# Passive Treatment Technologies for the Treatment of AMD From Abandoned Coal Mines, eMalahleni, South Africa-Column Experiments

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## Aims and Objectives

general aim of the research was to contribute towards mine water treatment solutions in SA by investigating passive treatment systems in remediating AMD from coal mines. study investigated a DAS system in treating AMD from an abandoned coal mine in eMalahleni, Mpumalanga Province and compared it with RAPS which have been investigated and implemented in many parts of the world.

By ensuring that the main aim is met the following objectives were looked at:

- Reaching neutral pH (6~9)
- Lower concentrations of metals, e.g. Fe<1 mg/L, Al<0.15 mg/L and Mn<1 mg/L
- Lower sulfate levels (<200 mg/L)

## Materials and Methods

### Feedstock

AMD treated for this study was collected from a discharge collecting point of an abandoned mine situated about 25 Km South East of eMalahleni. A 25 L container was used to carry the acid water from the site to the laboratory. container was rinsed many times (about 5 times) before it with the AMD. acid water is characterized by pH levels that are approximately 2.7, EC values that are extremely high (~1672 mS/m), high sulfate levels and high concentrations of metals (Fe, Al and Mn) exceeding industrial water standards as set by DWAF (Table 1).

| Parameters | Average Douglas discharge | Target water quality range (DWAF)-Industrial standards |
|---|---|---|
| pH | 3 | 6~9 |
| EC (µS/m) | 1672 | 70 |
| Al (mg/L) | 115 | 0.15 |
| Fe (mg/L) | 180 | 0.1 |
| $SO_4^{2-}$ (mg/L) | 6091 | 200 |
| Mg (mg/L) | 20 | 30 |
| Mn (mg/L) | 5 | 0.05 |

**Table 1:** Average water results AMD and the target water quality range (DWAF Standards).

Cow manure that was used comprised pH of approximately 6.8, EC was about 280 mS/cm and moisture content was measured to be 68.9%. Limestone used in both treatment systems contained about 93% of calcium carbonate in the form of calcite ($CaCO_3$) and dolomite ($CaMg(CO_3)_2$. particle sizes of the limestone used in the DAS system were <0.106 mm while the limestone used in the RAPS system were >7 mm.

### Experimental setup

Two passive treatments, i.e. DAS and RAPS, were staged in the laboratory for the passive treatment of AMD.

**DAS:** Acid water was pumped with a peristaltic pump at a constant rate in an upward movement into the column containing a mixture of 25% (v/v) limestone and 75% (v/v) wood shavings. residence time in the treatment system was set to 24 hours so that there can be enough for sampling resulting in the acid water being treated to be in contact with the material in one column for 12 hours.

**RAPS:** Acid water was pumped with a peristaltic pump through a tube at a constant rate into the column containing a layer of manure underlain by limestone. Manure substrate occupied 30% (v/v) of the column, while the limestone occupied 50% (v/v). In a downward movement, the treated water from the column into the second column which is the same material contained in the column. residence time of 24 hours was set for the acid water to be treated in the passive system with 12 hour contact time of the treated water in each column.

### Analytical methods

XRD and XRF analysis were used for the reactive material (limestone) for mineral and elements (traces and major) and concentrations before and use respectively. Tests for water pH, redox (pE), EC, TDS and dissolved oxygen (DO) were done in the laboratory to evaluate the quality of the treated water using pH and EC meter, also called multi-meter. multi-meter was calibrated every time before use. For the conductivity probe, EC solution was used for calibration and pH calibration solutions, 4.0, 7.0 and 10.0, were used for the pH probe.

water samples were collected weekly following WRC 2000 procedure and submitted for the IC and ICP-MS (inductively coupled mass spectrometry) analysis to identify concentrations of metals and metalloids. Alkalinity and acidity tests were also conducted to check whether the water is acidic or alkaline.

### Geochemical method

PHREEQC was used to evaluate the behavior of the selected treatment methods in order to predict its in treating AMD.
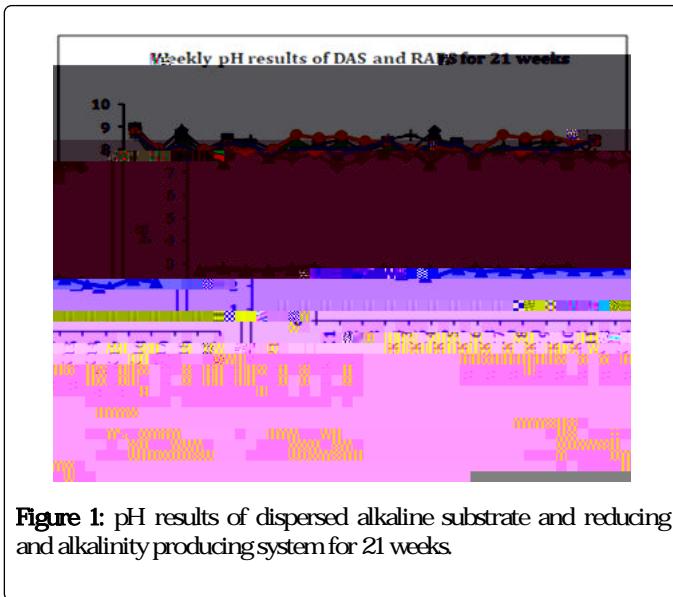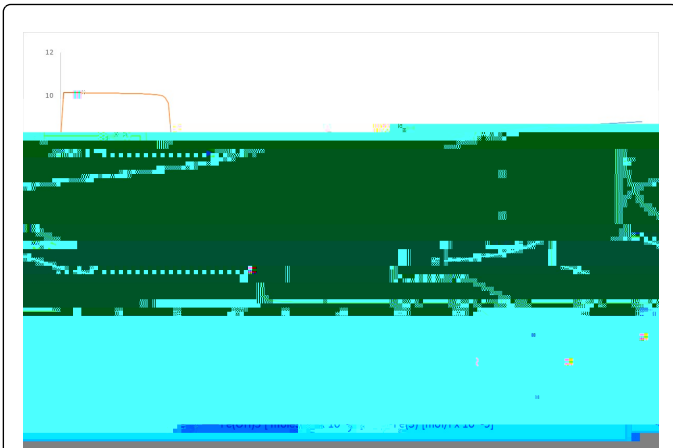
**Figure 1:** pH results of dispersed alkaline substrate and reducing and alkalinity producing system for 21 weeks.

pH increase was primarily due to the calcite dissolution (Equation 3 and 4), releasing $Ca^{2+}$ into the solution resulting in generation of alkalinity in the systems to be increased from 0 mg/L in the acid mine water to an average of 462 mg/L as $CaCO_3$ in the DAS system and 272 mg/L as $CaCO_3$ in the RAPS system.

$$CaCO_3 + 2H^+ \quad Ca^{2+} + H_2O + CO_2 \quad (3)$$

$$CaCO_3 + H_2CO_3 \quad Ca^{2+} + 2HCO_3 \quad (4)$$
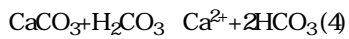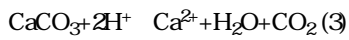
increase in the $Ca^{2+}$ concentration was witnessed in the DAS

**Figure 4:** PHREEQC simulation results showing an increase in pH and a decrease in Eh when the AMD solution reacts with calcite.

Mn concentrations were reduced by the two passive treatment

Some of the contaminants that were equal or increased by the two systems are mentioned below.