ABSTRACT: THE KNEW PROCESS - RECOVERY OF ACID MINES WATER PROFITABLY

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Acidic mines effluent water has presented an expensive problem to recover up until the advent of the KNEW process (Potassium Nitrate ex Waste) patented in 2011 by Trailblazer Technologies. In the KNEW process the polluted waste water from mines is neutralised, filtered to remove coarse particles and precipitated heavy metals, then pumped through an ion exchange battery to remove all the dissolved ions leaving a water of any designed quality.

The ionex battery is regenerated with dilute nitric acid for the cation resin bank and ammonia solution for the anion resin bank. The nitrate blend is treated with sodium carbonate to cause all the multicharged cations to precipitate and to be separated for use in agriculture as a soil ameliorant. The residual sodium nitrate solution is mixed with an equimolal amount of potassium chloride and evaporated with the result that the least soluble salt – sodium chloride – crystallizes out and is separated pure and dried for supply to the chlor-alkali industry. The residual liquor is cooled to produce a pure crystalline potassium nitrate which is separated and dried for supply to horticulture as a primary fertilizer. Another option is to use vegetable ash which has a very high potassium carbonate content as a raw material to precipitate out the multicharged elements giving an even more economic route to the formation of this potassium nitrate.

The anion regenerant solution is treated with methanol to precipitate out most of the ammonium sulfate almost chloride free and is separated, dried and supplied to agriculture as a fertilizer. The residual liquor is treated with sodium hydroxide to recover the ammonia content for recycling and the remaining sodium chloride is recovered by evaporation and added to the cation arisings for supply to industry.

The overall economic picture of the process reveals that the sale of the potassium nitrate pays for the purchase of all the raw materials and the costs of operating the process and even leaves a reasonable profit. If the water produced can be sold -and this is not often the case – then an additional profit can be realised.

The KNEW process is one of the few processes that can beneficially remove the worst and most difficult to deal with pollutant, namely, sodium. As over 60% of South Africa's water is used in agriculture and as all of this water evaporates on the soil to which it is applied this cation causes more devastation to our soils than all other dissolved solids together and must be removed from the environment. The KNEW process also removes all other dissolved ions beneficially and creates a lot of desperately needed less skilled jobs in the chemical processing plants.

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The mining of minerals from the earth's crust will always leave a void from where the more valuable material has been removed and this void will fill with pristine rain water when the wet season arrives. During this water's sojourn in the manmade cavity it will dissolve any soluble salts that it contacts and if the water ingress is excessive then this now polluted mass will spill over into the nearest water course together with its load of salts spreading its problem into the rivers that feed the nation.

This pollution that is generally called Acid Mines Drainage (AMD) and can be quite variable in its make-up due to the wide variety of mining operations in South Africa. In the gold, uranium and platinum mining areas the dissolved salts are mostly sulfate oriented due to the pyrite ore associated with the reefs that are being mined while coal mines create a salinity problem due to the coal fields being fossilized sea beds with dried up salt lakes above them which salinity re-dissolves into the rainwater influx.

Most of the research effort up until the present has been devoted towards developing processes to remove the major dissolved ion – sulfate – along with iron and heavy metals such as manganese and chromium. Little work has been directed towards the removal of dissolved sodium but as will be shown in this paper this is by far the most dangerous pollutant in this mines effluent.

Sodium is a quiet killer of the soil as it attaches to the clay particles in the soil and is not readily removed. When the sodium ion is attached to the clay particles it hydrates and causes the clay to swell making the soil impervious to water and air. Without water and oxygen penetration into the soil the agricultural yield drops quite drastically and this is a far more serious long term problem than any other associated with AMD. Between 60% and 95% of any country's fresh water is used by agriculture so South Africa's water scarcity affects food production far more than it does the much heralded possibility of potable water shortages in urban areas. It is, therefore, of the utmost importance that any process used to clarify AMD be able to remove the sodium content of the water completely from the environment, as well as the toxic heavy metals and, where applicable, and residual radio-activity, if any. It is a misdirection of effort to be concentrating only on sulfate reduction or removal as this ion is essential for agriculture and is purchased in large quantities by agriculture to add to their irrigation water to enhance the protein content of the crops.

To put this argument into perspective it is sobering to think that the daily off-take of the Rand Water Board is 3300ML/day while all of the AMD arising across the mining area is estimated to be about 350ML/day. So to be putting a large and expensive effort into partially or completely cleaning AMD for drinking water purposes seems to be misguided and is usually promoted as a revenue source to try to justify the viability of a particular process. It is far more important that AMD be brought to a quality suitable for agriculture and to be returned to our water courses for irrigation purposes than to be trying to supplement the lesser requirements of the city user.

Thus it became clear that effort had to be put into not only removing and delisting all the toxic heavy metals which are relatively small in volume but to beneficiate the permanently soluble salts like sodium and chloride which cannot be immobilized and to convert them to good use effectively removing them from the environment and at as little cost as possible.

It was clear that none of the precipitation processes could achieve this requirement and this lead to reviewing the work done in reverse osmosis (RO) and in ion exchange.

RO produces the required product water but concentrates the brine problem, uses large amounts of power and is expensive to run. Ion exchange suffers similarly except that it does not use much power. It was, thus, essential that a process be created to convert the arising concentrates to useful products that would remove the permanently soluble salts from the environment and would, if possible, cover its cost of operation.

A solution, the KNEW process, an acronym for Potassium Nitrate ex waste, was developed by Trailblazer Technologies in 2010 which successfully removes all the dissolved salts and converts them into beneficial raw materials for agriculture and industry. The KNEW process thus covers all the costs of the operation from the sale of these end products, uses very little power, creates much needed jobs in the chemicals processing and does not rely at all on the revenue from the sale of water for its economic justification.

THE KNEW PROCESS

It must be stressed that the KNEW process is a means of turning the regeneration mixes from an ion exchange operation into useful and relatively valuable exit products as opposed to all other processes that extract the pollution salts from AMD but produce valueless or troublesome brines and solids. The KNEW process can be fitted after and ion exchange (IX) extraction or reverse osmosis (RO) and convert them into profitable operations but it makes no sense to do this after RO as it is comparatively very expensive to operate while IX can achieve approximately the same at low pressure and low cost.

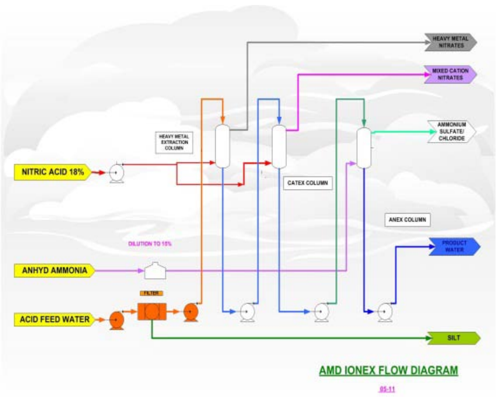

Diagram 1 is a schematic of an IX operation where radio-activity – if present – is first removed for recovery followed by the removal of the cations in the water solution and then the anions leaving a residual water of the design quality. The catex and annex resins are regenerated when exhausted using nitric acid and ammonia to give solutions of nitrate salts of the cations that where present