and 28,000 veterans receive some governmental “disability benefits”. Similar cases have been reported by British soldiers. However, it is not realistic to attribute the Gulf Syndrome to DU only. In fact, the syndrome should result from a series of concomitant causes:

- chemical and/ or biological pollution caused by bombing the enemy’s industrial plants
- use of DU weapons
- stress, eating disorders

In addition: injections into soldiers of vaccines and experimental antidotes to chemical and biological weapons; likely use of chemical weapons, antimalaria drugs distributed among the troops; smoke from the bombing of oil wells; massive use of pesticides in the desert; bacteria and microbes typical of the desert and contained in local foodstuffs.

We have deliberately separated the first three concomitant causes from the others: the first causes are in fact in common with an analogous “Balkans Syndrome” which is appearing among Italian troops and may well cause more fatalities in the future.

[11] DL 17 Marzo 1995, n. 230 (Legislative decree, March 17 1995, no. 230), published in Supplemento Ordinario alla GU n. 136 del 13 Giugno 1995, Serie Generale (Ordinary Supplement of the Italian Official Journal, no. 136, June 13, 1995, General series), with subsequent integrations introduced by Decreti Legislativi 27/5/2000 (Legislative decrees, May 27, 2000) for implementation of directives 96/29/EURATOM and 97/43/EURATOM.

We return to the chemical pollution of the NATO bombing, simply noting here that the combined effects of contaminants will highlight the paramountcy of different factors in different areas. This in turn will allow us to observe – possibly only when effects are patent – variations in the epidemiological situation, depending on which type of contamination has taken place.

Concerning DU risks in the Balkans, we report an estimate based on the figures illustrated by Carlo Pona in his article "Rischi legati all'impiego bellico dell'Uranio impoverito" (The risks of DU for military purposes), in the book *Contro le nuove guerre*, Odradek: Rome, Oct. 2000 (*Against New Wars*, not yet translated into English), also available in the proceedings of the conference "Cultura Scienza e Informazione contro le nuove guerre" (Culture, Science and Information against New Wars), organised at the Polytechnic of Turin in June 2000 by the Anti-War Network of Italian Scientists. See another article in the same volume: Giannardi, C. & D. Dominici, "Esposizione della popolazione da uso dell'uranio impoverito" (A study of population exposed to depleted uranium).

The following dosimetric estimate is based on a code of calculation specially developed by Argonne National Laboratory, USA [12].

Calculation concerning DU exposure and contamination is based on three hypotheses: for each attack, 10 kgs of DU rounds were used, and each of these 10 kilograms have been transformed into aerosol and dust, evenly distributed over a surface of 1,000 m². The mass of all these DU rounds corresponds to a volley of 33 antitank projectiles cal. 30 mms: the numbers are perfectly acceptable if the aim is, for example, to destroy a tank, as not all the rounds will hit the target.

These are the premises from which doses absorbed by adults have been calculated: they should be considered to apply to subjects in the vicinity of a bombarded target as well as to subjects who were exposed to fallout, to DU dust suspended in the air, or through the food chain. However, these are conservative estimates: according to official data supplied by NATO itself, such a situation may have taken place about 1,000/ 1,500 times during the aggression. According to Yugoslavian sources, the correct number is twice as much.

The circumstances under analysis are

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[12] RESRAD. Code of calculation was elaborated by US Department of Energy (DOE) in accordance with guidelines for the implementing of residual radioactive material. It was developed at the Environmental Assessment Division of Argonne National Laboratory. Methods are described in: *Manual for Implementing Residual Radioactive Material Guidelines.* Supplement of *US-DOE Guidelines for Residual Radioactive Material.*

(For more information, see the article):

1. immediate inhalation of uranium aerosol during attack
2. inhalation of suspended particles, caused by a long stay in contaminated sites
3. ingestion of vegetables immediately after attack
4. external exposure to contaminated soil
5. contamination through ingestion of DU-contaminated foodstuffs

We believe the most remarkable problem is not the dose absorbed by individuals, but the dose administered to the population as a whole. For an estimate of collective dose, data for each individual should be multiplied by the number of individuals exposed[13]. According to the estimate made by the International Commission for Radiological Protection (ICRP), we can expect cancer rates to grow by 1 new case per 50 men-Sieverts (although this is probably an optimistic assumption, underestimating the actual risk[14]).

The effects of inhalation and ingestion, immediate and delayed alike, seem to be the worst. The following chart summarises the findings of various contributions to the issue:

Overall radiological impact			
Hypothesis: 10 kgs of DU released during attack. Concerned area: 1,000 m². Soil density 1.5 kg/ dm^3			
		? Sv/ year	? Sv (non-recurring exposure)
External exposition	Surface	1,450	
Inhalation	Immediate: 1 min		22,600
	Short stay		0.14/ 14
	Long stay	42/ 4,200	

[13] Collective effective dose results from the multiplication of individually-absorbed dose by the number of individuals exposed. It is calculated in men-Sieverts.

[14] The correlation ICRP made between dose and biological effect (tumour) is based on studies on Hiroshima survivors. In the 70s, Rotblat made an important point: the population under analysis (subjects who had entered the city in the few days immediately after the atomic explosion) may have been unrepresentative, as they had somehow been “selected” (in the Darwinian sense) by long years of warfare. The other data offered by scientific literature (e.g. data on miners, or other occupationally exposed) are almost always referred to adults, often under medical supervision. In the 80s, ICRP therefore started revising its risk estimates: revision led to a decrease in admissible doses. In the case of Kosovo, the population is still under stress from their exodus and return, but thanks to refugee camps and humanitarian aids, they have not undergone any selection of the weakest. The risk for these people is likely to be proportionally higher.

Ingestion	1 gr of soil		3.35
	Drinkable water (3 l/ gr)	900	
	Food: short term		43
	Food: long term	70	
	Partial result	2,500/ 6,700	22,600 + 45/ 60
	Result (1st year)	2,600/ 6,800 + 22,600 (non-recurring)	

For the sake of prudence, annual results consider non-recurring exposure, which is far from insignificant on the population as a whole. Therefore, the annual dose per person should be close to the maximum values presented in this estimate, i.e. about 5-6 mSv per year.

On a sample of 8,000 to 10,000 subjects a year, this entails one case of cancer more than what is reported of a (non-irradiated) control group. Applied to a population of two million, this amounts to 200- 250 additional cancer cases a year.

As for military personnel, the situation becomes more complicated, because of their different "social and living" habits as compared to civilians. Soldiers have more occasions and modes of exposure. Let us just consider the position of helicopter pilots as regards dust inhalation, for instance. Or, for that matter, builders of military installations, not to mention soldiers who clear battlefields. The greatest risk should apply to "mine clearing" specialists. Moreover, activities of military personnel involved in peacekeeping – rather than in direct warfare – are typically performed in sites where contaminating weapons are more likely to have been used.

Far from being immoderate, it is prudential to suppose (until more precise estimates appear) that military personnel exposure could prove two or threefold as compared to the estimate presented in the above chart. Cancer rates may therefore increase by one case per 2,000 / 5,000 subjects a year. Considering 40,000 Italian soldiers serving in Yugoslavia, we could therefore expect 10 to 20 cases a year to occur in addition to what is normally expected.

It should be noted that, over a population of 40,000 young and healthy subjects (aged 25 on average), annual incidence of leukaemia is low[15] (less than one case): as a consequence, all the cases reported in the last few days should be regarded as being "exceptional", even though, in the absence of direct evidence, they cannot be attributed to any particular carcinogen.

In any case, our estimate has been made with the best available information. Our data are consistent with recently reported pathologies, and they will be updated and improved as soon as reliable experimental findings on local contamination levels are made public.

During the Kosovo war, an NGO called Landau Network, based in the Italian town of Como, scientifically predicted the consequences that would arise within a few a years. Their study, which had been requested by the Italian Foreign Ministry during the war, highlighted the radiological risks of DU use for military purposes. When it was finished, in June 1999, findings were transmitted to the Italian Senate Committee for Foreign Affairs. In November 1999, Prof. Predrag Polic from Belgrade came to Italy with samples of topsoil which were analysed in the Bologna ENEA laboratories under the supervision of Dr. Paolo Bartolomei. One sample was found highly radioactive, about one hundred times more than normal. Subsequently, questions were raised in Parliament by Senators Tana de Zulueta and Giangiacomo Migone. In March, another question was raised about the inhumanity of these weapons.[16] In March 2000, this study was presented in a lecture held before the Italian Senate. It is therefore impossible that the Italian government could be unaware of these facts.

Last year, the Federal Republic of Yugoslavia, through its Ministry of Development, Science and Environment published a detailed report[17] on the environmental effects of the NATO bombing. One chapter in the report is on depleted uranium. The DU load deposited is estimated at 50,000 rounds, i.e. about 15 tons, an estimate higher than NATO's. For the sake of prudence, we refer to NATO's figures (31,000 rounds) in this article.

Soil contamination has been proved by gamma spectrometry at the Nuclear Science Institute of Vinca, near Belgrade, and the data include samples of soil with DU concentration up to 235 kBq/ kg. It appears that DU-bombed areas have already been located and fenced off to stop access until the area is decontaminated by removal of topsoil and subsequent disposal in waste dumps. Tomahawk missiles are not mentioned, whereas according to direct sources, these missiles have been used in the vicinity of Belgrade (Rakovica air station) and Novi Sad.

[15] ISTAT (National Statistics Institute), Indicatori socio sanitari nelle regioni italiane (Social and Medical Indicators for Italian Regions), http://www.istat.it/Primpag/sanita/indice.html (in Italian).

[16] Article, *Il Manifesto*, January 4, 2001

[17] Izvestaj SRJ: *Posledice: NATO Bombardovanja za Zivotnu Sredinu SR Jugoslavje.* April 2000.

4) ASSESSMENT OF DU POLLUTION.

Thesis: we show that the presence of DU is difficult to determine experimentally

Experimental assessment of DU pollution in Yugoslavia is still an open issue. However, we believe that some facts should have been ascertained immediately after the war.

U^{238} in DU is notoriously difficult to detect, because of its tendency to mix with natural uranium – unless one manages to calculate its isotopic ratios with decay radionuclides of the Thorium series for each type of soil involved. When DU does not derive from primary enriching processes, but from fuel reprocessing in plants, then[18] it combines with $Plutonium^{239}$. However, in the concentration under examination, this is also difficult to detect. But it remains possible to test environmental samples for the presence of U^{236}, as U^{236} is only found in reprocessing of exhausted nuclear fuel, and it therefore indicates the presence of Plutonium.

Moreover, the metal micronisation film found on bodies and soil after the metal has burnt, is so small that it is difficult, but not impossible, to determine the presence of DU by means of gamma spectrometry. With its 0.048 MeV, U^{238} is a low-energy emitter: therefore, in order to gather data on it, it seems necessary to perform radiochemical observations, in addition to an initial gamma-ray screening.

It would help to record mechanisms of reconcentration in environmental or biological mediums, i.e. sites in the ecosystem where DU accumulates. One such physical mechanism is reconcentration for atmospheric causes, such as drain-out, whereas bioconcentration entails the presence of bioaccumulators, which do not seem to be highly likely in the case of Uranium.[19]

The problem is further complicated by the effects of dilution and wash-out, which tend to bring the metal underground and disperse it: therefore, surveys made today may have more difficulty detecting this contaminant. In addition, since June 1999 (when the Italians entered Pec), there have been 5 months of war disinformation: in fact, information on DU and basic precautions to be taken when working with radioactive material were withdrawn from soldiers (the NATO "Multinational Brigade West", guided by the Italian Army Biological and Chemical Nuclear Unit actually issued a dispatch on DU as late

[18] Carlo Pona, op. cit. (*Contro le nuove guerre*) page 106.
[19] See the review presented in Ribera D., Et Al., "Uranium In The Environment: Occurrence, Transfer And Biological Effects". Rev. Environ. Contam. Toxicol, 146: 53-89 (1996).

as Nov. 22, 1999). Military personnel have thus been unwittingly engaged in removing evidence – however scant and contaminated – of the attack (i.e. corpses; wrecks, unexploded rounds etc.). In fact, some evidence may well be found in the soldiers' lungs, kidneys, bones or genes, whereas soil and water investigation would certainly elicit less data. The only thing left to do now is use the information supplied by the Pentagon, or surveys by Yugoslavian scientists.

The most important factor involved in DU "removal", connected with exposure of local population, is the fact that local civilians have often picked up contaminated material from battlefields and sold it, believing it was iron[20]. These are the most seriously exposed people. The main reason why uranium is found in small quantities on bombing sites lies precisely in this aberrant clearing. These people represent the "critical group" on which medical attention should focus, together with children who picked up pieces of DU-contaminated wrecks or still play in grounds littered with pieces of DU rounds.

To conclude, we mention a research project based on biological effects and bioindicators (M. Cristaldi, "Reti di biomonitoraggio per valutazioni preventive di rischio territoriale" [Biomonitoring network for a preventive assessment of risk in concerned areas] in *Contro le nuove guerre*, op. cit). Indicators to be tested are among the most widely spread (e.g. rodents), and the aim is to determine DU effects and biological risk in critical areas (e.g. the most populated ones). We believe that this research project should be put into practice, as it would elicit data for more accurate estimates, to be added to data provided by other projects already under way. Findings should allow us to fence off all risk areas as well as to implement preventive measures in favour of groups effectively or potentially exposed to DU.

In addition to the specific considerations on DU that we have dealt with in the first part of this paper, we deem it necessary to discuss two points that broaden the perspective of the "DU problem in the Balkans".

A. DU IS ONLY THE TIP OF AN ICEBERG AS REGARDS THE CONSEQUENCES OF A HUGE "CHEMICAL WAR"
B. THOUSANDS OF NEW CANCER CASES HAVE ALREADY BEEN CAUSED BY WARS IN YUGOSLAVIA

It is thus impossible to keep silent in front of the upsetting scenario that the DU issue should in fact contribute to bring back to the fore.

A. DU IS THE TIP OF AN ICEBERG AS REGARDS THE CONSEQUENCES OF A HUGE "CHEMICAL WAR"

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[20] Article. K.Gustunicic, *Limes*, Sept. 1999. http://www.limes.net

It is important to point out that the DU issue is no more than the tip of an iceberg ad regards the consequences of a chemical, radiological and environmentally destructive war (which can be summarised in a single phrase as "CARCINOGENIC WAR") conducted by NATO against Yugoslavia and the entire environment in the Balkans. We refer to the articles by Ivan Grzetic, a Yugoslavian scientist, in the book *Contro le nuove guerre*, and to Knut Krusewitz's remarks[21]. These and other sources offer more precise and detailed data. In the "Kosovo war" alone, NATO dissipated the equivalent of 7% of the annual global production of oil. The Alliance bombed and destroyed 16 large refineries and chemical plants, 39 power plants, 77 industrial plants, and subsequently released in the environment thousands of tons of: mercury and its compounds; dioxin; ammonia; vinyl chloride monomer; dichloroethane, toluene diisocyanate, heavy metals, PCB, polycyclical aromatic hydrocarbons, ethylene chloride, phosgene etc. All these chemical compounds, without exception, are carcinogenic. One can imagine the consequences of bombing the Pancevo and Novi Sad refineries, not to mention the devastation of the entire Danube basin, inside and outside the Yugoslavian territory.

It is therefore unsurprising to see – now as well as in the future – new cases of cancer arise among military personnel, civilians, volunteers and population who have lived or still live in Yugoslavia. The additional protocol of the 1977 Geneva Convention ratified after the civilian consequences of US chemical bombings in Vietnam, has been violated. The protocol provided that serious, extended and long-lasting damage – including unintentional damage – inflicted on the civilian population must be considered as "war crimes". A judgement recently given by the Hague Tribunal may also be in contradiction with the Geneva protocol: the Court actually refused to recognise the disproportionate character of damage inflicted on civilians by the bombing of military targets, including the case of Pancevo, where toxicity has reached peaks 10,000 times higher than allowed limits.

Today, however, consequences of the war are hitting the Allied armed forces: except, of course, those who, like the US and Britain, limited themselves to bombing harmless people from on high. A month ago, the Environmental Committee of the European Council declared that NATO's bombing had "overlooked" international law, especially because of its use of DU weapons and its release of poisonous substances into the Danube after the chemical plants went on fire. Such environmental damage had been predicted. It has been obvious since the beginning of intervention, and it can therefore be considered to be intentional. It is against this background that one of the most popular Portuguese newspapers demanded that Solana be indicted for war crimes. However, the most serious health hazard caused by the bombing will appear within several years: the same delay in the emergence of consequences has been observed in Porto Marghera, an industrial centre near Venice

[21] Berlin Technische Hochschule Report; Article *Il Manifesto*, Jan 4, 2000.

where pollution has been the order of the day for many years: only now, after cancer cases emerged, can judges talk about veritable massacres due to toxic releases, although these are far lower than those reported two years ago along the Danube.

A. THOUSANDS OF NEW CANCER CASES HAVE ALREADY BEEN CAUSED BY WARS IN YUGOSLAVIA

Making an estimate of the effects of DU on military personnel is certainly difficult, but looking at the first evidence about Yugoslavian civilians is not. In Pancevo, for example, annual cancer rates were already high before the bombing of the chemical plants: but the figure rose from 2,000 to around 10,000 (an estimate made by the Mayor and by the Councillor responsible for environmental issues in the 12 months following the attack[22]).

Yugoslavian epidemiological data show that chemical pollution should be regarded as an important concomitant cause of most new tumours among subjects living in Yugoslavia during or after the wars: in fact, all these cancer cases cannot be explained by DU alone. This consideration is not fundamental in itself, but it is important in order to point out that the DU problem should not overshadow other war crimes committed by NATO (e.g. the bombing of a chemical plant upwind of a town). On the contrary, DU should represent a moral milestone to gauge the reasons for these crimes, which aim at destabilising entire geopolitical areas.

Attention to these issues has been awakened by the illness and death of a number of Italian soldiers. However, we cannot suppress our indignation at the silence in recent months over the fact that people in Yugoslavia have been dying of cancer and birth defects: this has happened to thousands of people more than before the war, not to mention thousands of fatalities during the conflict.

If this kind of damage is being inflicted on foreign soldiers, who benefit from privileges in terms of health service and quality of living, what of the populations living in the area for the last ten years, after the Bosnian war, in the almost unbearable situations brought about by after-war poverty and embargo? But the scenario is even more upsetting: figures of the cancer rate increase are as steep in Pancevo as in Yugoslavian cities that have not been the specific target of a chemical war (e.g. Cacak). Therefore, chemical/ environmental causes must not be enough to explain the situation. For instance, this dramatic increase may indicate a drop in immune defences: plausible reasons include the stress induced by the intensity and type of bombing, regardless of the material of which bombs were made. It should also be noted that depression has

[22] Article: in *Rinascita*, II, no. 50, pages 16-17 (Dec. 22, 2000).

increased dramatically in Belgrade and in the most heavily bombed cities (see M. Saric Tanaskovic in *Contro le nuove guerre*).

On many occasions, the most dramatic data have not come from Yugoslavian authorities, but from independent institutes that are often underfinanced (e.g. the German Dessau-based Ekocontrol o the University of Thrace, in Greece), or from appendixes attached to official reports of the United Nations (UNEP-Balkans Task Force). This UN report actually unveils extremely interesting details, although the first UNEP mission had been decided during the war to “avoid speculations on the effects of NATO’s intervention”. UNEP did not actually arrive at demonstrating that the war caused an environmental catastrophe, but it reported on the catastrophic environmental conditions in Pancevo and Novi Sad.

This highlights an uncommonly evil and unaware complicity between victims and executioners: the result is concealment of important evidence of environmental war crimes against present and future generations, who seem to be destined to suffer from genetic alterations still difficult to determine.

NATO is not alone in concealing evidence of its own actions from its own allies – as we have seen in recent days. Yugoslavian institutions – as well as authorities from nearby countries subordinated to NATO – often show signs of recalcitrance over denouncing syndromes that their people suffer from because of the war. Reasons of public order have been invoked to prevent evacuation of the Belgrade population when they were threatened by a toxic cloud coming from Pancevo. The same reasons persuaded gynaecologists in cities subject to chemical bombing to informally suggest that women becoming pregnant in the two years following the attack should resort to abortion, due to the risk of conceiving malformed foetuses. The same reasons may cause the Ministry of Environment to disappear from Yugoslavia, possibly to be incorporated into the Ministry of Health. But there are also economic reasons: for example, what do victims get out of reporting a crime? If the crime was reported, in this case, farmers would be forced to stop selling their products: their products may well be polluted, but they remain the farmers’ only source of income. If the crime was reported, workers would never see the rebuilding of their factory: factories along the Danube would no doubt be environmentally unsustainable, but they remain the workers’ only way to make a living. And what of house owners, who would see the value of their assets plummet?

But the first victim of all wars, the truth, comes to the surface, sooner or later. This is why each control commission should be carefully monitored, because controllers should not be uncontrolled. For this reason, it is up to scientists to take the floor and report each of these crimes, even if this may be detrimental to individual interests. Action should be taken for the sake of all living beings, and in unremitting solidarity with future generations.