

## **Depleted Uranium and Health: Facts and Helpful Suggestions**

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A significant development in ballistics has been the DU (depleted uranium) kinetic energy penetrator. It is able to pierce armor, including DU armor that can withstand conventional shelling, and as it slices through hard materials, it heats up and ignites. Burning at high temperatures, it often completely destroys its target, whether an armored tank, a concrete bunker or conventional vehicle. As the nearly pure uranium metal in the penetrator burns, it sends up smoke containing fine particles of uranium oxide aerosol. The smoke particles are extremely small and can be easily inhaled without realizing; most are about 1 micron in diameter (1/1000 of a millimeter), which is not even visible to the naked eye [1].

### **What are uranium oxides and are they dangerous?**

There are 3 major uranium oxides produced by burning, these are  $\text{UO}_3$ ,  $\text{U}_3\text{O}_8$  and  $\text{UO}_2$ , known as uranium trioxide, triuranium octoxide and uranium dioxide, with the latter two predominating. Although uranium is one of the densest metals known, the oxides in the smoke and dust are not so dense and remain suspended in the air for a long time. In fact, particles of DU oxides were detected more than ten miles from a National Lead DU munitions plant in Colonie, NY years ago, causing the State of New York to shut down the plant for excessive release of radioactive materials into the environment [2]. Uranium, in any form, is considered to be a chemical poison as well as a radiation hazard if taken internally, although moderate in comparison to other chemical poisons and radiation hazards.

These oxides dissolve in water (and body fluids) at very different rates.  $\text{UO}_3$  dissolves relatively quickly (hours to days), whereas  $\text{U}_3\text{O}_8$  dissolves more slowly (weeks to months) and  $\text{UO}_2$  dissolves very slowly (months or years) [3]. The rate at which they dissolve depends very much on the size of the particles and the properties of the solvent. Very small particles of  $\text{UO}_2$  (<0.01 micron) seem to dissolve relatively fast and are absorbed from lung as quickly as soluble uranium compounds [4]. Particles of either  $\text{UO}_2$  or  $\text{U}_3\text{O}_8$  with average diameter of 0.5 microns cause much greater lung damage in animals than particles with average diameter of 2.3 microns or larger [5,6]. Larger particles tend to get removed from the lungs in phlegm. There was much greater retention of the uranium in the lungs with the smaller particles, as well as greater kidney damage, indicating more absorption of the uranium into the blood. There have been numerous studies of the effects of inhaled uranium oxide particles on lab animals with their toxicity ranging from negligible to severe. The toxicity depends on many factors, including not only size of the particles, but how the particles were prepared, how they are administered (dry or in a liquid) and many other factors [7].

The effect that DU shells have on their targets lures the curious to see what destruction it can do. Just walking or rummaging around a DU destroyed vehicle long after the dust has settled can resuspend the fine particles of uranium oxide, which may be inhaled or cling to skin and clothing. Inhaling a mixture of the uranium oxides with a wide range of particle sizes in the smoke and dust coming from burning DU penetrators or resuspended dust works like a time release capsule, with the uranium oxides dissolving at different rates and entering the bloodstream over a prolonged time.

### **How toxic is uranium?**

There is continuing debate about how toxic uranium really is. Uranium is not absorbed from the digestive tract very well. Less than 2 percent of uranium oxides taken in by mouth get absorbed and enter the blood, with the bulk of it passing through in the feces [8]. Uranium also doesn't exert its toxic effects immediately like cyanide or strychnine, but instead can take several days, so it may not be noticed for more than a day that poisoning has occurred. An acute nonlethal dose of uranium causes kidney damage within two weeks, which is somewhat reversible, with restoration of most kidney function after several months [9].

Several studies have been done to determine whether high levels of uranium in drinking water have any ill health effects. People drinking well water with high levels of uranium generally don't show any chronic illness, but urinalysis indicates that higher levels of uranium in drinking water results in increased indicators for kidney damage [10-12]. The correlation seems to be linear and indicates that any increase in uranium exposure would result in an increase in the degree of kidney damage, even if it is not sufficient to cause acute toxic effects. It has also been found that exposure to moderate levels of uranium for some time makes the kidney more resistant to a subsequent toxic dose. Perhaps the kidney problems that appear to occur when people are exposed to high levels of uranium for the first time, will gradually return to normal once they are removed from the source of contamination, although it is not possible to say whether recovery would be 100 percent.

### **What is the most likely way to get toxic exposure to uranium?**

The inhalation of DU dust is the most likely route for uranium to enter the body and do serious damage, with the smallest, invisible DU dust particles doing the greatest damage. Consequently, you may not realize that you are even getting inhalation exposure. As these dust particles slowly dissolve in the lungs and the uranium is absorbed into the blood, it gets distributed to all parts of the body [13,14]. Most health professionals looking for uranium poisoning will focus on the kidney because that organ is the most vulnerable and kidney malfunction can be easily diagnosed by analyzing urine for specific clinical parameters, such as alkaline phosphatase or beta-microglobulin. However, when constant low doses of uranium are being absorbed, as they would be from DU dust particles in the lungs, it gets distributed to bone, brain, liver, lymph, spleen, testes and other organs. Once deposited in these tissues, there are several things that can happen.

### **What health effects result from exposure to uranium oxides?**

Uranium dust may do permanent damage to the lungs resulting in chronic respiratory problems [15,16]. Uranium exposure also affects neurological function. Rats exposed to uranium had impaired nerve cell function [17, 18] and 1991 Gulf War veterans who were excreting high levels of uranium in their urine showed some impairment in cognitive function [19]. Uranium exposure can have a wide range of health effects that may also include skin rashes, headaches, blurred vision, sensitivity to light and sound, localized numbness and urinary symptoms, such as kidney stones, increased urine volume and blood in the urine.

Researchers at the Armed Forces Radiobiology Research Institute (AFRRI) in Bethesda, MD and others have found that uranium causes mutations in DNA [20, 21] and uranium exposure can result in increased chromosomal aberrations [22-26]. It is a widely accepted principle in molecular biology that agents that cause mutations or damage DNA can cause

cancer. Mutations in the DNA of germ cells (in the testes and ovaries) may lead to birth defects or miscarriage. It is plausible that uranium exposure in a man could lead to increased risk of birth defects in his children conceived after the exposure [27].

### **Does exposure to uranium cause people to get cancer?**

Studies at the Armed Forces Radiobiology Research Institute showed that human cells grown in culture dishes could be transformed into cancerous cells when exposed to uranium [28]. Researchers in Albuquerque, NM implanted DU metal into the muscle of rats (a model for shrapnel wounds), causing 18% to develop sarcomas (cancerous tumors around the implant site) [29]. Epidemiologic studies found modest increases in certain types of cancers in uranium workers, including cancers of the lung, lymph nodes, kidney and brain [30-33].

The uranium processing and milling industries had stringent safeguards built in when they were developing because uranium was known to be toxic. Workers were closely monitored with radiation badges and frequent urine tests, and if exposed to too much radiation, were removed from the high exposure risk areas until their exposure level dropped below the acceptable limits for a given time period. Consequently, the increased risk of cancers in this industry is not large, but is significant. The latency period, or time between exposure to a carcinogen and development of cancer can be many years (often 5 to 20 or more years for heavy metal carcinogens).

### **What are practical protective measures for exposed individuals?**

During the Manhattan Project to develop the atomic bomb in the early 1940s, many scientists investigated the toxic properties of uranium. They found that uranium oxides stick very well to cotton cloth, but did not wash out with soap or laundry detergent [34]. The uranium would wash out with a 2% solution of sodium bicarbonate (baking soda). Clothing can become contaminated with DU dust and normal laundering will not remove it. Those at risk of DU dust exposure should have their clothing washed with baking soda (about 6 ounces of baking soda in 2 gallons of water).

Other studies done in the 1940s found that some uranium compounds could be absorbed through the skin (of lab animals) [34]. More recent studies done in the late 1980s and 1990s found that even relatively insoluble uranium oxide could damage skin cells when applied daily for a month, resulting in the skin becoming thinner and more permeable [35]. If the uranium oxides dissolve, they are more easily absorbed [36, 37], and certain oils and lotions may cause the uranium to be absorbed through the skin more quickly. Some uranium oxides can dissolve in sweat, making it easier for them to be absorbed. If clothing is highly contaminated with DU dust, and if it remains in contact with sweaty skin for long periods of time, there could be significant amounts dissolved and absorbed through the skin. Therefore, it is important to get the clothing clean and free of uranium contamination.

### **Is there any antidote if uranium exposure is suspected?**

It was found that giving animals sodium citrate protected them from an otherwise lethal toxic dose of uranium [38-40]. Sodium citrate is a neutralized form of citric acid. The sodium citrate caused the animals to excrete uranium faster, resulting in less uranium being deposited in the body. Would this help to protect people who have had toxic exposure to uranium? It was not tested in humans, but it would probably offer some protection. Citric acid is a natural component

of citrus fruits and juices. The food industry adds citric acid and sodium citrate to many different foods, especially beverages, although citrus fruits and juices provide the greatest amount of citric acid or citrate. Carbonated sodas have very little citric acid. If one suspects or anticipates DU exposure, it may be wise to consume fruits and drinks that contain citrates or citric acid, which also lowers the risk of developing kidney stones.

Other substances, known as chelating agents, that could be used for chelation therapy in case of uranium poisoning, haven't been studied extensively and clinical trials have not been performed to see if they are suitable for human use. Some of these chelating agents can be toxic themselves and would have to be administered under a doctor's supervision. It would seem that consuming citric acid and citrates, which are already found in fruits and beverages would be the safest and simplest approach if uranium poisoning is suspected. Most commercial beverages have less citric acid than citrus juices and large amounts of added sugar, which may make them less desirable because of the calories from sugar.

### **What fruits or beverages have the most citric acid?**

Citrus fruits have the greatest amounts of citric acid. Lemon, lime and grapefruit (and their juices) are the richest sources of citric acid, with oranges, orange juice and similar fruits providing relatively large amounts [41]. Squeezing a lemon or lime into water or other drinks will also provide a good amount. Although commercial soft drinks add citric acid or sodium citrate, the amounts are generally less than in the natural juices. Commercial lemonade, orange juice from concentrate and cranberry juice are also reasonably good sources.

### **Conclusions**

It is best to avoid exposure to DU dust by staying away from vehicles or buildings destroyed by DU. If you are in an area where there may be DU dust, avoid breathing the dust. Breathing through several layers of clean (uncontaminated) cotton cloth may help, if a protective mask is not available. Clean any clothing that may have been contaminated by washing with baking soda. Absorption of uranium oxides through the skin may be slow, but it would be wise to not have uranium oxides on clothing and in constant contact with the skin over long periods of time. Try to eat citrus fruits and drink citrus juices or beverages with citric acid or citrates in them to help minimize the toxic effect of this heavy metal poison. Citric acid has the added benefit of helping to prevent kidney stone formation.

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[41] The author has analyzed of more than 40 different drinks, including fresh citrus fruit juices for their citric acid content. The author thanks Ms. Aviva Nussbaum for her technical assistance in the analyses. Data is also available in: *Documenta Geigy: Scientific Tables*, 5<sup>th</sup> Ed., Geigy Pharmaceuticals, New York, 1959, pp.230-233 and in later editions.