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The WRC operates in terms of the Water Research Act (Act 34 of 1971) and its mandate is to support water research and development as well as the building of a sustainable water research capacity in South Africa.

TECHNICAL BRIEF

Mine-water treatment

Growing knowledge of the Waterberg Coalfield

A completed Water Research Commission (WRC) study undertook a detailed Acid Base Accounting investigation of the coal-bearing Karoo formations in the Waterberg Coalfield.

Background

The large resource base coal zones of the Waterberg Coalfield, located in the Limpopo Province, will enable the mining of coal in this area and will continue into the future. As the demand for energy in South Africa increases in the coming years, the coal produced from this area will provide essential.

Coal can either be extracted by opencast pit or subsurface mining methods, depending on the depth and quality of the coal seams. However, opencast pit mining methods produce more waste rock than subsurface methods, due to the removal of the lithologies both over and in-between the coal zones.

The oxidation of iron sulphides, present within the discard dumps and coal stockpiles, can influence the hydrochemistry of the groundwater. The main concern is the generation of acid rock drainage (ARD).

During mining operations, the open pit can be backfilled with plant discards, overburden and interburden of various combinations thereof. On completion of mining the open pit is covered with topsoil.

The main aim of the study was to identify the potential of acid generation from the overburden, interburden and plant discard that will be removed and placed on the discard dumps, and possibly used as backfill material. Acid Base Accounting (ABA) is used as a prediction tool to determine the acid potential of the lithological units.

Among others the study sought to determine the acid-base potential of all the different geological layers; determine the best methods of how to handle these spoils and discards in order to minimise the risk of acid generation; and if underground mining will be practised.

Geology

There are two main coal-bearing formations in the Waterberg. The upper Grootegeluk Formation ranges in depth from 60 to 110 m in the south and the lower Vryheid Formation, a more carbonaceous and interbedded sequence, at about 55 m in thickness. This is composed of areas with full successions of coal where all the coal-bearing strata of the Grootegeluk formation are present.

There appears to be a general upwards decrease of coal to mudstone ratio present within certain zones. The Grootegeluk Formation has a distinctive upper coal unit with well-developed thick coal layers alternating with well-developed mudstone layers. Towards the bottom of the succession both coal and mudstone layers alternate more frequently and are thinner.

Geohydrology

The groundwater potential of the formations is limited due to the low permeability, storage and transmissivity. The Eenzaamheid Fault forms the southern boundary within the study area. This boundary separates the area into two distinct geological units, the Karoo Supergroup to the north of the fault, and the Mokolian Supergroup to the south fault.

There are two distinct types of aquifers found in the groundwater system of the geological formations of the Waterberg Coalfields. The two aquifers in the area are associated with an upper weathered (sandy) material groundwater system and an underlying competent and fractured rock material groundwater system.

Acid Base Accounting

In order to assess the various acid and base producing potentials of the material sampled from various sections in the study area, ABA tests were performed. This consists of two parts of tests, static and kinetic.

The static test provides a rough indication of the acid generation potentials of the various lithological units. The kinetic test is done over a period of 20 weeks and helps to establish which of the samples are prone to produce acid by exposing it to water and oxygen and to establish the rate of constituent leaching.

The results of the ABA tests were used to indicate the acid generating potential of the overburden, interburden and composites. Elements that will be leached in the vicinity of the mining area will influence the quality of the chemistry of the groundwater.

Except for two samples, all the composite samples received turned acidic upon oxidation. The composites are discard fractions that were obtained after different density treatments at the mine.

The samples with the best base potential (not turning acidic) were the overburden samples from Grootegeluk. Most geological layers adjacent to the coal bearing layers contained an acid potential.

Both shale and mudstone have both acid and neutralising potential, while most of the sandstones beneath 60 m have a distinct acid generating potential.

The amount of metals that go into solution increases as the pH decrease. This is an important factor to keep in mind, especially with samples used as neutralising material. The metals are usually toxic. The total salts leached into the environment (aquifers topsoil) will also increase due to the solubilisation of elements suddenly exposed to weathering. The concluded acid generation potential of each lithology was then considered during the process of determining an optimal backfilling methodology. The Grootegeluk Colliery is the only coal mine currently in the Waterberg Coalfield, and was therefore used as a case study for determining the optimal backfilling method.

It was concluded that the currently applied backfilling method at the Grootegeluk Colliery is the most appropriate backfilling method, because it promises the lowest long-term environmental risk for water contamination. It was concluded that the backfilling method applied at this colliery can also be applied to other mines within the Waterberg Coalfield as a recommended guideline.

Main conclusions of the study

Chemical and biological processes play an important role in the production, release, mobility, and attenuation of contamination in acid rock drainage waters. The rate of oxidation can vary depending on the accessibility of air, moisture and microbes to the pyrite surfaces.

The type of mining and mineral processing plays a part in the initiation of the acid mine waters in the mining environment, and the methods that are employed have to be used in connection with the appropriate remediation and treatment to minimise the generation of acid rock drainage. Neglect to these factors can cause acid rock drainage problems that will be hard to control once it has begun.

The ABA results determined that the interburden and discards used as backfill material has a potential to generate acid. This includes the composite samples with various densities from the processing plant. Overburden material, on the other hand, has a neutralising potential.

The ABA illustrated that the shale and mudstone samples have both acid and neutralising potentials and the majority of sandstone samples beneath 60 m have a distinct acid generating potential.

The amount of metal in solution increases as the pH drops. The high concentration may be due to the presence of pyrite in the coal and interburden sandstone samples. Overburden samples have the lowest sulphate concentration which is ten times lower and more when compared to all areas of analysis as well as composite samples.

The pH directly affects the type of metals that are mobilised. In pH conditions around two there is a high leaching of heavy metals occurring. Various analytes are released at different pH values. Nickel and other constituents' increases in solution at lower pH environments.

The amounts of TDS from the full, partly weathered and Middle Ecca successions are directly related to the iron and sulphate values. The increase of these elements increases the amount of salts that are liberated from the samples. The Middle Ecca has a lower total salts that are liberated than the full and partly weathered successions.

The fly ash from Matimba Power Station has a high potential to reduce acidity. The fly ash showed a limited alkalinity over time, in the event of an acidic condition persiting for long periods. The readily available soluble salts in ash will result in higher salt loads that will be mobilised into the pit water.

The composite material can be used as backfill material within the pit. It only becomes a risk upon exposure to oxgygen and water. The Waterberg area has a relatively low annual rainfall, high evaporation and deep groundwater levels, thus the risk to produce acid from infiltrating water is limited. The risk of exposure to oxygen leads to the spontaneous combustion of discard material.

Based on the investigated scenarios for backfilling, the mixture and/or layering of a combination of material are recommended.

The layered option, which is the current means of backfilling at Grootegeluk Mine, has the lowest long-term environmental risk for water impact. It reduces acid rock drainage rates and leaches alkalinity into underlying acid generating discard material.

The process of mining and beneficiation, stockpiling of coal, coal products and waste is an important factor in management practice, as it makes the environment and water more vulnerable to degradation. More care should be taken in understanding and managing exposed rock or waste piles, which create paths for pollution migration.

It is also important to understand the physical characteristics of the mine waste/stockpiles such as permeability and weathering, which play a role in accelerating the process of acid rock drainage. Prints of mismanagement, neglect and a lack of knowledge have left areas with abandoned mines with acid rock drainage issues.

Further reading:
To order the report, *A detailed Acid Base Accounting study of the coal-bearing Karoo formations in the Waterberg Coalfield* (**Report No. 2142/1/14**) contact Publications at Tel: (012) 330-0340, Email: orders@wrc.org.za or Visit: www.wrc.org.za to download a free copy.