The Nuclear Chain

Uranium Mining

Poisoned Earth

Former uranium mining site in the Cave Hills National Forest, South Dakota, USA. Photo courtesy of James Ruddy

Why mine uranium?

Uranium is a naturally occurring radioactive heavy metal, present in extremely low concentrations all over the world, in soil, rock and water. It exists in several configurations, known as "isotopes". The most common isotope is U-238 (over 99 % in nature), but the isotope prized by the nuclear industry is U-235 (only 0.7% of natural uranium). When the U-235 form is sufficiently concentrated – through an industrial process called "enrichment" – a fission chain reaction can be achieved and sustained. "Nuclear fission" is the splitting of atoms to release energy – in a controlled manner it can be harnessed to produce electricity while uncontrolled fission is

Radioactive decay

Uranium – like all radioactive elements – undergoes a process of decay. Over long timespans, uranium releases energy and changes its form to produce other, distinct, elements in a continuous cascade. The U-238 isotope takes 4.5 billion years to decay by fifty percent – known as one "half-life" – which in turn produces different radioactive elements, creating a radioactive decay chain from uranium through to eventually reach a stable isotope of lead. Important decay products in the uranium cascade – known as "progeny" – include thorium, radium, radon gas, polonium and bismuth – all of these emit radioactive waves or particles (the release of energy during radioactive decay).

the basis for a nuclear weapon. From the 1940s to the 1960s, uranium was mined primarily for use in nuclear weapons, but since the 1970s most of the mined uranium is processed into fuel for nuclear reactors.

Uranium mining – what is the problem?

Uranium and its decay products – known as "progeny" – are harmful to human health for two reasons:

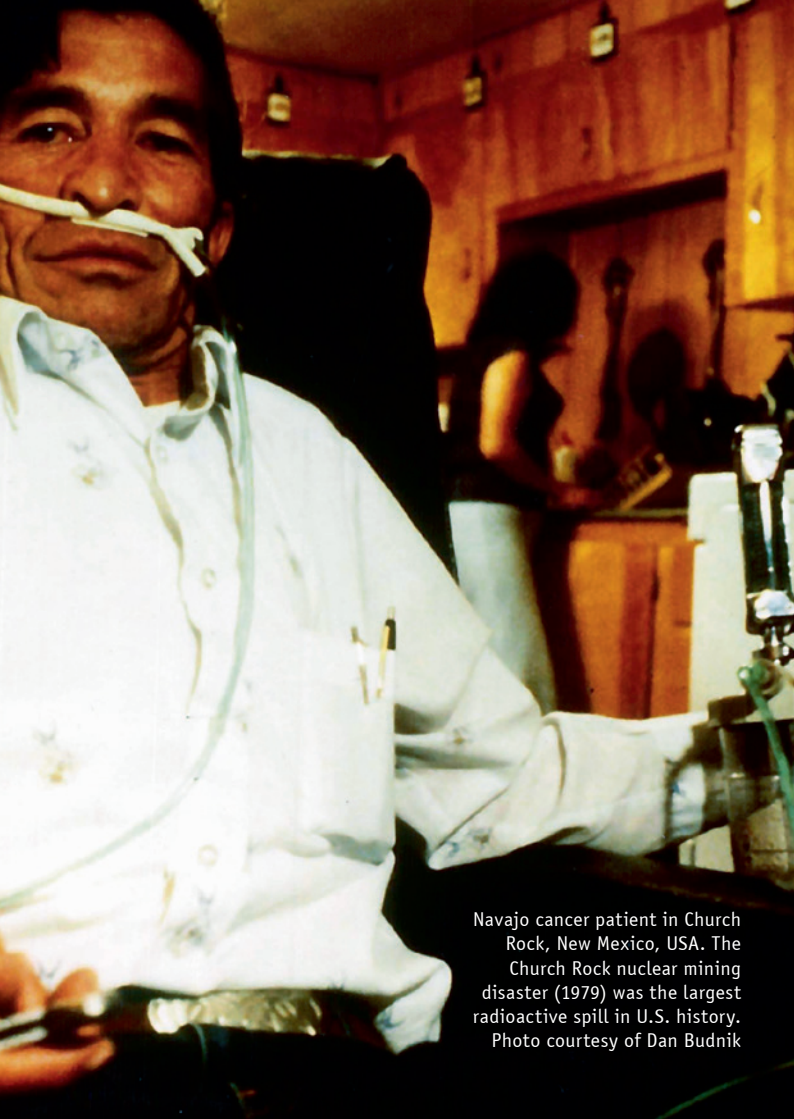
1. Uranium is a heavy metal and – even at low levels – is chemically toxic to humans, particularly to the kidney.

2. Uranium and its decay progeny emit "ionising" radiation: energy delivered in (gamma) waves and (alpha and beta) particles, which have the capacity to disrupt the microscopic contents of living cells and alter the electrical charge of materials they contact.

How does uranium affect people's health?

Humans and the environment are exposed to uranium and its decay progeny through mining, processing and disposal of the uranium-bearing ore:

Miners are exposed to radiation from radon gas which is present in elevated concentrations in mines – especially underground mines. Workers in the processing mills where the uranium is extracted from the excavated ore are exposed to radioactive dust. Workers and members of the general public are potentially exposed to radiation from "tailings" (processed ore, managed as a solid-liquid mix in a tailings dam). Uranium and its progeny can leach into groundwater and expose surrounding populations to the chemical and radio-toxicity, particularly when drinking water supplies are affected.



Navajo cancer patient in Church Rock, New Mexico, USA. The Church Rock nuclear mining disaster (1979) was the largest radioactive spill in U.S. history. Photo courtesy of Dan Budnik

Uranium is both a chemical toxin, a heavy metal, just like nickel or chromium, and it is a radioactive toxin. In different forms it is damaging to the kidneys and can cause lung and bone cancer and leukaemia. Uranium is also harmful to genes.

Kidney damage

Uranium is chemically toxic to the kidneys, which are responsible for detoxification and maintaining blood pressure, salt, water and sugar balance, as well as numerous endocrinological functions.

Cancer

Radon gas is regarded as the second most potent cause of lung-cancers globally, after tobacco. Its hazardous nature has been well documented over decades, in multiple studies in many countries. The decay products of the gas include radioactive lead, bismuth and polonium – alpha and/or beta emitters – which are deposited in lung tissue as they decay from inhaled gaseous radon. Radium is also prevalent in dust from mining and in the waste stream. It is a gamma emitter and a cause of bone cancer, cancer of the nasal sinuses and mastoid air cells, as well as leukaemia.

Genetic damage

Uranium is also "genotoxic," meaning that it damages our DNA. The genotoxicity of uranium may be a combination of both its chemical and its radiological properties. While DNA damage is mostly

reparable by cells, alpha-particles are more likely than other forms of radiation to cause DNA breaks that are not readily repaired. Damaged DNA is associated with many diseases in humans, like cancer and inheritable disease, as well as teratogenic (abnormal physiological development) effects, including mental retardation and birth defects. Cancer may not appear for 10–40 years (latency), although this period can be as short as 5 years for leukaemia.

Ionising radiation injures DNA through two mechanisms:

- transference of its energy to atoms in biological tissue which then become electrically charged, leading to the formation of free radicals which then damage the cell's genetic blueprint (DNA), leading to genetic mutations; and
- direct DNA disruption along the track the ionising radiation traverses through the cell's nucleus.

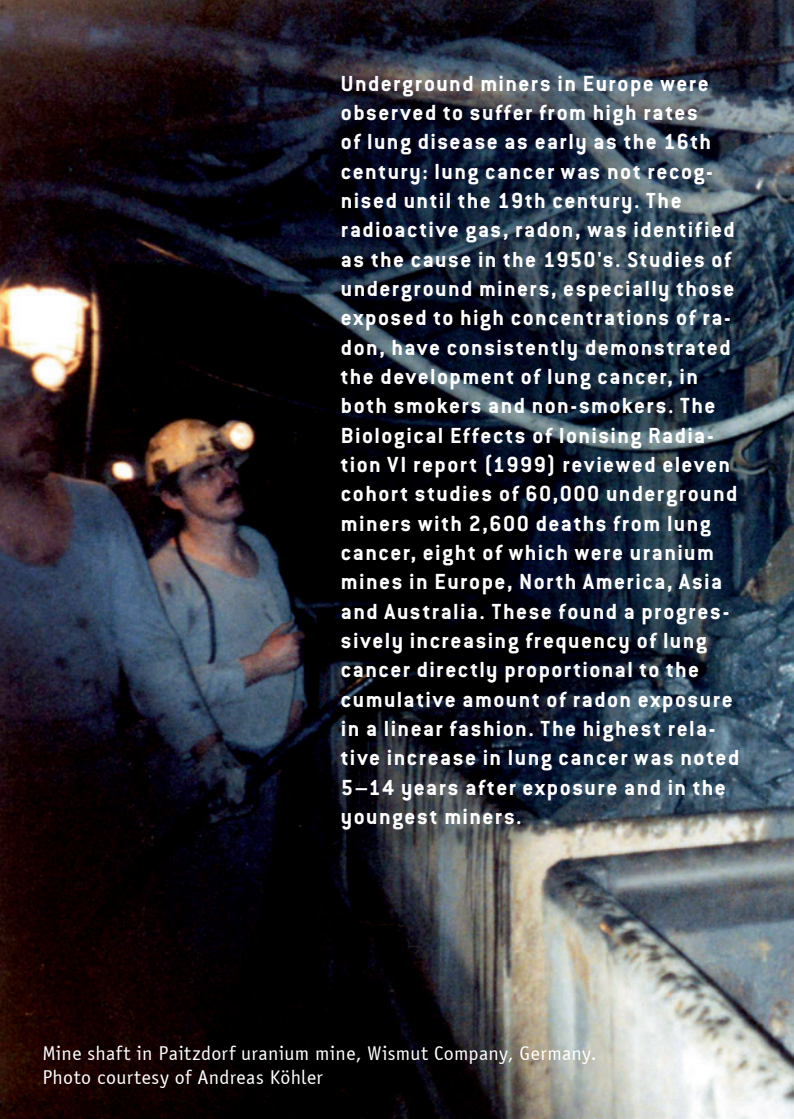
Germany: A historic legacy

Uranium mining in East Germany for Soviet nuclear weapons by the Wismut company caused thousands of cancers and destroyed the environment in the region. More than 20 years after mining ended, its effects can still be seen.

The mountain range of the Erzgebirge and the adjacent Vogtland was home to one of the world's largest uranium mining conglomerates, run by the Wismut company in the years 1946–1990. While by 1990, 5,275 cases of lung cancers were officially recognized as a result of work in the uranium mines, new cases of lung cancer in former uranium miners are not recognized as occupational diseases.

In 2006, the British Journal of Cancer published a study on former uranium miners of the Wismut company which demonstrated a rate of 50%-70% increase in the rate of lung cancer, leading to a staggering 7,000 radiation-induced deaths amongst the 59,000 subjects surveyed[1].

The effects of uranium extraction and processing do not stop with the consequences for miners and mill workers: uranium can be transferred through the food chain from soil to plants, animals and humans. The concentration of uranium is still high, compared with natural background levels, in the farmed river floodplains which drain former uranium mining and milling areas in Saxony.



Underground miners in Europe were observed to suffer from high rates of lung disease as early as the 16th century: lung cancer was not recognised until the 19th century. The radioactive gas, radon, was identified as the cause in the 1950's. Studies of underground miners, especially those exposed to high concentrations of radon, have consistently demonstrated the development of lung cancer, in both smokers and non-smokers. The Biological Effects of Ionising Radiation VI report (1999) reviewed eleven cohort studies of 60,000 underground miners with 2,600 deaths from lung cancer, eight of which were uranium mines in Europe, North America, Asia and Australia. These found a progressively increasing frequency of lung cancer directly proportional to the cumulative amount of radon exposure in a linear fashion. The highest relative increase in lung cancer was noted 5–14 years after exposure and in the youngest miners.

Mine shaft in Paitzdorf uranium mine, Wismut Company, Germany.
Photo courtesy of Andreas Köhler

Namibia: Environmental toxicity

Namibia is the world's fifth largest uranium producer. The mine, run by the company Rio Tinto, is a human rights concern because of working conditions as well as a health risk to workers.

The Rössing uranium mine, commissioned in 1976, has been a cause for environmental, humanitarian and health concerns for more than 30 years through unsafe working conditions, radioactive effluent and tailings. It is now the world's largest open-pit uranium mine. Miners at Rössing are exposed to dust and inhale radon gas on a daily basis: although vast quantities of water are used to keep uranium dust on the ground, the use of explosives in open-pit mining cause large clouds of radioactive dust. This dust is carried to the fields and settlements of the nearby town of Arandis and to the region's

Rössing uranium mine, Namibia.
Photo: Conleth Brady/IAEA, creativecommons.org/licenses/by-nc-nd/2.0

waterways. Elevated levels of uranium have been detected in groundwater. A study performed by the Charité University Clinic of Berlin demonstrated a six-fold increase in uranium excretion amongst uranium miners as well as elevated rates of chromosomal aberrations, and significantly reduced white blood cell counts[2].

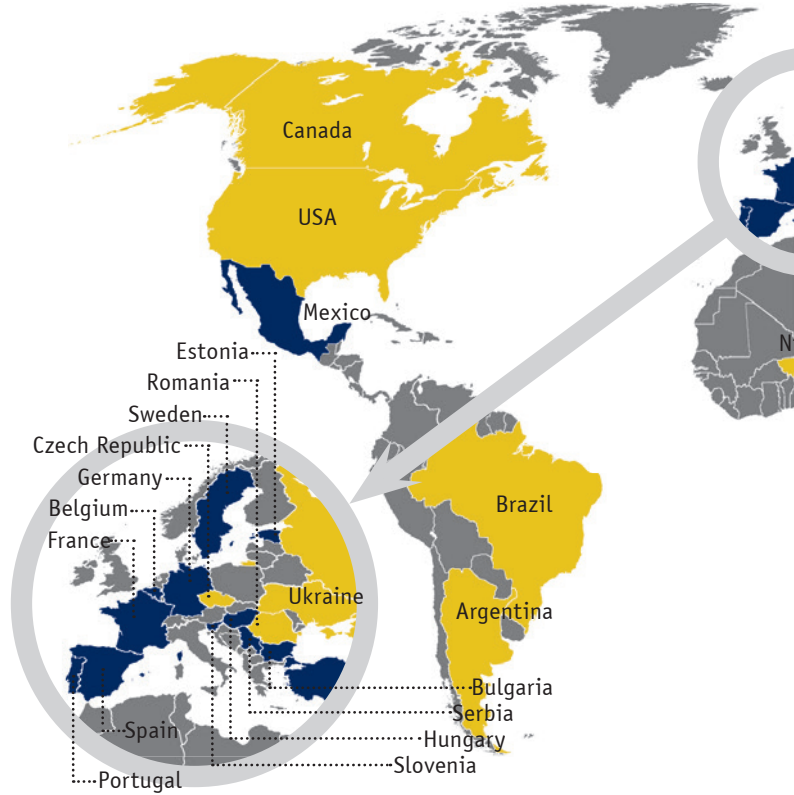
Ranger uranium mine, Australia
Photo: Green MPs/ creativecommons.org/licenses/by-nc-nd/2.0

How it is mined

Uranium is widespread across the planet in extremely low concentrations but seldom sufficiently concentrated to be economically recoverable. Uranium ore can be mined by underground or open-cut methods, depending on its depth. The extracted ore is crushed and ground up, then treated with acid to dissolve the uranium, which is then recovered from solution. Uranium may also be mined by in situ leaching (ISL), where it is dissolved from the ore-body and pumped to the surface for further processing.

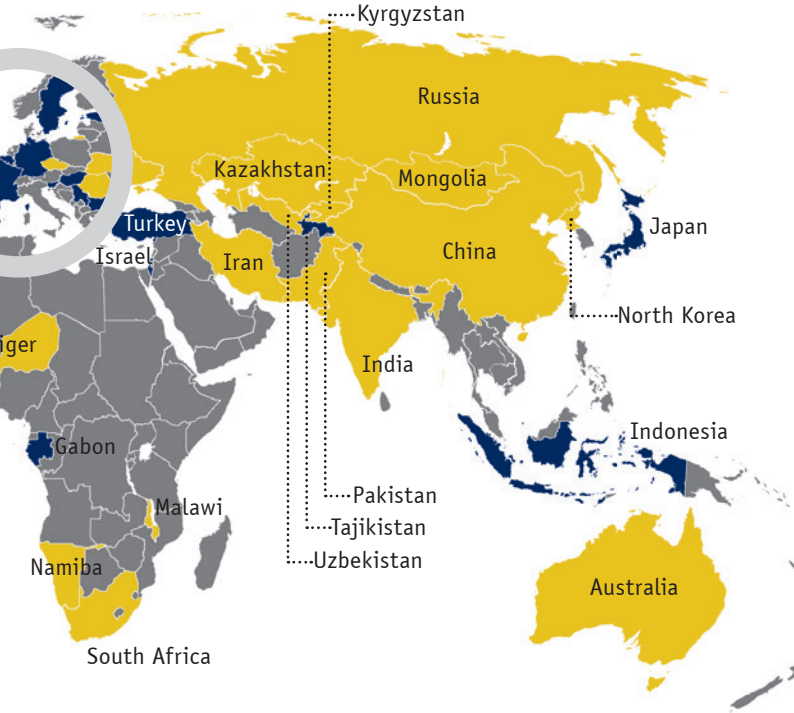
The global picture

Although Australia's uranium resources make up about 35 % of the world's total reserves, Kazakhstan is currently the largest supplier to export markets – with 38 % of the global market in 2013. Canada was the world's leading producer until 2008. Other countries with significant production and exports include Niger, Namibia, Malawi, South Africa, Russia, Ukraine, USA and China.



Countries operating uranium mines and mills

Countries with decommissioned uranium mines and mills



Site of the Church Rock nuclear mining disaster.
Photo: Doctress Neutopia, creativecommons.org/licenses/by-nc-sa/2.0

Kazakhstan: World's largest producer

Uranium deposits in Kazakhstan contain some 12% of global reserves, ie. in-ground metal / uranium. Their mines also produce some 38% of current global uranium supply. It has an expanding mining sector, producing about 22,500 tonnes in 2013. Kazakhstan plans to expand uranium mining until at least 2018.

Almost all of the country's uranium operations employ in situ leach (ISL) mining. The ISL method avoids making a mess above ground, but leaves toxic levels of heavy metals and radionuclides in the ground water. In Kazakhstan, a country that has seen the disastrous effects of the Soviet Union's use of nuclear testing and waste disposal, officials with the state-owned uranium company, Kazatomprom, express no concern about the legacy of its rapidly expanding use of ISL mining. They argue that natural processes will clean the mining sites.

United States of America: Indigenous injury

The Navajo Nation is the largest Native American reser-

vation in the USA, covering 27,000 square miles in Arizona, Utah and New Mexico. United Nuclear Corporation (UNC) opened the largest underground uranium mine in the United States in 1968 in Church Rock, New Mexico. UNC's Church Rock Mill, which employed about 200 Navajo workers, produced more than two million pounds of uranium oxide (U_3O_8) per year. The surrounding land was used for livestock grazing and recreation. On July 16th 1979, the earthen dam containing radioactive wastes from the ore extraction process breached, releasing approximately 1,100 tons of radioactive mill waste and 360 million liters of radioactive effluent into the nearby Puerco River. Hundreds of miners in the Navajo Nation have died or experienced illness from the now abandoned mines, which continue to expose residents to uranium and other contaminants through airborne dust and contaminated drinking water[3]. Many homes were built using radioactive mine wastes and families living in homes built with uranium tailings were exposed to high levels of radon. Today, the Navajo Nation has banned uranium mining on lands that it controls.

Canada: Increase in lung cancer

The Canadian province of Saskatchewan has some of the world's most extensive and most highly concentrated uranium deposits and produces uranium for nuclear power plants all over the world. But miners working there have a much higher rate of cancer than elsewhere in Canada[4].

After almost half a century

of mining, uranium from the Athabasca Basin in Northern Saskatchewan is used in almost every nuclear power reactor in Canada, the U.S., Japan, South Korea and Western Europe. Recently, high-grade uranium ore deposits have been discovered and developed at McArthur River.

Radiation effects are most evident in the uranium miners themselves. The Saskatchewan Uranium Miners Cohort Study showed that while the miners generally tended to show better health parameters than the average population ("healthy worker effect"), their rate of lung cancer was significantly increased by 23–30 %. Of the 16,770 miners in the cohort, 2,210 (23 %) were diagnosed with cancer between 1969 and 1999[5]. Further studies were not undertaken, because the authorities claimed that new mining safety standards were much better than before and that no effects were likely to be seen in statistical analyses.

On the issue of radioactive waste disposal Saskatchewans Premier Blakeneym stated in the 1970s: "We have had to make a leap of faith and assume that a satisfactory means of disposal will shortly be found."

India: Death downstream

India's uranium mines have poisoned rivers and, in turn, people. Babies are being born deformed and many die early. Fertility is affected, as well as life-expectancy.

In 1967, India's state owned Uranium Corporation UCIL began mining uranium near Jadugoda and later also near the surrounding villages of Bhatin, Narwapahar

Jadugoda: People bathing near uranium mine tailings.
Photo courtesy of Swaroop Singh

and Turamdih, employing 5,000–7,000 people in the mines. Villages like Dumridih are located right next to the tailing ponds. During the dry season, dust from the tailings is blown through these villages. During the monsoon rains, radioactive waste spills into the surrounding creeks and rivers, causing further internal radiation as villagers use the contaminated water for washing and drinking. Mine tailings have also been used to construct roads and houses in the villages.

An independent study carried out by the Indian Doctors for Peace and Development in 2007 surveyed nearly 4,000 households in a large-scale case-control study[6]. They found that babies born in the affected area had almost twice as many congenital deformities as the general population and that these led to death in 9 % of the cases – more than 5 times the mortality rate found in control villages. The study also showed a higher rate of infertility amongst couples in the affected area, a lower life expectancy and a higher mortality rate due to cancer.

With support from all over the world local communities in Australia have resisted the opening of new mines, hampered operating projects and challenged the adequacy of rehabilitation activities.

Jabiluka

In 1998 the closure of the Northern Territory's Jabiluka mine followed a David v Goliath struggle led by the Mirarr Aboriginal people – the traditional land owners – actively supported by many thousands of people around Australia and across the world. This struggle included an eight month peaceful blockade involving over 5,000 people and more than 500 arrests. Eventually the mine operator, the Rio Tinto Group, agreed that the mine would not go ahead. On August 12th, 2003, rehabilitation works commenced and one of the world's biggest mining companies returned 50,000 tonnes of unprocessed uranium ore back underground, literally closing off access to the 1.5 kilometre mine tunnel.

Koongarra

Plans for uranium mining at Koongarra near Nourlangie Rock, NT, have been permanently ended by Aboriginal Traditional Owner opposition and the area being formally included in Kakadu National Park.

Photos: From the documentary "YELLOW CAKE – The dirt behind uranium," Courtesy of Um Welt Film, Germany

"Everyone seems to be only concerned with what is happening today or next year, yet no scientist can tell us properly what will happen at the mine site in a hundred years' time when they are all gone and no-one cares ... None of the promises last, but the problems always do."

Yvonne Margarula
Senior Traditional Owner, Mirrar, 2003

"I have said no to uranium mining at Koongarra because I believe that the land and my cultural beliefs are more important than mining and money. Money comes and goes, but the land is always here, it always stays if we look after it and it will look after us ..."

Jeffrey Lee
Senior Traditional Owner, 2013

Uranium waste hazards

Although the uranium is extracted from the mined ore for further processing, most of the radioactivity from uranium progeny remains in the waste rock. This waste rock – the "tailings" – is then disposed of, usually in the vicinity of the mine-site. The tailings can constitute enormous volumes of radioactive material over the life of a mine: the Olympic Dam mine in South Australia has already generated well over one million tonnes of tailing waste after over twenty years in operation. The residual radioactive progeny includes thorium-230 which decays to produce radon gas: with a half-life of 76,000 years, thorium 230 will produce radon for many millennia. In

the atmosphere, radon decays into radioactive polonium, bismuth, and lead, which enter water, crops, trees, soil, and living creatures, including humans. In intact rock formations, radon gas is largely trapped within the rock. But in the finely ground tailings, radon gas has multiple access routes to the surface and the atmosphere, particularly through wind and water. Depending on the quality of tailings management, the people living in the surrounding environment will be exposed to the radiation from radon gas and radium-contaminated dust over succeeding generations.

Olympic Dam Tailings, Roxby Downs, Australia
Photo courtesy of Jessie Boylan

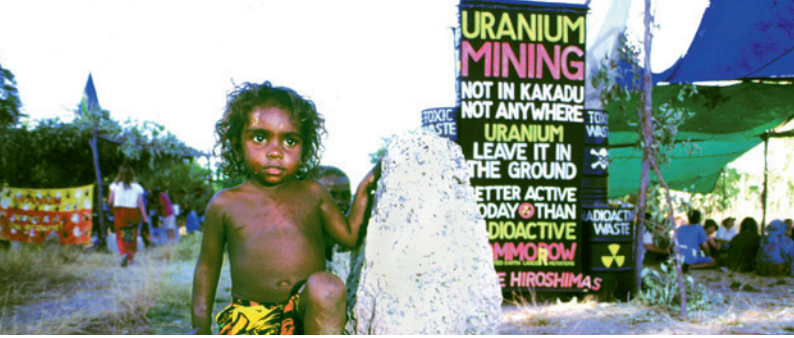
We need:

Health assessment

Population-based health studies are needed in current and former uranium-mining districts to correctly assess the full extent of the damage uranium mining has caused. Also, ongoing screening is important to identify health problems as they occur and provide appropriate treatment. Before a mine is opened, we need baseline health studies at future uranium mining sites.

Scientific research

Independently funded research on the effects of uranium – and the effects of all radionuclides – on health is currently lacking. In particular we need studies of transgenerational effects in nonhuman species with which humans share many biochemical pathways and studies of hazards of uranium mining to surrounding populations.



What needs to happen?

The International Physicians for the Prevention of Nuclear War (IPPNW) are calling for a ban on uranium mining because uranium ore mining and the production of uranium oxide (yellowcake) are irresponsible and represent a grave threat to health and to the environment. Both processes involve an elementary violation of human rights and their use lead to an incalculable risk for world peace and an obstacle to nuclear disarmament.

Moreover, we need to advocate for an environment free of radioactive waste, as well as representation and greater transparency in environmental and policy decision making. Governments should be required to fund the cleanup of abandoned mines that produced uranium.

Photo: Mirrar child at Kakadu National Park, the site of the Jabiluka uranium mine, Australia, 1997. Friends of the Earth International, creativecommons.org/licenses/by-nc-nd/2.0

Further information

You can download our call to action for a ban on uranium mining for others to sign here:
http://tinyurl.com/uraniumcall

Read the folder with the Declaration of Basel, the IPPNW-resolution on uranium minung and the essay „The Death that Creeps from the Earth“:
http://tinyurl.com/baseldeclaration

You can find out more about uranium mining and how to get involved at these sites:

- **www.nuclear-risks.org/en**
- **www.wise-uranium.org**
- **www.uranium-network.org**
- **www.australianmap.net**

References

All references can be found here: http://www.nuclear-risks.org/en/uranium-mining/resources/reference-list.html

Documentaries:

"Buddha Weeps in Jaduguda Jharkhand": **http://youtu.be/upzt4ESu908**
"Jadugoda – The Black Magic": **http://youtu.be/elOmavVcG3M**
"Left in the Dust": **http://youtu.be/ioRtzOWm07A**
"Uranium – is it a country?": **www.strahlendesklima.de/en/uranium**
"Yellow Cake – The dirt behind uranium": **www.yellowcake-derfilm.de**

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The Nuclear Chain

Those who advocate nuclear power often refer to the different stages of uranium processing as the "nuclear fuel cycle." But it is not a cycle, it is a dead-end; it begins with uranium and ends with radioactive waste. Each link in the chain causes irreversible damage to the environment. Millions of people throughout the world suffer from the effects of the civil and military nuclear industries.