Hazards of Uranium

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1. Basics about Uranium

Uranium (U) is a natural, radioactive and chemo toxic heavy metal, which is found in traces in rocks, soils, plants and water (Merkel et al. 2008 – see references section at the end of this paper). Unavoidably taken up with solid and liquid food, uranium is a potential health risk and may affects all forms of life due to the impact of radiation from uranium isotopes and its decay elements, and the toxicity of uranium as a heavy metal (UBA 2005, Schnug et al. 2008, Coetzee 2008).

Uranium was first discovered in 1789 by Martin Heinrich Klaproth, who was a leading German chemist at that time. Almost 100 years later, Antoine Henri Becquerel discovered the radioactivity of uranium salts. In Paris in 1898 Marie Curie extracted for the first time 0.1 gramme radium from 1000 kg of uranium ore. She died of leukaemia in the age of 67 on 4th of July, 1934.

Uranium deposits were intensely mined after the German physicists Otto Hahn, Fritz Straßmann and Lise Meitner showed in 1932 in Berlin that uranium is fissionable and thus can be used to produce energy. Uranium is the fuel for nuclear reactors and a main raw material for nuclear weapons.

Since 1985, radioactive contamination of food has been measured in Becquerels (Bq)[2]. When the risk of ionizing radiation to humans is discussed, the calculated unit Sievert (Sv) is used to describe radiation doses[3]. Uranium concentration in water is usually expressed in the mass unit microgramme per litre (µg/l) or parts per billion (ppb), and uranium concentration in soils in milligramme per kilogramme (mg/kg).

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[2] 1 Bq is defined as the activity of a quantity of radioactive material in which one nucleus decays per second.

[3] Sievert is an arithmetic unit of radiation dose. It attempts to reflect the biological effects of radiation by weighting factors for tissue or organs. These factors are selected for the type and energy of the radiation which targets the body from the outside or radiates within the body due to incorporated radiation. International bodies like the ICRP or the IAEA, which are part of the industrial nuclear business, set up weighting factors and units for description of radiation effects and natural background levels. Rolf Sievert, a Swedish medical physicist, is known for his work on radiation dosage measurement and research into the biological effects of radiation.

2. U Decay Chain

Natural uranium consists of three isotopes: **U-238, U-235, and U-234.** Isotopes are atoms of the same element with the same number of protons (and hence the same chemical properties), but a different number of neutrons, and thus different atomic weights. Uranium isotopes are radioactive.

The nuclei[4] of radioactive elements are unstable, so that they are transformed into other elements, typically by emitting particles. This process, known as radioactive decay, generally results in the emission of alpha or beta particles from the nucleus. It is often also accompanied by emission of gamma radiation which is electromagnetic radiation (e.g. X-rays). These three kinds of radiation have very different properties but they have in common that they are all ionizing radiation and as such are able to break chemical bonds, damaging or destroying living cells.

Table 1: Some characteristics of uranium isotopes

Isotope	Proportion in natural U (%)	No. of Protons	No. of Neutrons	Half-Life (yr)
U-238	99.284	92	146	4.46 billion
U-235	0.711	92	143	704 million
U-234	0.0055	92	142	245,000

U-238, the most prevalent isotope in uranium ore, has a half-life of about 4.5 billion years – i.e. half the atoms in any sample will decay within this period of time. U-238 decays by alpha emission into Thorium-234, which – in turn – decays by beta emission to Proactinium-234[5], which decays to Uranium-234, and so on. The various decay products, (sometimes referred to as "progeny" or "daughters") form one series starting with Uranium-238. After several more alpha, beta and even gamma decays, the series ends with the stable isotope Lead-206. Radium 226 and Radon 222, which decays to Polonium 218, belong to the variety of daughter elements of uranium.

3. Longevity of Uranium and Decay Products

Uranium and associated decay products such as Thorium-230 and Radium-226 will remain hazardous for thousands of years. They emit radiation energy which is characteristic and defines every radionuclide. The radiation of nuclear conversion consists of charged particles, usually accompanied by electromagnetic waves. Natural uranium is generally at equilibrium. This means: 1 milligrammme of Uranium-238 has an activity of 12.356 Bq (Schmitz-Feuerhake & Körblein 2005).

[4] The nucleus of an atom is the central core that comprises almost all the weight of the atom. All atomic nuclei (except Hydrogen-1, which has a single proton) contain both protons and neutrons.
[5] The isotope Protactinium-234 exists in two different energy states, and it emits gamma rays when undergoing transition to the lower-energy state.

Table 2: Activity of 1 mg of specified substances

1 mg U-238	1 mg U-236	1 mg U-235	1 mg U-234	1 mg Pu-239
12.4 Bq	2,400 Bq	80 Bq	231,000 Bq	2,300,000 Bq

When uranium deposits are mined, the natural situation changes completely and uranium and its decay products become more hazardous to the environment and people due to the radioactive and toxic contamination of air, water, soil and the ingestion and inhalation of uranium and the decay products by humans.

Keeping in mind the long half-life of uranium, governmental regulations like radiation protection laws - if implemented at all - cover only a period of 1,000 years for mill tailings and at most 500 years for “low level “- radioactive waste and therefore are inadequate. This stresses the urgent need for adaptation and update of existing regulations and laws. Otherwise future generations - far beyond the promised protection by regulations - will likely face significant risks from uranium mining, milling, and processing activities (Makhijani 2006).

Uranium is important for nuclear weapons and nuclear power because it is fissionable when bombarded with neutrons whilst releasing energy during this process (artificial nuclear fission). Of the naturally occurring uranium isotopes, only **U-235** can sustain a chain reaction - a reaction in which each fission produces enough neutrons to trigger another fission. Thus the fission process is maintained without any external source of neutrons.

In contrast, **U-238** cannot sustain a chain reaction; however, it can be converted to Plutonium-239, which sustains such a fission process. Plutonium-239, virtually non-existent in nature, was used in the first atomic bomb tested on July 16th 1945 in Hiroshima and the second one dropped on Nagasaki on August 9th 1945.
Since that time, man-made radioactivity has been increasing rapidly on earth. The related risks of mining and processing the natural heavy metal uranium have increased in parallel.

4. Uranium Mining

According to the International Atomic Energy Agency (IAEA) in Vienna, uranium is mined in at least 25 countries, and this figure will likely expand to over 30 countries in the future (IAEA 2008).

Uranium mining and processing poses a tremendous threat to workers and the population in the surrounding areas through the release of radiation and exposure to heavy metals and chemicals (Chareyron 2008, Andrejew 2008, Schmitz-Feuerhake et al. 2008, Brougge 2007, Thomas 2008, Young & Woollard 1980).
Dust and uncontrolled discharges of contaminated water, commonly known as acid mine drainage (AMD), are a major mining related environmental and health problem (Merkel et al. 2002, 2008, Oelofse 2008, Kohrs 2008, Schmidt et al. 2005).

After closure of mines and mills, the radioactive and toxic contamination of the environment will remain and causes costly environmental and socio-economic impacts (Chareyron 2008, Lange 2008, Waggitt 2007, Wade et al. 2008).

Nearly sixty years of uranium mining and milling just in Europe left more than 7,000 legacy sites behind. Among them are 87 tailing sites at 63 different locations, spread over 12 European countries. These cases are officially acknowledged: other uranium contaminated sites are still ignored. Uranium mining legacies are already a heavy burden worldwide.

5. Mining and Processing of Uranium increases Health Risks Dramatically

For the last 100 years it has been well-known that uranium mining causes lung cancer. The German mine workers called it Schneeberger lung disease, but did not know that it was induced by uranium.[6] The disease goes back to the 16th century, when it was first mentioned in literature.

Today kidney diseases and diseases of the respiratory tract are proven uranium effects in humans. Research has defined a causal relationship to uranium mining and milling.
There are also clearly proven uranium effects in humans other than diseases of the respiratory tract (Schmitz-Feuerhake and Bertell 2008):
All solid cancers, benign and unspecified tumors, blood diseases, leukemia, lymphoma[7], multiple myeloma[8], gastric cancer, liver cancer, cancer of the gallbladder and extrahepatic bileducts[9], kidney cancer, mental disorders and birth defects. The early stages of life are known to be most sensitive to radiation (Stewart 1992).

All health effects were found in health studies on uranium miners over the years.

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[6] The Schneeberger lung disease is a form of bronchial or alveolar carcinoma caused by the effects of the radioactive radon gas.
[7] Lymphoma is a type of cancer involving cells of the immune system called lymphocytes.
[8] Multiple myeloma is cancer of plasma cells. These are immune system cells in bone marrow that produces antibodies. Myeloma is regarded as incurable and belongs to the hematological malignancies. These cancers affect blood, bone marrow and lymph nodes.
[9] Extrahepatic bile duct cancer is a rare disease in which malignant (cancer) cells form in the part of bile duct that is outside the liver.

Table 3: Uranium effects in humans other than diseases of the respiratory tract (Schmitz-Feuerhake and Bertell 2008).

Diseases	Collective	Reference
All solid cancers	U- workers	Ritz 1999
Benign and unspecified tumours	U-miners	Roscoe 1997
Blood diseases	U-miners	Roscoe 1997
Leukemia	U-miners Underground miners	Mohner et al. 2006; Rericha et al. 2006; Darby et al. 1995
Lymphoma	U-workers	McGeoghegan et al. 2000
Multiple Myeloma	U-miners	Tomásek et al. 1993
Gastric cancer	Underground miners and Population in U contaminated region	Darby et al. 1995, BEIR IV 1988, Wilkinson 1985
Liver cancer	U-miners Underground miners	Tomásek et al. 1993 Darby et al. 1995
Cancer of the gallbladder and extrahepatic bileducts	U-miners	Tomásek et al. 1993
Kidney cancer	U-workers	Dupree-Ellis et al. 2006
Mental disorders	U-miners	Tomásek 1994
Birth defects	U-miners population in U contaminated region	Müller et al. 1992, Shield et al 1992

Health effects of exposure to uranium can be a result of **chemical and radiological toxicity of uranium.**

Uranium has long been known as a nephrotoxin (poisonous to the kidneys). Uranium targets particularly lungs and kidneys. The most remarkable damage caused by uranium is cancer. Uranium binds to biological molecules and follows calcium in its distribution within the body and thus builds up in bone and teeth. Studies showed that the brain is also a target for uranium toxicity (Royal Society 2001, ENVIRHOM 2005. Notably mammals seem to have a high sensitivity to uranium.

Once uranium is inside the organism, it is transferred to the extracellular fluids and transported through the blood to other organs. Uranyl, the soluble form of uranium, builds complexes with proteins and anions in the organism. Uranium can accumulate in the body and may have synergistic effects with other chemical and radioactive substances.

Uranium weakens the immune system and causes all sorts of health disorders including dermatitis and allergic reactions.

In addition uranium is suspected to be a neurotoxic compound which alters the normal activity of the nervous system in such a way as to cause damage to nervous tissue.[10]
More recently, uranium has been proven to mimic the effect of oestrogen at drinking water levels, which are considered as being “safe” by authorities (Schnug et al. 2008)[11].

Uranium has a high affinity to DNA, which results in abnormally high absorption of natural background radiation and accelerates genotoxic effects (Busby et al. 2008, Henner 2008).
This advanced biochemical and biophysical aspect of uranium contamination is described as “photoelectron enhancement effect”. This means: uranium particles or uranium atoms bound to DNA amplify effects from external irradiation.

Common dose-effect assumptions are therefore not sufficiently reliable to deny possible detriments by incorporated radioactivity. This is especially true for uranium miners and affected populations (Busby & Schnug 2008).

6. Underestimation of Health Effects, Criticism of ICRP and IAEA Dose Limits

Investigations have revealed that common risk assessments underestimate the dangers of uranium contamination and occupational exposure of uranium workers (ECRR 2006, ENVIRHOM 2005, Schmitz-Feuerhake 2008, Bertell 1985).

In 2007, the German Society for Radiation Protection (Gesellschaft für Strahlenschutz e.V., GSS) and the European Committee on Radiation Risk (ECRR) published statistics about the underestimation of health effects due to the exposure of the population to low level radiation. They found that official risk estimations must be multiplied by a factor of 100 to 2,000.

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[10] Symptoms may appear immediately after exposure to uranium or be delayed. They may include limb weakness or numbness, loss of memory, vision, and/or intellect, headache, cognitive and behavioral problems and sexual dysfunction.
Individuals with certain disorders may be especially vulnerable to neurotoxins.

[11] The World-Health-Organisation (WHO) considers a level of 15 microgram (µ) uranium per litre in drinking water as safe. The German government set a limit of 2 µU/l for mineral waters used in baby nutrition. Scientists demand there should be no uranium in drinking water for babies (Lindemann 2008).

Table 4: Health damages by chronic exposure of a population to low dose radiation.

	Genetic diseases	Mortality by cancer	Effects after exposure in womb	Diseases other than cancer and tumours
ICRP risk data	1.3% per Sv	5% per Sv	no effect < 0.1 Sv	no effect
Evaluation by ECRR	Underestimation by factor 100-2000	Underestimation by factor 100-2000	Cancer Deformity Cerebral disability Mental illness Down Syndrome Child diseases Stillbirth Infant mortality Spontaneous abortions Low birth weight	Manifold

Data in Table 4 shows that **radiation is 100 to 2,000 times more dangerous than previously thought** (Schmitz-Feuerhake 2008, ECRR 2006).

That is a fundamental criticism of the guidelines provided by the International Commission on Radiological Protection (ICRP) [12]. The ICRP together with the International Atomic Energy Agency (IAEA) advises governments in implementing legislation addressing radiation protection for employees, public and the environment. They also recommend radiation limits for workers and population caused by incorporated radioactivity due to inhalation, ingestion, skin absorption and contamination directly entering the blood stream through wounds.

Following ECRR, the official dose-effect assumptions to evaluate incorporated radioactivity by the ICRP are not adequate. Proof is given by looking at the health data analyses following the nuclear accident in Chernobyl on April 26th 1986 (Yablokov 2006). The effects are higher than predicted by the estimated dose and the official dose-effect assumptions (ECRR 2006). The same holds true looking at the Wismut uranium workers in Germany.

Evaluation of occupational risks was shown in the German Wismut uranium miners study (BfS 2006). Since there were no individual exposure data for German uranium miners available, general guidelines were adopted for the recognition of lung cancer as being related to occupation.

[12] ICRP rules provide the fundamental principles and quantitative bases upon which radiation protection measures were established, while leaving the responsibility of formulating the specific advice, codes of practice, or regulations that are best suited to the needs of their respective countries to the various national protection bodies (agencies) (ICRP 2004).

In addition to there was some evidence found for other cancers than lung cancer (Grosche et al. 2008). Dr. B. Grosche and his colleagues from the Department of Radiation Protection and Health of the German Federal Office for Radiation Protection observed a total of 20,684 deaths of uranium workers in the follow-up period from 1960 to 2003. They draw the conclusion that there is evidence of a small radon related risk of extrapulmonary cancers, compatible with official dosimetric calculations for organ doses.
Other possible U-related diseases were not analysed by Federal Institutes.

Therefore the official results are not compatible with observed reality in U-mining areas, where peoples' lives are at risk and workers pass away prematurely due to mining related sickness and leave their families also affected by uranium (Feuerhake 2008, Hoffmann 2008, Brougge 2007, 2002, Dropkin et al. 1992).

7. Dosimetry

Uranium workers are monitored to ensure that absorbed doses of radiation are within the official limits of international regulations (ICRP / IAEA Standards).
The radiation dose as measure for biological effects is based on a physical quantity, the absorbed dose, but because of numerous effects in blood, tissue and organs also on the type and energy of radiation.

Because it is not possible to measure directly the harm uranium causes inside the body, regulators use **calculations** and **risk models such as "weighting factors**[13] in order to get a comparable dose quantity unit for different irradiated parts of the body. For that purpose the ICRP introduced the so-called **"effective dose"**. It takes account of the different propensity of organs and tissues to develop cancer.

Thus the **radiation dose** is interpreted and equipped with a factor that acknowledges the relative biological effectiveness. Employing this method, an attempt was made to evaluate how much damage is caused by a certain amount of uranium to which the body has been exposed. However, the definition of dose does <u>not</u> include information about the irradiated part of the body.

Dose limits and exposures in rules and official regulations are given as effective dose and therefore should be applied with caution. As shown above they may be wrong.

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[13] The "weighting factor" was derived as a simple constant for protection purposes. The science of radiation biology has defined the Relative Biological Effectiveness (RBE) for comparing the different kinds of radiation of the same energy dose. The RBE depends on many factors as, e.g., energy of the radiation, energy dose and dose-rate (dose per time), and the investigated biological impact (Körblein, Schmitz-Feuerhake 2005).

Table 4: Exposure by natural and technical radiation sources (Thomas 2008)

Source	Dose	Remarks
Natural background	ca. **1 mSv/yr**[14]	Whole body dose
Increase cosmic radiation at 1500 m altitude	0.3 mSv/yr	Whole body dose
Radon in houses	5-50 mSv	Bronchial dose
X-ray film usually	several mSv	Mean tissue dose
CT-scan	10-100 mSv	Mean tissue dose
Radiation therapy	**Several 10 Sv**	Mean tissue dose
Dose limit for workers	**20 mSv/yr**	**Effective dose**
Dose limit population	**1 mSv/yr**	**Effective dose**

8. Uranium Mining – The Past

Uranium has been mined in **Germany** from 1848 till 1990 by the Soviet-German company Wismut. It left behind

- more than 1,400 square kilometres open uranium mines and pits,
- 311 million cubic metres of tailings and
- 160 million cubic metres radioactive and toxic sludge.

After re-unification of former East Germany (GDR) and West Germany (FRG) in 1990, the German government invested 6.2 billion € (approx. 74 billion Namibian Dollars) to minimize environmental damages to the former uranium mining and processing sites. Remediation is still going on. However, a number of old sites are left out of the programme and nobody takes responsibility for cleaning them up.

More than half a million people worked for Wismut over the years. Many workers died of uranium related diseases. 5,237 uranium miners received compensation because they suffered from lung cancer. There are many other negative health effects from exposure to uranium, its decay and by-products. In particular toxicity, which is incorporated due to inhalation and ingestion of uranium, sustain great damages to the organism. Silicosis and tuberculosis cases were well-known amongst Wismut workers, but up till today there is no recognition of uranium-related diseases other than lung cancer – and hence no compensation (Schmitz-Feuerhake 2007).

However, in the 1960s, serious respiratory diseases were accepted generally as plausible hazards of mining in the **USA**. Furthermore, there were clear observations that other respiratory diseases, including silicosis, tuberculosis, pneumonia, and emphysema, were causing deaths in uranium miners at rates approaching those from lung cancer. For the Navajo uranium workers, the death rate from non-malignant respiratory diseases was similar to that from lung cancer (Brugge et al. 2002).

[14] 1 mSv/y means one millisievert per year

9. Uranium in Namibia

In **Namibia,** uranium is found in low-grade ore bodies mainly in the Namib Desert. Uranium was discovered in Namibia in 1928, and mining started in 1976 by **Rössing Uranium Limited, which is today owned largely by Rio Tinto** based in London (UK).[15]
Lately a number of companies applied for exploration and mining licences, amongst them being Paladin Resources Ltd. from Australia, operating Langer Heinrich Mine since 2006, Forsys Metals Corp. (Valencia uranium project) and Uramin Inc., a subsidiary of AREVA (Trekkopje uranium project).

Rössing has been digging for uranium in Namibia for 32 years. The ore is mined through drilling and blasting in an open-pit mine; a large territory is already and an even larger one will be affected by mining and processing of uranium. Huge quantities of water and chemicals are used and leave vast amounts of dangerous tailings and waste rock piles. Due to the desert climate and strong winds, the fine uranium dust contaminates large areas and the people in the vicinity of the mine. Plants, animals, soils and drinking water are poisoned too. Especially heavy rainfall spoils ground and surface water due to drainage and leakage.
The production of uranium oxide (yellow cake) begins with mining the ore. Then the ore is treated in a chemical process. It runs through crushing, grinding and leaching processes. At that stage, the uranium content of the pulped ore is oxidized by ferric sulphate and dissolved in a sulphuric acid solution (Rössing 2008). Through slime separation, thickening and continuous ion exchange (CIX), a more concentrated uranium solution is attained. Chemical processing in the solvent extraction plant (SX), then precipitation, filtration; drying and roasting finally produce uranium oxide, so-called “yellow cake”.

The final product is then packed into metal drums and transported overseas to converting facilities and from there to enrichment plants for further processing.

In 2007, 1,400 workers and 400 contractors at Rössing Uranium Limited mined 34 million tonnes of rock and Rössing exported 3,046 tons of yellow cake to North America (30%), Europe (13%), Asia (29%) and Japan (26%)[16]. At full capacity, the company can produce 4,500 tonnes of uranium oxide per year (Rössing 2008).[17].
The uranium content of ore mined and processed by Rössing lies around 0.03%.

10. Occupational Health at Rössing

In Namibia a radiation protection law is not in place yet. Therefore, Rössing Rio Tinto has been working with “Rössing Standards” for more than 30 years.

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15 Rössing is owned to 69% by Rio Tinto, 15% by the Iranian government, 10% by IDC of South Africa, 3% by Namibian government with 51% voting rights and 3% by individual stakeholders.
16 The international nuclear corporation AREVA, based in Paris, plans to start mining in Namibia in 2009 and will sell 35% of its uranium to China (Earthlife Namibia 2008)
17 Average human radiation doses are estimated at **3.6 milliSievert per year (mSv/yr**). More than half of the dose is incurred to the lung by inhalation of radon progeny (Thomas 2008).

According to Rössing an effective dose of 20 millisievert per year should not be exceeded by working in the mine. Table 5 and Table 6 show figures given by Rössing end of October 2008.

Table 5: Cumulative Doses (External Dose) for Rössing Miners

Life Time Dose			
Year	Min (mSv)	**Max (mSv)**	AVE (mSv)
1990	0	**80.71**	9.54
1997	0	**81.06**	13.07
2007	0	**117.14**	16.2

Table 6: Dose Rate

Work Area	**Dose Rate (µSv/h)**
Control	**10**
Mining Equipment	0.6-1.0
Pit	1.3-1.7
Crushing	0.8-1.2
Leaching/Sands Slimes Separation	1.1-2.0
Continuous Ion Exchange (CIX)	1.5-3.5
Solvent Extraction (SX)	1.5-2.1
Final Product Recovery	**2.0-3.5**
Tailings Impoundment	1.2-1.4
Workshops	0.2-0.5
Offices	0.2-0.3
Arandis	0.18-0.2

Radiation exposure at Rössing is monitored by means of a randomly selected group of employees from similar exposure groups.
The **average annual radiation dose** received by workers, according to Rössing, vary between **1.2 mSv** for those people working in the offices, and up to **4.8 mSv** for workers in the Final Product Recovery, where the U-oxide is produced and prepared for transports (Rössing 2007).
End of October 2008 Rössing announced that the company will publish a health study evaluating radiation risks amongst their U-workers in the near future.

11. No Safe Dose for Uranium

Dr. Alice Stewart, who passed away in June 2002, was a Medical Doctor and Professor for Social Medicine, winner of the Alternative Nobel Prize and expert on low level radiation.

In September 1992, she attended the World Uranium Hearing (WUH) in Austria, where she pointed out, that “probably every childhood cancer, except the man-made ones from X-rays, could be due to background radiation.” Dr. Gordon Edwards, Mathematician from Quebec in Canada added: “Now we know that not only cancer is caused by radiation, even down to the lowest levels – also genetic mutations and mental retardation are caused by low level-radiation” (WUH 1992). By “mutation” we mean a disturbance of the behaviour of a cell brought about by damage to the DNA" (Stewart 1992). It is important to acknowledge that neither natural background radiation, nor man-made artificial radioactivity have any positive effect on health and environment.

Results in epidemiology show strong evidence that even low dose irradiation causes serious diseases (Hoffmann 2008). Thus, there is no safe dose for radiation, although it is well known that the higher the dose, the higher the risk of damage. In addition, the older an individual is the higher will be the amount of uranium that has been accumulated in the body. This implies that the risk for contracting damages from uranium generally increases not only with the amount of uranium absorbed but also with the time of exposure and thus with age (Schnug et al. 2008).

It can be concluded that there is **no safe dose** for uranium and there is no so-called “**no-observed adverse-effect level** (NOAEL) for uranium (De Kok al. 2008). According to EU guideline (67/548/ EWG), uranium and uranium compounds must be labelled as “very toxic” for inhalation and ingestion (Fleckenstein 2004).

12. Uranium in the Environment

Uranium contamination in water and soil can also be observed in mining and processing of other resources such as gold, silver, coal, oil, gas, copper, tin and rock phosphates (Birke et al 2004, 2008, Wade et al. 2008, De Kok et al. 2008, Merkel et al. 2006, 2008). Anthropogenic activities increase uranium contents and the spread of uranium in the environment.

Scientists from the Institute for Crop and Soil Science at the Federal Research Centre for Cultivated Plants (JKI) in Braunschweig (Brunswick), Germany studied the influence of the use of uranium-containing phosphate-fertilizers in agriculture. The results of their research showed that uranium applied to soils by fertilization accumulates in soils and a significant amount of uranium seeps into water bodies (De Kok et al. 2008, Huhle 2008, Haneklaus et al. 2008, Knolle 2008). It is important to note that the production and use of uranium-containing phosphate fertilizers has detrimental effects on environment and humans (Falck 2006, Kratz 2006, Schnug et al. 2008).

Uranium in drinking water is an issue of increasing concern, since extraordinarily high uranium levels were discovered in bottled mineral water. German tap water has been tested for uranium but in most cases the uranium content was below 2 microgram uranium per litre (Birke 2004, Knolle 2008).

Studies undertaken by various South African researchers highlighted the occurrence of uranium in aquifers (Coetzee et al. 2008). All samples taken in South African Bushmanland and Namaqualand areas in 2007 exceeded the World Health Organisation's drinking water guideline of 15 microgrammes per litre [18]
Uranium in drinking water increases the daily intake and results in accumulation of uranium in bone, liver and kidney (Thomas 2008). Uranium intake through drinking water is a serious health concern (Schnug et al. 2008).

13. Uranium accountabilities and necessities in legislation

Uranium endangers the environment and all forms of life. Uranium contamination goes along with all stages in the civil - military nuclear chain and shows up with highly toxic and radioactive waste coming out of each step of uranium processing (Diehl 2008, Lindemann 2007).

As shown in the paper, the official calculations of radiation dose limits and risk models for uranium are not compatible with observed impacts of uranium to miners and populations in mining areas (Shindondola-Mote 2008, Lange 2008, Kahlert 1992).

Although the uranium industry still denies uranium-related health effects observed in workers and their families, these facts are obvious and must be examined and acknowledged. The mining industry must pay compensation to the affected workers and families.

In addition the former workers and the local population must be entitled to benefit from medical care when they become sick, even years and decades after the closure of a mine. Uranium induced diseases can occur up to 25 years after exposure.

Authorities need to control mining companies and ensure that monitoring and maintenance are in place according to high safety and radiation protection standards, implemented by national law.

The public must have unrestricted access to environmental and health information to ensure their rights to uncontaminated drinking water, safe food and personal health.

There is a need for independent expertise worldwide. There should be open access to health data of uranium miners for independent scientific analysis.

Damage to ecosystems, in particular ground and surface water resources as well as health damages to people should be expressed in monetary terms. Thus, the real costs of uranium mining will be allocated to the mining companies, and finally to the price of uranium.

[18] 15 microgramme = 0.015 milligramme per litre

We are far away from identifying all the dangers of uranium mining to environment and people worldwide and especially from dealing with the problems in a responsible and safe way.

Instability of Governments and wars among nations and peoples are increasing not only the nuclear safety problems but all contamination issues.

It was all for nuclear weapons", said Gordon Edwards in 1992 at the WORLD URANIUM HEARING. That's the main reason for the aggressive dispute of health impacts by the mining industries in spite of huge knowledge about health risks". The access to uranium and fissile material assures being a member of the international "power game".

Nuclear Energy can never be a safe and reliable energy source for the future. The burden to future generations is unacceptable. Humanity needs to find a better solution.

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