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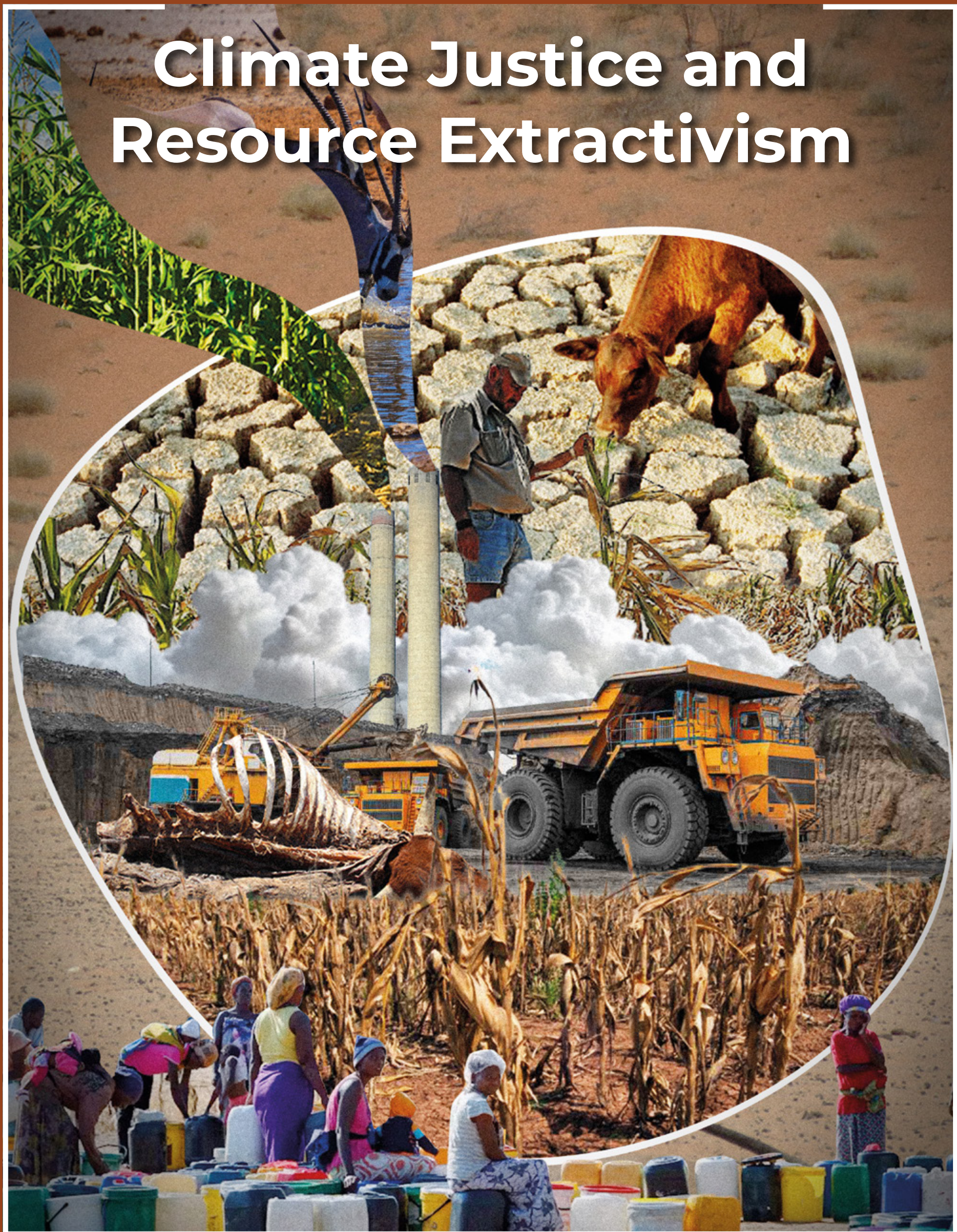

Environmental Threats Posed by the Proposed In-situ Leach Mining of Uranium to Underground Potable Water Aquifers in the Stampriet Artesian Basin

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Introduction

Uranium, apparently in commercial quantities, has been discovered by Headspring Investments, a subsidiary of Uranium One, the international exploration, mining and processing arm of the Russian state-owned company Rosatom, in the main underground artesian potable water aquifer of the Stampriet Artesian Basin (SAB) in the Leonardville area. Because of the high water table, this can only be mined by the in-situ leach (ISL) mining method. In conjunction with high water usage by irrigation operations, this method has the potential to cause extreme contamination of the potable water by the highly toxic solutions associated with mining operations. There are no mining activities at present, but an application for an environmental clearance certificate to carry out ISL test mining has been submitted by Headspring Investments to the Ministry of Environment, Forestry and Tourism (MEFT). This would allow for contamination of the aquifer to begin, and must be prevented before test mining, let alone large-scale mining, even starts. Descriptions of ISL mining and its associated problems are reported in many publications of the International Atomic Energy Agency, the Canadian Nuclear Safety Commission, CSIRO Australia, the Nuclear Energy Agency, the USA Environmental Protection Agency, the USA Nuclear Regulatory Commission, Radiation Safety, the World Health Organization, World Nuclear Association, and many others. The Stampriet Aquifer Uranium Mining Association (SAUMA) has been opposing the proposed mining since August 2021.

Background

The Stampriet Transboundary Aquifer System covers 86 647 km2. The Namibian sector, the SAB, constitutes 73% thereof, covering 63 252 km2 in the dune-covered, waterless Kalahari of southeastern Namibia. For more than a century, this has been a farming area relying entirely on the underground aquifer water for its livelihood.

Contamination of the aquifer by any mining activity would be a major disaster for all surface life that depends on the water.

Mineral exploration for base and rare metals began in 2011 in the Leonardville area. Environmental impact assessments (EIAs) for this activity were poor, particularly with regard to revealing the critical importance of the groundwater, but environmental clearance certificates were nevertheless issued and have been renewed ever since. Exploration licences were endorsed to include uranium in 2017. By late 2021, 602 exploration and hydrogeological boreholes had been drilled. SAUMA reached out repeatedly to the Ministry of Agriculture, Water and Land Reform (MAWLR), the MEFT, and the ministries of Mines and Energy, and Health and Social Services to discuss the dangers that ISL mining poses for the potable water aquifers in the basin. Only the MAWLR listened, cancelled two drilling permits in the basin, and refused an application for additional drilling. Exploration drilling has ceased for the moment. Presently, 40 Exclusive Prospecting Licences (EPLs) for uranium cover 2.66 million hectares (40% of the SAB). Eventually, after more than 30 PowerPoint presentations by SAUMA to the public, scientific organisations and farmers' unions over a period of almost three years, and support from newspaper reports and press releases on the topic, Cabinet committees were tasked with preparing reports (as yet unpublished) on the proposed ISL mining and making recommendations to Cabinet. The EIA that accompanied the application for an environmental clearance certificate to erect and run the test mining pilot plant was so atrocious that the MEFT has required a more comprehensive EIA to be submitted.

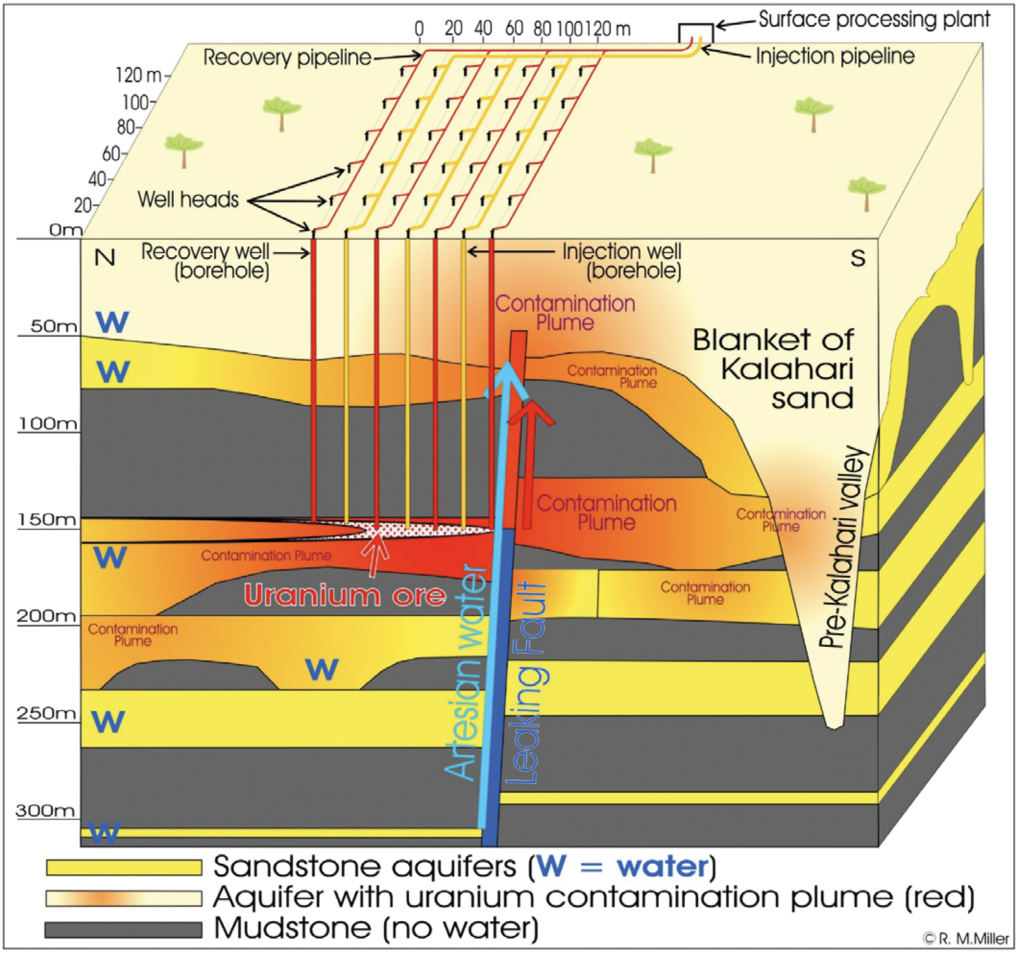
The Challenges

To understand the dangers that the proposed ISL mining poses for the underground potable water aquifers in the SAB, one needs first to understand the geology, the aquifer sandstones that are the source of the underground water, the water quality, water usage, water legislation, how ISL mining works, its magnitude, and its inherent problems.

Geology of the SAB and aquifer sandstones

The underground geology below the unconsolidated Kalahari sands consists of alternating layers of porous aquifer sandstone and impervious mudstone. Five layers of porous aquifer sandstone extend throughout the Stampriet Transboundary Aquifer System (Miller, 2008; UNESCO, 2016) and are also pumped for potable water. The lower four aquifers are under high artesian water pressure and the water flows freely

Figure 1 *Schematic diagram of an in-situ leach uranium mining operation*



Source: Author

Schematic diagram of an in situ leach uranium mining operation showing the underground lithology with water-bearing sandstone layers (yellow) in the Stampriet Artesian Basin, a fault displacement thereof (potential zone of leakage), a typical sandstone-hosted uranium orebody, a wellfield with wells (boreholes) for injection of acidic leach solutions (orange) and recovery of the uranium-rich mine solution (red), the corresponding well heads and pipelines to and from the surface processing plant, and the potential locations of the spread of contamination haloes of dissolved uranium in the water-bearing sandstones and Kalahari sands.

out of most of the deep boreholes in the upper reaches of the Auob, Nossob and Olifants river valleys. The upper three artesian sandstone layers, collectively called the Auob Formation, form the thickest aquifer and contain by far the largest quantities of groundwater. The Kalahari sands are themselves an aquifer.

In places, the underground aquifers are in contact with each other. Numerous long linear fractures of highly permeable broken rock (termed faults) cut vertically right through the rock succession. Two fault directions are present, north-south trending and up to 200 km long in the western part of the basin, and northeast trending further east.

The uranium orebodies occur at the top of the Auob Formation artesian sandstone aquifer.

Groundwater quality

With the exception of water in uranium orebodies, the water in the Auob Formation is good quality potable water throughout the basin. NamWater supplies this water to all the towns. All irrigation water is pumped from the Auob Formation. The yield of the deep Nossob Formation is limited. Its quality deteriorates southwards. Many farm boreholes tap only the variable quality water in the uppermost sandstone aquifer (the fifth of the aquifer sandstones) and the Kalahari sands.

Groundwater outside uranium orebodies throughout the world contains only minute amounts of uranium that are well below the World Health Organization (WHO) safe guideline for potable water of 30 micrograms of uranium per litre. Such is the case in the SAB. It is only in the uranium orebodies that the dissolved uranium and radionuclides exceed WHO safe guidelines. However, only a few analyses of uranium and radionuclides in SAB water have been carried out, but more are planned.

Water usage

There are approximately 7 000 boreholes in the SAB, a few extending to below the base of the Nossob Formation. The earliest artesian borehole was drilled in 1912 just north of Stampriet and yielded 110 cubic metres (m3) of water per hour (UNESCO, 2016) (1 m3 = 1 000 litres). Farm boreholes tap all aquifers, but irrigation (88% of total abstraction) and town supply (7%) are sourced from the Auob Formation. Irrigation projects pump between 20 and 107 m3 of water an hour all year round. The annual volume abstracted by irrigation is about 6 million m3. A few large, year-round irrigation operations pump at a continuous rate of 50 m3/hr and more. Such high abstraction has resulted in a fall in the Auob Formation water table of 20 m. However, recharge along the northern and western margins of the basin restores the water table during exceptionally good rainy seasons that occur every 10 to 20 years (Kirchner et al., 2002).

When an individual borehole is pumped at a rate greater than the rate at which water can flow into the borehole, a cone of depression of the water table around the borehole develops. A porous sandstone cannot deliver the continuous yields that the large irrigation projects are pumped at. Such yields are only possible from boreholes drilled into the long faults with highly permeable broken rock. Groundwater flow modelling shows that such pumping draws water mainly from the fault for a distance of up to 40 km away, creating not a cone of depression, but a valley of depression of the water table along the fault.

Water legislation

The legislated boundary of the SAB is defined in Ordinance 35 of 1955 and was incorporated in the Water Act (54 of 1956), which declared the SAB as a Water Control Area. Key aspects of this act are incorporated in the Water Resources Management Act (11 of 2013) which was promulgated in August 2023. In terms of the latter, all artesian areas are defined as Water Protection Areas in which no borehole may be drilled without a drilling permit from MAWLR. In order to prevent leakage and help maintain the artesian water pressure, drilling permits are issued with strict instructions of where and how casing is to be cemented in place before drilling proceeds into the artesian aquifer.

The Water Resources Management Act specifically states that a person, organisation, institution, entity or authority may not cause a water resource to be polluted, and defines "pollute" as "directly or indirectly to alter the physical, thermal, chemical, biological, or radioactive, properties of the water so as to render it less fit for any beneficial use for which it is or may reasonably be used …" If mining or even test mining were permitted, this would be in contravention of the safety measures built into the Act.

How ISL mining works; its magnitude

Because of the high artesian water table of the Auob Formation, conventional open pit and underground mining cannot be undertaken. Such mines would flood immediately. Only ISL mining is feasible. This involves injecting a leach solution consisting of water containing a little sulphuric acid and oxidizing chemicals via injection boreholes into the uranium orebody in the underground aquifer. Migration of the leach solution through the orebody takes one to two months to dissolve the uranium and moves at a rate of about 0.5 m to 1 m/day. The resulting pregnant mine solution is then pumped to the surface via production or recovery boreholes to a processing plant. Other radioactive elements and heavy metals in the orebody are also dissolved by the leach solution. Recovery boreholes pump a little more solution out than is pumped in to ensure flow of the solution is always directed towards the recovery boreholes. Once recovery of uranium is complete in the surface processing plant, this slight excess of solution is bled off to evaporation ponds. This bleed solution still contains small amounts of uranium as well as the dissolved radionuclides and heavy metals which settle out during evaporation. The remaining water is recharged with a little acid and oxidant and reinjected. Such recycling can be repeated up to about 100 times.

The mine solution is highly toxic and contains concentrations of dissolved uranium up to 3 000 times the WHO safe guideline for potable water of 30 micrograms uranium per litre of water. The dissolved uranium, radionuclides and heavy metals in the mine solution pose a huge risk to the aquifer.

Large ISL mines generally have thousands of injection and recovery boreholes spaced, on average, 20–30 m apart. Mining can last decades because orebodies are divided into smaller mine units that are mined sequentially. Mining of each unit lasts between one-and-a-half and five years. The Lost Creek Mine in the USA, for example, has 19 mine units covering about 1 700 ha (half the area of an average farm in the SAB) and will end up with about 26 000 boreholes.

All ISL mines are surrounded by monitoring boreholes in order to detect escape of the mine solution out of the mine area or into overlying and underlying aquifers (called an excursion). Water in the monitoring boreholes is analysed approximately every two weeks for uranium and radionuclide content. Various procedures are undertaken if such an escape is detected.

Inherent problems associated with ISL mining

Problems occur both on the surface and underground. The latter are of the greatest concern because they cannot be seen, are in the aquifer, and are in water under high artesian pressure. Typical surface problems are broken and leaking pipelines that lead from every borehole to the surface plant; spills of uranium-bearing solutions and reaction chemicals; radioactive radon gas in the plant; leaking evaporation ponds; wind blowing away dried precipitate powder in the dry evaporation ponds; handling of drums of the final yellow cake product; and accidental exposure of personnel to high-grade solutions or yellow cake.

The underground problems cannot be seen and are not always immediately apparent. These include broken casing or improper cementing of casing (i.e. boreholes failing pressure integrity tests); broken pumps or other hardware that require replacement; broken or blocked filter screens; loss of injection or recovery pressure; pressure build-up in boreholes; and escape of toxic mine solution (excursions) from mine areas, contaminating lateral and overlying aquifers. Pumping also has to stop or be reversed when parts are replaced or screens need unblocking during routine workovers (approximately every 2–3 weeks).

Add to these problems the underground geology. Faults are a major problem. The artesian pressure can force water and toxic mine solution up the broken rock of faults into overlying aquifers. Cross-contamination from one aquifer to another can take place where aquifers are in contact with each other. Rusted casing in old boreholes and incorrectly sealed boreholes are always a source of cross-contamination.

Irrigation projects are scattered across the northern and western parts of the basin, precisely where the uranium exploration licences are located. These pump between 20 and 107 m3 of water an hour all year round. The high pumping rate of the larger irrigation projects induces a flow of water through the underground aquifer of 22 m/day and more, and from as far away as 40 km. This is far greater than the rate of flow of 0.5–1 m/day of the leach solution flowing from injection to recovery boreholes. Such continuously high induced flow rates are bound to draw toxic mine solution out of the mine area into the rest of the aquifer for many kilometres. The danger for the escape of mine solution becomes even greater during mine stoppages for repairs and regular workovers.

Accidents and violations of ISL mining regulations are by no means uncommon. The World Information Service on Energy – Uranium Project's Issues at operating uranium mines and mills – USA has extracted lists of over 750 licence violations and reportable events from the United States Nuclear Regulatory Commission's ADAMS (Agencywide Documents Access and Management System) database. These occurred between 1996 and 2023 on US ISL mines belonging to Strata Energy, Peninsular Energy, Ur Energy, Cameco, Uranium One, and Uranerz Energy. Fines were imposed in some cases.

The violations and events included: over 300 spills of injection and production fluids; over 150 excursions (underground leakages of mine solution out of the mine area); spills of chemicals or brines; over 70 boreholes (‘wells’ in US terminology) that failed pressure integrity tests (i.e. were leaking); over 80 cases of monitoring boreholes missing scheduled testing; over 20 cases of leaking evaporation and waste water ponds, as well as damaged yellow cake drums and exposure of personnel to yellow cake; incorrect rate of filling of yellow cake into drums; incorrect operation pressures and bleed rates (removal of excess solution after processing); problems with shipping papers; missing radiation work permits; incorrect calculation of radioactivity and exposure dose rate; failure to remove topsoil and protect topsoil, missed daily inspections; failure to carry out monthly gamma rays surveys of buildings; problematic Environmental, Safety and Health reports; storage facilities for radioactive material not properly secured; inadequate material release surveys; and illegal modification of licence boundaries, amongst others.

Actions

SAUMA must continue to create awareness of the dangers that the proposed ISL mining of uranium in the aquifers of the SAB poses to the potable water, the livelihoods and the economy of the SAB. The revised EIA for pilot plant test mining will have to be critically evaluated by geologists, hydrogeologists, environmentalists, the Namibia Agricultural Union, the authorities, and farmers, once it is available.

Outcomes/Conclusions

At a UNESCO-sponsored meeting held on 17 June 2024 with various presentations on this subject, Minister Schlettwein concluded his speech with the comment, “At the end of the day we cannot survive without water and food, but we can live without coal or uranium.”

Such ISL mining of uranium in underground potable water aquifers would not be allowed in Australia (personal communication: Dr. Ian Lambert, author of Australia’s In-situ Recovery Uranium Mining Best Practice Guide, Commonwealth of Australia, 2010). Common sense dictates that this should also be Namibia’s stance.

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