SALT TAILINGS-THE ULTIMATE SALINE RECLAMATION CHALLENGE[1]

by

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Abstract: Potassium, one of the three essential nutrients necessary for plant growth is supplied in fertilizer form by the beneficiation of various potassium rich evaporates referred to as potash. Canada, mainly Saskatchewan produces about 20% of world production and has almost 70% of the world's conventionally mined ore. Of the 71 operations throughout the world, most rely on standard shaft mining techniques and dispose of their tailings on surface. Tailings which comprise at least 60% of even the best grade ore as found in Saskatchewan, are predominantly NaCl. Contamination of surface and ground water by brine originating from surface storage of waste process brine and precipitation on the salt tails is the main environmental concern facing the industry. The industry has met with some success in containing the brine and limiting environmental impact using both active and passive containment measures. Little consideration has been given to the abandonment and decommissioning of potash tails piles. If mining techniques remain the same, by the time Saskatchewan's reserves have been depleted using conventional underground techniques, the 10 existing tailings piles comprising 250 M tonnes of salt will increase to 200, containing 30 000 Mt and covering 1600 km^2. The impact on Saskatchewan's ground and surface water resource will be disastrous unless alternative methods of tailings disposal can be developed or the tailings can be isolated from the environment. As long as a mine is operational, supporting active brine containment measures, ground water contamination can likely be kept to an acceptable level. Decommissioning will be site specific and likely involve a number of options at any one site. Surface storage of salt wastes, especially in a rechange position will no longer be acceptable in Saskatchewan due to the potential for extensive ground and surface water contamination. Research is required to determine the capacity of both surficial and deep aquifers to receive brine; long term changes in the rate of brine release from salt tailings; the feasibility of returning salt tailings underground; and reclamation of severely salt contaminated sites using soil covers and vegetation.

Additional Key Words: salt tailings, potash, reclamation, containment, brine disposal, aquifers, deep well injection

Introduction

Research into reclamation and environmental concerns regarding potash waste is in its infancy. Even though potassium (K) is one of the three major plant nutrients, its widespread use as a fertilizer did not develop as quickly as it did for nitrogen and phosphorous. Potassium is a relatively common element accounting for about 2.5% of the earth's crust, and until recently has been available to crops in sufficient quantities. The increase in demand for potash as a source of potassium fertilizer has resulted in expansion of mining facilities throughout the world, notably in Saskatchewan. Due to its brief history, there is little understanding and until recently, little awareness of the short and long term environmental implications of the extraction and processing of potash ore.

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History

It was not until 1861 that the first potash mine was completed in the Strassfurt region of Germany. Development was restricted to Germany, until 1914 when France became involved following the discovered the Alsatian deposits.

It took the outbreak of World War 1 to initiate a potash industry in North America. Unlike the situation in Germany and France, the initial potash processing was not associated with underground extraction but rather with the use of naturally occurring surface evaporates at Searles Lake, California, Utah's Great Salt Lake and in Northern Nebraska. Within 3 years production peaked to 70 kt/a KCl at 65 plants but rapidly declined to a handful of producers, once the European sources were again accessible. It was not until 1931 that North America became a significant supplier of potassium, eventually opening seven mines near Carlesbad New Mexico. During the same period, European reserves were exploited in Poland, Spain and Russia, and at the Dead Sea in Palestine. Following World War 11 the Soviet Union annexed Poland's East Galatian mines, and Germany's production was split 60-40 between the German Democratic Republic (GDR) and the German Federal Republic (GFR).

Despite the initial discovery of potash in Canada during oil exploration in 1943, it was not until 1952 that the first attempt to exploit the vast Saskatchewan reserves was

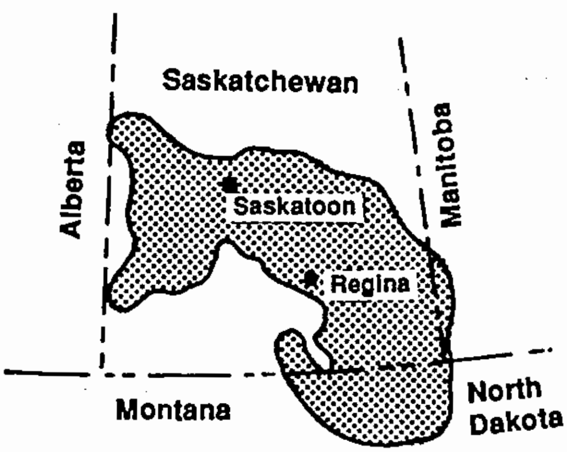

Figure 1: Location of Saskatchewan's potash ore body.

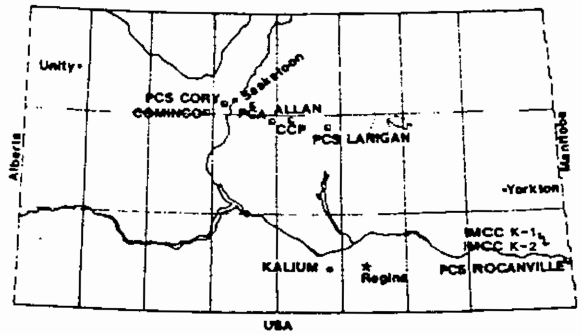

Figure 2. Location of Saskatchewan's 10 potash mines and refineries.

undertaken (Fig 1, 2). Exploitation of the ore body, that would eventually account for 70% of the world's conventually recoverable reserves, and 20% of it annual production (Energy, Mines and Resources 1982, Sheldrick and Stier 1978) did not get underway due to shaft flooding until 1962. By 1969 Saskatchewan's 10 mines were operating with a total capacity exceeding 10 M t/a.

During the late 1950's and the early 1960's China began processing surface brine and Sicily began to mine its underground reserves. About the same time as Canada entered into potash production, Spain began exploiting its Navarra deposit and the Soviets opened their first mine in Byelorussia. In 1964 the United States commissioned their newest potash operation at Cane Creek, Utah. In the latter part of the 1960's the Congo Basin reserves in West Africa were opened, only to be flooded and closed in 1977.

Most recent activity has been confined to Great Britian (1973) , eastern Canada (1983 and 1985, New Brunswick), Brazil (1985), and Australia (1974-1976), Israel and Jordan (mid 1980s). The latter three are surface operations (The British Sulfur Corporation 1985).

Ore Bodies, Recovery and Processing

The vast majority of the world's 71 potash mining operations exploit subsurface evaporites (Sheldrick and Stier 1978), deposited as long ago as 400 million years ago, as in the case of the Saskatchewan and Byelorussia. Deposits range from 100 m below surface to in excess of 1200 m, with most between 500 m and 1000 m. Two operations are open pit and seven exploit surface deposits. The remainder are conventional subsurface mines with the exception of three which extract feed by solution mining.

Although there are a number of potash ore types, the most common and richest in K is sylvinite - a combination of KCl and sodium chloride (NaCl). Separation of the KCl in North American is by flotation with dissolution and recrystallization to enhance recovery. Flotation separates KCl from the salt wastes through attachment of air bubbles to the KCl particles. Dissolution and recrystallization exploits differences in solubility between KCl and NaCl. Dissolution - recrystallization is used alone in several plants in France, Germany and in older operations in eastern Europe and the Russia. Only one refinery, located in West Germany utilizes electrostatic separation to remove NaCl prior to flotation.

Waste Generation and Handling

Flotation and recrystallization consume large quantities of water. In Saskatchewan about 1 m^3 H_20 is required for every tonne of KCl produced (Fig 3). Brine migration from the extensive waste management sites is the most significant environmental concern facing the potash industry. Air

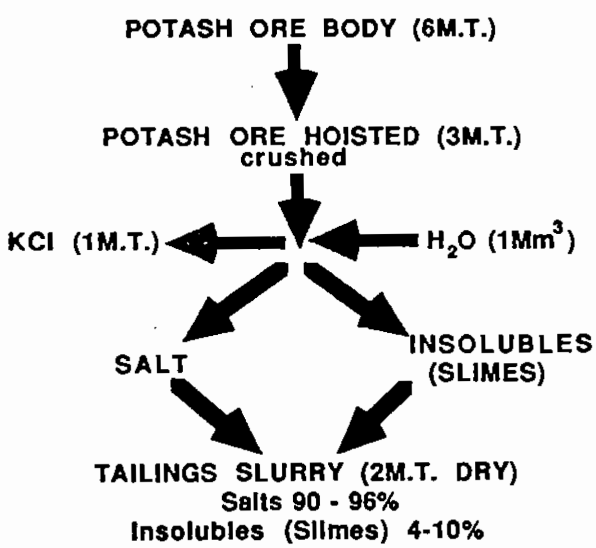

Figure 3: Process flow chart showing water consumption and product to waste ratio.

emission impacts on soil and vegetation are relatively minor , due to effective controls. (Hart 1983, Rennie 1983).

Production of solid waste is significant even in the richest ore bodies. In Saskatchewan, the waste : product ratio is about 2:1 (Fig. 3). NaCl is the major waste component , comprising more than 90% of the total waste, with KCl (<10%), and insolubles (2-9%) make up the remainder. The insoluble fraction, also referred to as slimes and insols is mainly clay and dolomite, and small quantities of quartz, potassium feldspar, microcline and anhydrite (SRC 1982).

In most cases solid wastes are disposed of on surface. Under certain geological conditions they are returned underground as is done in the Hanover area of Germany, in New Brunswick and in some mines in the U. S. S. R.. Although no producer in Saskatchewan disposes of waste in this manner, the Potash Corporation of Saskatchewan (PCS) (Taylor and Butcher 1983) has considered using solid waste to support the mine back to increase extraction efficiency and reduce surface waste storage. International Minerals and Chemical Corp. (IMC), also located in the southeastern Saskatchewan, is presently investigating the feasibility of returning solid waste underground in the form of a slurry.

Dissolved salt waste and waste brine are in some situations injected into saline aquifers. In West Germany over one-third of the 20 Mt of salt waste generated per year is injected into saline aquifers above the mining formations (Scroth 1977, 1973) while in Saskatchewan 10 to 15% of the salt waste is disposed of in aquifers below the ore body. In Germany some of the brine (1%) appears to be resurfacing. Saskatchewan's receiving formations which are much deeper (>1 000 m) discharge in Manitoba and N. Dakota (Reeves 1989). The impact of a possible increase in the discharge rate, due to injection has not been studied.

In Saskatchewan, even though the injection well capacity is sufficient to dispose of all process brine, most is still stored on the surface in large tailings ponds (Fig. 4) for slurrying of wastes. Additional brine is generated by precipitation falling on the tails pile and the brine ponds. Annual precipitation (35 cm) on tailings and brine ponds which cover from 100 to over 400 ha, can produce an additional 350 000 to 1 400 000 m^3 of saturated brine. Loss by evaporation likely accounts for a large proportion of this precipitation generated brine. France and the U.S.S.R. don't utilize injection, relying on disposal into surface waters and large evaporative ponds, respectively (Chomiak 1983, Scroth 1977, 1973).

Instead of utilizing deep well injection, the East German and French producers dissolve tailings and pump the salt waste into rivers. This practice has resulted in elevating chloride levels in some parts of the Rhine above limit set for human consumption (Chomiak 1983). Three mines located in Brazil and Atlantic Canada and Britain use the Atlantic for disposal.

The majority of potash wastes are stored on surface in Saskatchewan. Salt wastes are pumped as a slurry (25 - 30% solids) to large tails piles ranging in area from 50 to 200 ha, and 20 to 60 m in height. Due to the competence of salt tailings, pile slopes usually stand at 30° to 35°, with the exception of the long, gentle (2°) decant slope which serves to settle the solids before the waste brine reaches the brine ponds. The height of the piles does not seem limited by the tailings strength but rather by that of the soils underlying the tailing. Failure of foundation soils is possible due to build-up of pore pressure caused by rapid loading (Johnson 1984).

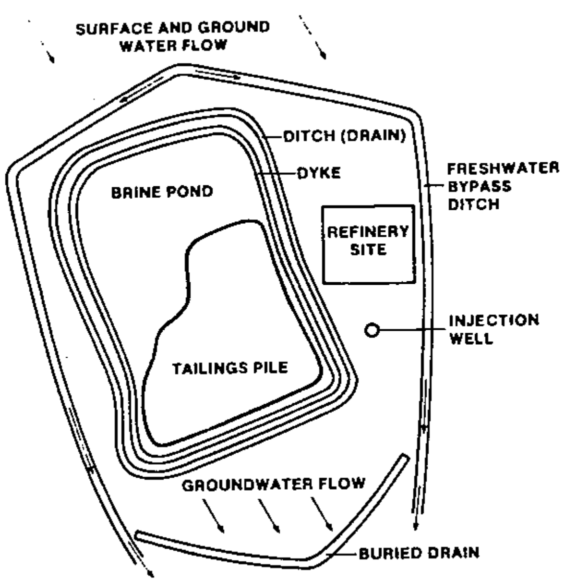

Figure 4: PCS Lanigans refinery and waste management site.

Tailings Hydrology

An understanding of the hydrology of potash tailings is required to determine the rate of brine generation and location of discharge, which is essential in designing a containment and decommissioning strategy. The only general model proposed for potash tailings was proposed for tailings in the Alsace region of France. Taleb and Valentin (1975) indicated that nearly one-sixth of the precipitation falling on potash tailings runs off the pile, while one-third infiltrates the surface and percolates through the pile to discharge in the groundwater. The remainder evaporates. In Germany, Scroth (1977) reported a similar evaporative component.

The European model does not at first appear to be applicable to the Saskatchewan situation where runoff and evaporation from the pile seems to be insignificant, at least for small events (Shook and Reid 1986). The differences may be explained by the nature of the pile surface. In Europe and the U.S.S.R. the tailings are frequently much higher in insoluble materials, which have been reported to form a crust of low permeability within a few years of abandonment (Heinz and Fiedler 1979, Bogomolov et al. 1977, Golovin 1976). Saskatchewan tailings are not only much lower in insoluble material but have also had little opportunity to weather (Hart 1988).

An unknown proportion of the total recipitation and process brine discharged (spigotted) on the tailings infiltrates into the tailings pile. This fluid recharges the brine mound (brine storage), located at the base of the pile, allowing the pile to act as an arificial aquifer. The mound can be a significant factor in determining brine movement into the underlying aquifers especially since the head for a given height of fluid, exceeds that of freshwater due to its greater density. While spigotting is on-going the mound has been reported as high as 7 m, however it is not known to what extent precipitation alone charges the mound (Shook and Reid 1986). An understanding of the size of the driving head is important in determining the potential for downward movement of brine from an abandoned pile.

Pile drainage is by seepage, and flow through large cavities (karsts). The relative importance of these two processes and the formation and extent of the karsting is unknown. Most knowledge is anecdotal. The Soviets (Bogomolov et al.1977) speculate that the karsting occurs close to the surface due to increased density of the tails with depth. In Saskatchewan where cavities have been observed discharging on surface, as well as at the base of pile it has been speculated that the latter might be due to upward movement of freshwater from surficial aquifers (Maathuis and van der Kamp1983). Karsting is also caused by spigotting of undersaturated brine which instead of flowing down the decant slope, bores through the pile just below the mouth of the spigot to surface down slope. It is not known if karsting is a phenomena of active tailings only. Although Maathuis and vander Kamp (1983) speculated that cavities are formed at the base of the pile, the upward movement of freshwater will likely cease as pore pressures from. rapid pile build up, dissipate.

Exactly where a pile discharges its brine is open to speculation. Discharge has been reported in the U.S.S.R. to be inhibited at the base of the pile due to the development of a dense and impermeable zone brought about by compression, and precipitation of salt in voids as a result of cooling with depth (Klement'yev et al. 1974). This however does not appear to be the case in Saskatchewan. There is evidence that PCS's Rocanville tails pile, which at 60 m in height, the tallest potash tailings pile in Saskatchewan, lacks an impermeable base. Whether this is due to general permeability of the tailings or to karst cavities is unknown. The head developed in the brine mound appears to have resulted in downward movement of brine into the surficial and and first intertill aquifers (10 m depth) (Hart 1985a).

Site Characteristics and Brine Pathways

To be effective, containment and decommissioning strategies must be based on a thorough understanding of the stratigraphy and the hydrogeological regime of the waste disposal site. Little information appears in the literature concerning siting conditions for potash waste management areas outside Saskatchewan.

Potash facilities in Saskatchewan are sited on a complex glaciated landscape (Fig 5), involving alternating layers of coarse and fine textured till deposits . The sands and gravels of the stratified drift may occur as surficial, intertill or intratill deposits (Clifton and Sauer 1983). The coarse textured deposits serve as aquifers while the finer textured till layers are relatively resistant to fluid movement, acting as aquitards. In most cases the surficial deposits are fairly permeable and are underlain by tighter soils (Maathuis and van der Kamp 1984, 1983).

Potash facilities are hydrologically situated in recharge or discharge positions (Tallin 1984) (Fig 6). Recharge sites are characterized by movement of surface and groundwater away from the tails pile and ponds. Flow is directed towards the waste management area at discharge sites preventing escape of contaminants. An intermediate situation also exits in which the brine tends to move away from the disposal site via the surficial aquifer but groundwater flowing upward from underlying aquifers prevents downward movement of brine. Most of Saskatchewan potash mines are sited on recharge positions, with the underlying aquifers serving as potential vectors for contaminant transfer.

Migration of brine occurs at most, if not all potash waste management areas, often with serious consequence. In French Alsace, Taleb and Valentin (1975) determined that the 10 potash waste piles which total about 200 Mt have seriously contaminated drinking water up to 25 km away. In addition the French operations contribute to the salinization of the Rhine by pumping 15 Mt/a into the system. Surface storage of salt wastes in the Soligorski area of Belorussia has resulted in groundwater contamination as well as salinization of agricultural soils (Klement'yev et al. 1976, Bogomolov et al. 1974, Turenkov and Zhugarev 1972, Bogomolov and Parfenova 1964, Kolpashnikov et al. 1970). According to Klement'yev et al (1976), contamination of the subsurface waters is spreading at a rate of 10 to 70 m/a. Brine release is not only of the insidious variety. In 1983, a brine pond dike failed in the Lvov area, releasing 4.6 m^3 of brine in a wall 6 m high. This dike failure resulted in serious contamination of the Dneister River, 15 km away resulting in the loss of fresh water for Odessa and Kishinev (Time 1983).

Extent and Impact of Brine Escape

In Saskatchewan, horizontal brine movement in the surficial aquifer ranges from very slight in the case of sites on clay deposits to 100 m/a for the more permeable sites located on recharge positions. The latter is most common in Saskatchewan (Hart 1985 a,b). Although considered to be inevitable at most sites, brine has not migrated into the deeper aquifers, except at PCS's mine at Rocanville in southeastern Saskatchewan. Fractures in the overlying till and a sufficiently large head in the tails pile appears to have resulted in contamination of the first interill aquifer, 10 m below surface.

To date groundwater contamination in Saskatchewan has been contained within a few kilometers of the waste management area. The potential does however exist at 8 of the 10 mines to seriously contaminate groundwater supplies and surface water bodies.

Brine Containment

Brine containment in Saskatchewan has concentrated on retarding the horizontal movement of brine in the surficial aquifer, where contamination is an immediate concern.

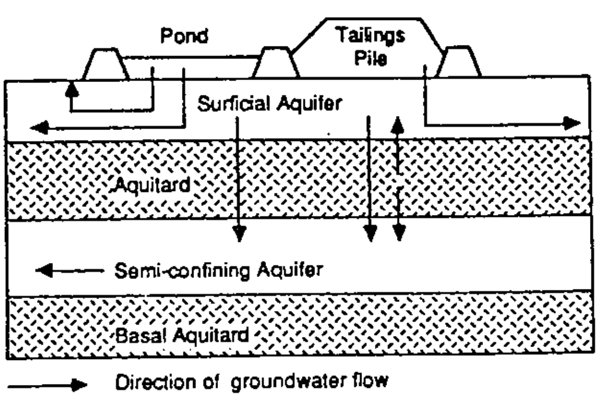

Figure 5: Typical stratigraphy associated with potash waste management area in Saskatchewan (after Maathuis 1989)

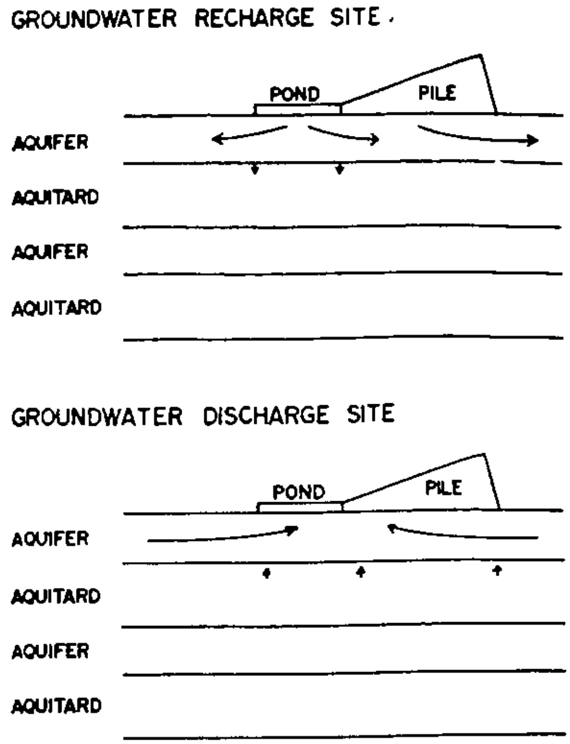

Figure 6: Hydrological positions of potash waste management facilities in Saskatchewan

Lining of brine ponds with synthetic liners, although a common practice in hazardous waste containment has only been attempted at one site in Saskatchewan. The first liners used proved to be totally inadequate , tearing easily and breaking down rapidly. A decade later a new liner, resistant to tearing and degradation due to ultraviolet radiation was installed in a small holding pond at PCS Rocanville. Its efficacy has not been evaluated (Hart 1985b).

Although an extensive system of dikes forms the core of all brine containment, it is usually backed up by one or more passive or active containment efforts (Fig. 7).

To be effective a dike must be constructed of material of low permeability, penetrating into the underlying aquitard. Keys or cut-offs are frequently lacking or have failed to penetrate the underlying aquitard. Ditches located peripheral to the dikes at four of Saskatchewan' s potash mines collect brine that has seeped through the dikes. As with keyed dikes, to be most effective the ditch must be cut down into the aquitard. Buried drains which are simply a more sophisticated ditch, have been installed at three sites and appear to have greatly restricted brine movement at two of the sites.

Slurry trenches are designed to retard brine movement in a similar fashion to keyed dikes. They differ, in that following excavation, the ditch is filled with a sem-liquid material of low permeability as opposed to an earth fill of low mositure content. Although common in hazardous waste containment, slurry trenches have been used in only one instance in the potash industry. Its poor performance which as in the case of failed cutoffs was likely due in part to inadequate penetration of the aquitard (Hart 1985b).

Although keyed dikes, ditches and drains have been used in Saskatchewan, to contain brine within the surficial aquifer. It is impractical to utilize these mitigation efforts in the deeper aquifers. Hydrodynamic containment, which involves pumping the affected aquifer, has been successful at PCS Rocanville. The wells have reduced movement of brine from 53 m/a to 3 m/a (Hart 1985b).

Saskatchewan's Potash Waste Disposal Options

During a conventional potash mine's operational life of about 65 years, 200 Mt of ore will be extracted resulting in more than 130 Mt of salt waste. Most will be stored on surface with the resulting tails pile and brine ponds covering about 8 km^2 at each of the 10 sites. By the time all economically

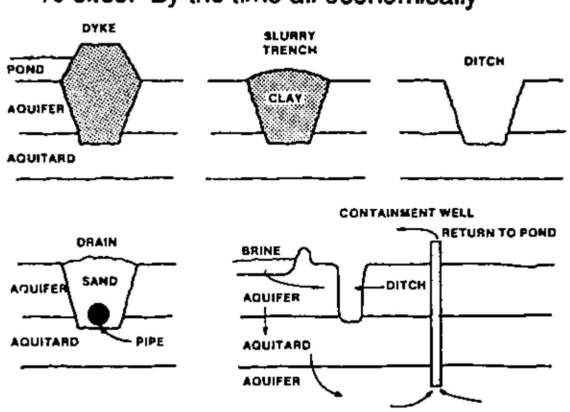

Figure 7. Brine containment structure in the Saskatchewan potash industry.

recoverable ore, estimated to be from 7 000 to 14 000 Mt KCl (The British Sulfur Corporation 1985, Sheldrick and Stier 1978) has been extracted by conventional mining techniques, 14 000 to 28 000 Mt of salt waste will have been generated. If salt wastes are handled as they are today, this translates into 100 to 200 tails piles and associated brine ponds occupying up to 1 600 km^2 of agricultural land. Saskatchewan has total reserves of 100 000 Mt KCl, if the potash is extracted by solution mining (The British Sulfur Corporation 1985). If the salt waste is disposed of on the surface, this could result in 600 waste management areas, occupying nearly 5 000 km^2.

A number of decommissioning options have been proposed:

1) Marketing Salt

Opportunities to dispose of salt waste through marketing are very limited. Saskatchewan's annual salt waste production due to potash mining (20 Mt), if marketed represents 15% of the world's commercial salt production. The Canadian prairies sell about 700 000 t/a of which 300 000 t/a is derived from potash processing. Abundance of world supply and low value of salt combined with the high cost of transportation to market, preclude any significant expansion in salt sales from the prairies.

2) Underground Disposal

Although seemingly an obvious answer to the waste disposal dilemma, underground disposal is not the panacea if first appears to be. There are a number of limitations: 1) The receiving ore body must be stable, allowing for backfilling without catastrophic collapse; 2) At best only 70 to 80% of the waste can be returned to the mine workings due to expansion during processing and the need for an extensive network of travel ways; 3) The waste presently on surface, which in Saskatchewan is about 250 Mt, cannot be returned to the mine since collapse has eliminated most of the openings.

3) Abandonment

It may be possible to simply abandon a tailings pile. In the case of a discharge location, the area impacted will be limited to the discharge basin, however the majority of Saskatchewan's potash facilities are situated on recharge sites. At these sites the brine release from the pile must not exceed the receiving aquifer's ability to safely absorb salt. An acceptable level of discharge will depend on the initial ground water quality and its intended use. It is also essential that impact, at the aquifers point of discharge must be considered as well.

Precipitation, and groundwater interaction with the pile and the brine pond largely determine the rate of release of brine from the waste management area. Evaporation in the arid prairie environment potentially accounts for all the precipitation falling on the brine pond and much of that which is discharged into the pond from the tailings pile. Although evaporation from an unweathered pile is minimal, the development of a insol rich surface of low permeability in response to pile leaching could result in increased evaporation due to longer surface residence time (Hart 1988). It would also result in an increase in brine level in the pile and a subsequent decrease in the driving head.

Brine generation from dissolution by groundwater at the base of the pile, could be reduced by construction of keyed dykes, drains and ditches located upstream of the waste management area, deflecting or intercepting groundwater moving towards the tailings and brine pond.

After abandonment brine escape might actually increase due to pore pressure decline in the foundation soils under the tailings pile.

4) Dissolution and Injection of Brine

If environmentally acceptable, the injection of waste brine could continue to account for a significant proportion of the brine generated at an active mine site. It is also feasible as part of the decommissioning strategy over the long term. In both cases the rate of salt disposal could be increased by dissolving salt in addition to that brought about by precipitation. It is unlikely, considering the volume of water required (4 000 l/t salt) and the increasing demand for fresh water, that water suitable for alternative use would be utilized to dissolve salt tailings. This has led Cominco, west of Saskatoon to investigate using moderately saline water for this purpose. Water from the Blairmore formation, about 500 m below surface would be used to dissolve tailings and then be pumped back into the formation.

As noted earlier, the impact on the point of discharge for the Blairmore and the deeper receiving aquifers has not been assessed.

5) Solution Mining

Of the 10 Saskatchewan potash mines only Kalium near Regina is successfully extracting KCl by solution mining. Although a large pile has been generated there is some evidence that it will be gradually returned to the mine and the process altered so that salt waste need not be stored on the surface. Recently, cessation of mining due to flooding, a concern for most of Saskatchewan's potash mines, occcured at Potash Company of Saskatchewan's (PCA) mine,east of Saskatoon. This prompted the company to convert to solution mining. When operational, it is hoped that the tailings presently on surface, as well as those generated during solution mining, can be returned underground. Surface subsidence may be a concern since solution extraction in a conventional mine, will as intended remove the ore which previoulsy served as support pillars.

If the conversion from conventional mining to solution extraction is practical and economical, other mines are likely to follow suit. Considering the much larger reserves available to solution mining and the potential for a much smaller environmental impact, it is possible that all future mines will utilize solution. extraction.

6) Reclamation - Revegetation and Capping

Regardless of which decommissioning option or combination of options is chosen, potash waste management areas must eventually be reclaimed. Due either to their areal extent and the proximity to uncontaminated ground and surface water, established methods of desalization are not practical. Leaching for instance, the most effective means of reclaiming severely saline soils (White and deJong 1975) would not only involve large quanities of fresh water but also result in the contamination of groundwater as the salt leached into the undulying aquifers.

North American producers have not attempted to reclaim potash tailings piles although some work has been done on the severely contaminated areas adjacent to the tailings pile. Thorpe (1989) experimented with two amendments in an effort to establish a vegetation cover over barren saline soil adjacent to a potash brine pond. He determined that under natural prairie conditions, upward migration of salts rapidly contaminated the 30 cm soil cover, as well as a similar depth of sewage sludge. Modelling revealed that even 150 cm of either material would be rapidly contaminated by the upward capillary movement of salts from the underlying saline soils.

The literature does not report any reclamation efforts in the Soviet Union, but does refer to minor successes in East Germany. Heinz and Fiedler (1979) reported the establishment of sparse, drough tolerant species on potash tailings in the district of the southern Hartz Mountains. These tailings unlike those in North America have developed a 0.5 to 1 m thick layer of salt-free insols. Pot experiments (Heinz and Fiedler 1981) using only 25 cm of salt free insol revealed the plants perished when the roots contacted the underlying salt wastes. Survival appeared to be related to the depth of the salt-free zone and root avoidance of the salt tailings. Initial success in establishing woody vegetation was also reported in East Germany by (Trillmich 1978).

Due to its arid environment, it is unlikely that a salt-free cover of insols will develop in Saskatchewan. The insol cover would likely remain saline due to capillary movement of salts from the underlying potash wastes..

Caps made of synthetics or soil are an option considered for tailings piles and associated land, severely contaminated by brine (Fig. 8). In order to be effective the cap must not only restrict downward movement of precipitation but also upward migration of salts. In the case of a tailings cap, water must be prevented from reaching the salt surface which would result in dissolution of the tails and collapse of the cover. A covering over brine contaminated land does not have to be impermeable, since a controlled release of

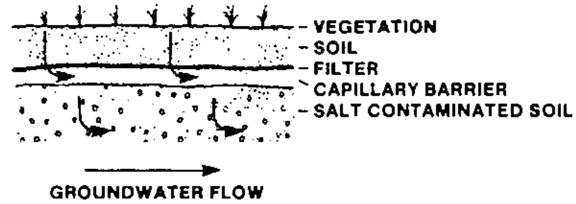

Figure 8. Soil - vegetation cap over salt contaminated soil.

salts into the underlying aquifer is acceptable. Upward capillary movement is not desirable in either situation.

Since a cap must be effective for hundreds if not thousands of years, synthetic membranes are not likely suitable due to their short life expectancy. A "natural" cap comprised of soil and maintained by a vegetation cover is likely to be more resilient.

Soil blankets are commonly employed in tailings reclamation, and decommissioning of industrial waste disposal sites (Marshall 1983). The major concern using this approach has been the upward migration of undesirable materials through the soil cover. This has led to contamination of the cap and the rooting zone, eventually disrupting the vegetation, resulting in cover loss through erosion. Arid regions such as the prairies where potential evaporation exceeds precipitation are especially prone to this phenomenon, as demonstrated by Thorpe (1989).

An appropriate soil cover depth necessary to prevent capillary movement has not been established, although the literature indicates that it likely is in excess of 2 or 3 m (Chopiak and Chekerda 1982,Yamamoto 1982, White and de Jong 1975). Unfortunately even if an effective depth can be established, penetration of precipitation by percolation or along cracks will result in tailings dissolution and collapse. An underlying coase textured layer could serve as both a capillary barrier to reduce the likelihood of upward movement of contaminants from the tailings as well as a drain, preventing moisture penetration into the underlying tailings.

Considering the nature of the underlying salt tailings it is doubtful that capping would be suitable for potash tailings pile. However the concept does appear promising for reclamation of the brine ponds, and severely salt contaminated soils (Fig. 8) Limited penetration by precipitation to the underlying brine contaminated soil would be acceptable, since dissolution and collapse would not occur as would be the case on a salt tails pile. Limited penetration would actually be desirable, if long term desalinization of the underlying soil is intended.

Summary

1) Potassium, one of the three major plant nutrients was first mined in Germany in 1961.

2) Saskatchewan's reserves account for 70% of the world's conventionally mined potash ore.

3) Saskatchewan's annual production of 10 Mt of KCl results in 20 Mt of salt tailings and 10 to 20 M m^3 of brine stored on surface.

4) As long as a mine is operational and can support active brine containment measures such as pumped drains and ditches, and containment wells, ground water contamination can likely be kept to an acceptable level.

5) For new mines, surface storage of salt wastes, especially in a rechange position will no longer be acceptable in Saskatchewan, due to the potential for extensive ground and surface water contamination.

6) Neither potash tailings piles nor the associated salt contaminated land have ever been decommissioned or reclaimed .

7) Decommissioning of present facilities will be site specific and likely involve a number of options.

8) Standard methods of reclaiming saline lands are impractical. Reclamation of saline soils adjacent to potash tailings and associated with brine ponds will likely involve soil covers with capillary barriers.

9) Research is required to determine:
- -the capacity of both surficial and deep aquifers to receive brine.
- -long term changes in the rate of brine release from salt tailings
- -the feasibility of returning salt tailings underground.
- -the effectiveness of soil caps for reclaiming salt contaminated sites.

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