Uranium Mining and Milling Waste Management in Northern Saskatchewan Extended Abstract

S. Thompson, K. Colburn, M. Pollock, S. Gordon, and J. Donev[1]
[1]University of Calgary, Alberta, Canada
jason@phas.ucalgary.ca

Summary

This extended abstract presents a review of the effectiveness of waste management practices currently used in Northern Saskatchewan's uranium mining industry. Short-term improvements could be made to waste rock management. Long-term improvements include extracting toxic metals from the tailings pit, and creating a recycle loop for the effluent water to be returned for use in the mill. Additional regulatory involvement was seen as necessary to implement the suggested improvements, either through an incentive system for extraction similar to carbon trading or via increased enforcement of lifetime total metals accumulation and loading limits.

1. Introduction

The uranium mining industry is not only important to Saskatchewan but also to the rest of Canada, which relies on nuclear power to generate about 15% of the nation's electricity requirements. The first step to generate nuclear energy begins by simply mining the ore from the earth using various surface or underground methods. Unfortunately, while recovering uranium, liquid and solid waste is generated with contaminants including radio-nuclides (radium-226, lead-210 and uranium), metals (particularly, high concentrations of nickel, molybdenum, and in some ores, arsenic is in oversupply), suspended solids, dissolved salts and ammonia; this brings the need for effective waste management.

Evaluation was completed of the effectiveness of the current waste management practices in Northern Saskatchewan. Good practices were identified, potential improvements suggested and recommendation of implementation strategies of improvements provided.

Three case studies of the uranium milling operations in Northern Saskatchewan were used for the purposes of assessing the waste management technologies currently in use. The three facilities included Cameco's Rabbit Lake and Key Lake, and Areva's McClean Lake. Throughout their history all facilities have each been used for mining, milling and tailings management.

3. Waste Management in Northern Saskatchewan

All three facilities follow the same general process. In terms of tailings, the first step is adjusting the geochemistry to reduce mobility of toxic contaminants. This varies with facilities, but the techniques used include thickening, adding chemicals to precipitate toxic metals (specifically targeting, arsenic and radionuclides) and adding chemicals to neutralize pH. The resulting product is sent to the Tailings Management Facility (TMF).

Modern TMFs are designed to protect the surrounding natural environment in the long and short term. One long-term goal of tailings management is to achieve highly consolidated tailings, by reducing the hydraulic conductivity of the tailings to achieve a value less than the surrounding rock. If the hydraulic conductivity of the surrounding rock is higher, the groundwater will travel around the tailings as opposed to through it. This is typically achieved by disposing the tailings in a previously mined-out pit. The bottom and edges of the TMF are lined with drainage rock and a covering filter. A raise well is attached to the bottom of the drain collecting leachate, and while removing liquid from the pore spaces of the tailings, the dewatering well improves consolidation of the final tailings. During operations, contaminants are contained hydraulically by creating a cone of groundwater depression around the facility. All ground water that could be potentially contaminated is captured. A water cover is typically used to prevent freezing of the tailings during deposition. If the tailings freeze, they will remain suspended and not consolidate fully. Also the water cover prevents excess radiation and dust generation. When the TMF is ready for decommissioning, the facility is capped with a low permeable cover.

Water onsite is managed effectively to minimize adverse environmental effects. Natural water channels are diverted to avoid the uranium mining site; hence potential contamination. Water collected from the TMF, runoff around the site, and waste streams from the millings process will be sent to the Water Treatment Plant (WTP) before being released to the environment. The WTP uses ferric sulphate to precipitate arsenic, barium chloride to precipitate uranium and lime and hydrogen sulphate to manipulate pH. A series of clarifiers are used to separate the clean effluent and sludge of precipitates. The sludge is sent back to the TMF. The effluent flow is regulated to ensure appropriate quantities are released based on natural stream conditions.

During operation special waste is stored on high-density polyethylene lined pads. Seepage from the mineralized waste rock that reaches groundwater is collected using a dewatering system. Runoff from the stockpiles is collected and treated appropriately. Processing the waste rock in the mill decreases the quantity and dilutes the high-grade ore typical in Northern Saskatchewan. Both special and clean waste rock may be used for the soil cover of the TMF, backfilling of excavated areas and other construction. This not only helps to reduce the amount of stockpiled material but also decreases the cost of aggregate. In the long term, remaining waste rock is either capped with a soil cover or submerged to prevent further oxidation and to stabilize the rock.

4. Technical Assessment and Suggestions

4.1 Positives in Northern Saskatchewan

The uranium industry in Northern Saskatchewan is providing an adequate level of waste management in today's regulatory body. The tailings are expected to behave as a solid, stable mass in the long term, and it is expected that groundwater will travel around the mass as opposed to through it. During operation, the surrounding dewatering system is effectively preventing groundwater contamination, and the collection of leachate through the raise well is removing soluble contaminants and treating them appropriately. The concentration of contaminants in the released effluent is below Saskatchewan Surface Water Quality Objectives [11], and water onsite is managed effectively.

4.2 Short-Term Improvements

Although the current waste management is adequate based on today's standards, this paper aims to be constructively critical. The informed public should question the accepted methods, and industry should continually improve their waste management practices.

The uranium industry is mitigating the long-term effects of waste rock, but during operation mitigations could be improved. The mines are in operation for decades, increasing potential metal leaching and/or acid generation. The current mitigation methods used during operation are focused on mitigating adverse effects that have already occurred such as collecting runoff. Environmental standards for metal mining in Canada recommends wherever possible to use waste rock as part of the backfill material in mined out areas [6]. The current collection system may still be used to treat any runoff water; however more proactive methods that prevent oxidation should be implemented in the first place to reduce the amount of treatment required.

4.3 Long-Term Improvements

The uranium mining industry needs to transition their accepted waste management practices in two areas in the long-term future. Toxic material should be extracted as opposed to being transformed, and effluent should be recycled as opposed to being released.

4.3.1 Transformation versus Extraction

Regulators and industry have accepted transformation of mobile toxins into an immobile, stable state as a sufficient method of waste management, there are more advanced methods of treatment. Ion exchange and crystallization are advanced extraction methods of water treatment that are able to recover toxic metals, alternative to simply transforming and transferring the problem to another state. Extracted metals can be stored as hazardous waste or traded as a commodity with another industry. [7]

When transforming waste, a large amount of chemical additives are used for precipitation and this increases the volume of solid waste. The large volume forces the use of a TMF and hence, stores it in the natural environment. If, however, the toxic metals were extracted, it would be feasible to store the waste in an above-ground hazardous waste facility eliminating potential contact with the natural environment, specifically groundwater.

There are a large variety of toxic metals associated with tailings due to the variety of ore accepted from different mines. If the metals were extracted, they could be used in other industries. Arsenic can be used to treat acute leukemia and locate tumours. Nickel is primarily utilized as an alloy,while lead can be used to produce electrodes, ammunitions and batteries. All of these metals are viewed as a nuisance to the uranium mining industry, yet they hold value in other industries. [7]

4.3.2 Release versus Recycle

The current water treatment methods reduce the concentration of radio-nuclides and heavy metals but do not eliminate them. The perception of contaminant loading into the environment is quite different when assessed based on single event sampling or cumulative mass loading. Effluent releases are well below guidelines on a daily basis, but there are suspected adverse effects from cumulative loading. The Department of Fisheries and Oceans predicted a loading of 103,230 kg of uranium into the natural water bodies over the lifespan of the McClean Lake operation [4]. The mill has a water requirement and effluent could be recycled back to the mill to meet this demand, in turn reducing the contaminant loading on the environment. To address the cumulative effects, industry should aim to have a closed loop system and zero effluent release.

4.4 Implementation of Improvements

Implementing long-term improvements is not going to happen overnight, and this is primarily due to the financial requirement. In order to implement the suggested improvements, regulatory involvement would be required. The regulatory interest would lie in creating incentives or enforcement to encourage industry to improve the quality of tailings, and decrease the quantity of effluent released in natural water bodies.

To encourage extraction of metals via enforcement, regulators could apply a surface solids disposal limit to the concentration of contaminants in the tailing facilities. This would be expressed in milligrams of contaminants per kilogram of tailings. The limit would be applied to all solids disposed under the ground surface.

Another enforceable technique to encourage “recycle versus release” is to limit the total cumulative environmental loading of each facility over its lifespan. This would require each company’s facility to track the total mass balance of contaminants released to the environment while the facility is in operation. If the mass balance approaches a maximum cumulative release of any one contaminant, the company would be required to extract that contaminant from their waste stream. If extraction were not viable, they would have to improve upon the recycle volumes in their millings process to reduce the amount of water released, thus avoiding a penalty of surpassing their maximum limits.

With respect to Surface Water Quality Objectives [11], the current objectives are applied across the province. Their objectives address water quality problems more specific to southern Saskatchewan’s water issues pertaining to total dissolved solids concentrations. Creating site-specific SWQO for areas of differing water concerns would be an effective means of addressing area-specific problems. A SWQO applied to the Athabasca Basin region would address their localized problems of heavy metals content in the release water. In addition, a site-specific

SWQO would create cumulative limits that would not allow for the continuous release of low concentrations of contaminants.

5. References

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