
# Treatment of Coal Mine Leachate for Neutralization and Metal Removal

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# OUTLINE

- Introduction
- Sampling points
- Open pit
- Objectives
- Water quality
- Process configuration
- Reactor design
- Feasibility studies
- Acknowledgements

# INTRODUCTION

## Acid mine water

## Sludge

Mokgadi, 2024

Understanding mining waste management and disposal methods, 21 May 2022.



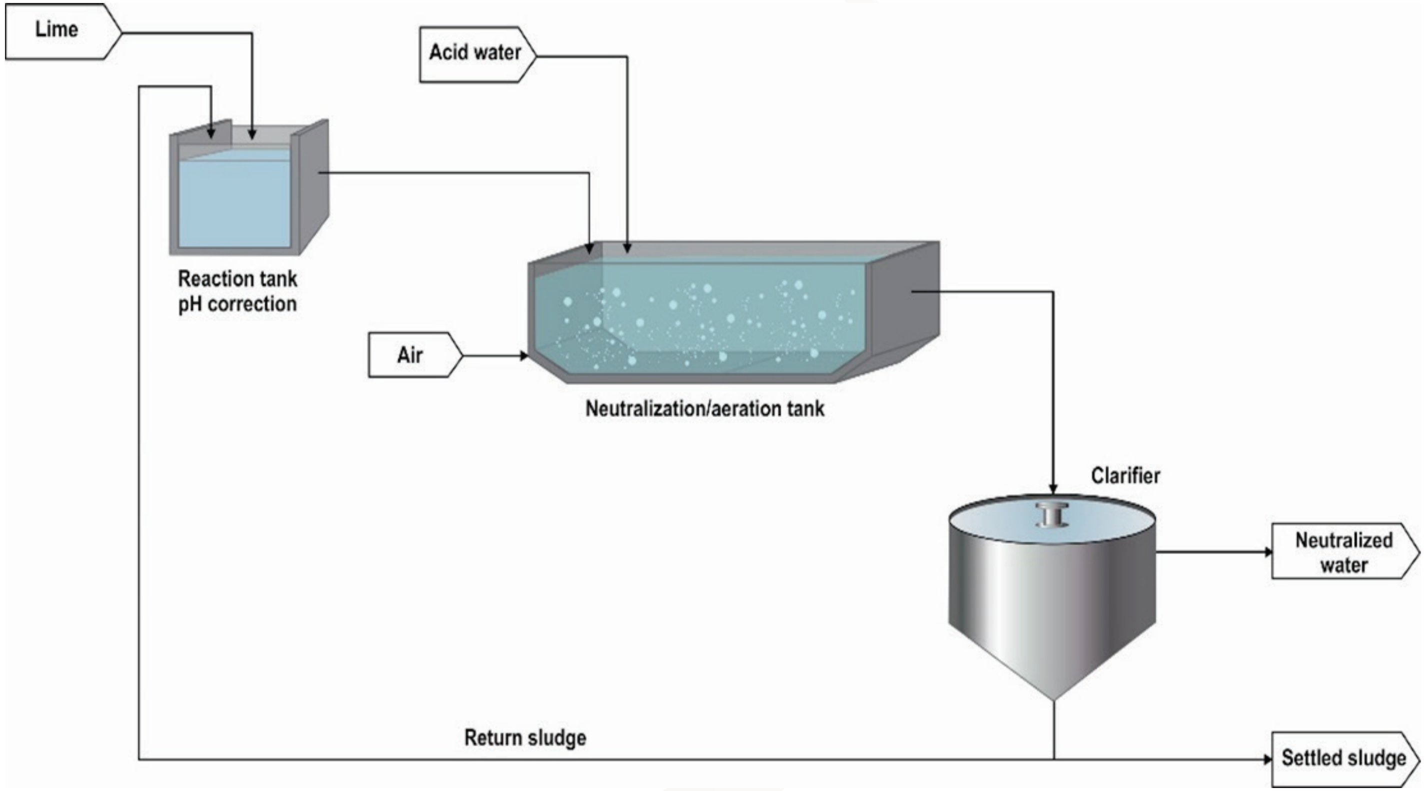
(Maree et al., 2013, Maree and Mthobeni, 2018, Mey and Niekerk, 2009, Reddy et al., 2010)

# INTRODUCTION CONTINUES….

- Acid mine treatment

- Alkalis such as $CaCO_3$ (ZAR 1050/t), $Ca(OH)_2$ ZAR (3 950/t), CaO (ZAR 2500/t) and $Na_2CO_3$ ZAR 10 000/t) can be used, ($1.00 = ZAR 19.04 – 16/04/24).

- HDS process configuration
  - Lime is expensive
  - High capital and maintenance cost due to gypsum scaling




Kostenbader and Haines, 1970, Gazette, 2008, Osuchowski, 1992.

# SAMPLING POINTS


**Figure 1: Google map for Khwezela colliery**

# OPEN PIT


**Figure 2: Google map for Khwezela colliery at mining site**

# OBJECTIVES

1. Provide process configuration to minimize capital and alkali cost,
2. Predict the water quality of the treated water,
3. Propose a reactor design to minimize capital and maintenance cost,
4. Feasibility comparison between conventional and proposed process configuration.

# WATER QUALITY (OLI SIMULATION)

**Table 1: Water quality of Pit water and after treatment with $CaCO_3$ and $Ca(OH)_3$ as predicted with OLI software**

| Parameter | | Feed | $CaCO_3$ | $Ca(OH)_2$ |
|---|---|---|---|---|
| Dosage | mg/L | | 4 521 | 195 |
| pH | | 2.0 | 5.9 | 9.8 |
| Acidity | mg/L | 16 030 | 10 | 0 |
| $H^{+}$ | mg/L | 282 | 0 | 0 |
| $Fe^{3+}$ | mg/L | 400 | 0 | 0 |
| $Al^{3+}$ | mg/L | 260 | 0 | 0 |
| $Fe^{2+}$ | mg/L | 212 | 6 | 0 |
| $Mn^{2+}$ | mg/L | 73 | 73 | 4 |
| $Mg^{2+}$ | mg/L | 250 | 250 | 186 |
| $Ca^{2+}$ | mg/L | 200 | 617 | 545 |
| $SO_4^{2-}$ | mg/L | 5 937 | 2 143 | 2 223 |
| TDS | mg/L | 7 614 | 3 089 | 2 958 |
| Gypsum | mg/L | 0 | 6 825 | 6 669 |
| $Fe_3O_4$ (Magnetite) | mg/L | 0 | 831 | 847 |
| $FeCO_3$ (Siderite) | mg/L | 0 | 14 | 0 |
| $Al(OH)_3$ (Gibbsite) | mg/L | 0 | 753 | 753 |
| $Mn(OH)_2$ ((Pyrochroite) | mg/L | 0 | 0 | 118 |

# PROCESS CONFIGURATION


Use precipitated $CaCO_3$ & $Ca(OH)_2$ for neutralization

01

Combine completely-mix reactor with clarifier

02

Replace conventional clarifier with slimes dam for solids separation and sludge disposal

03

# REACTOR DESIGN

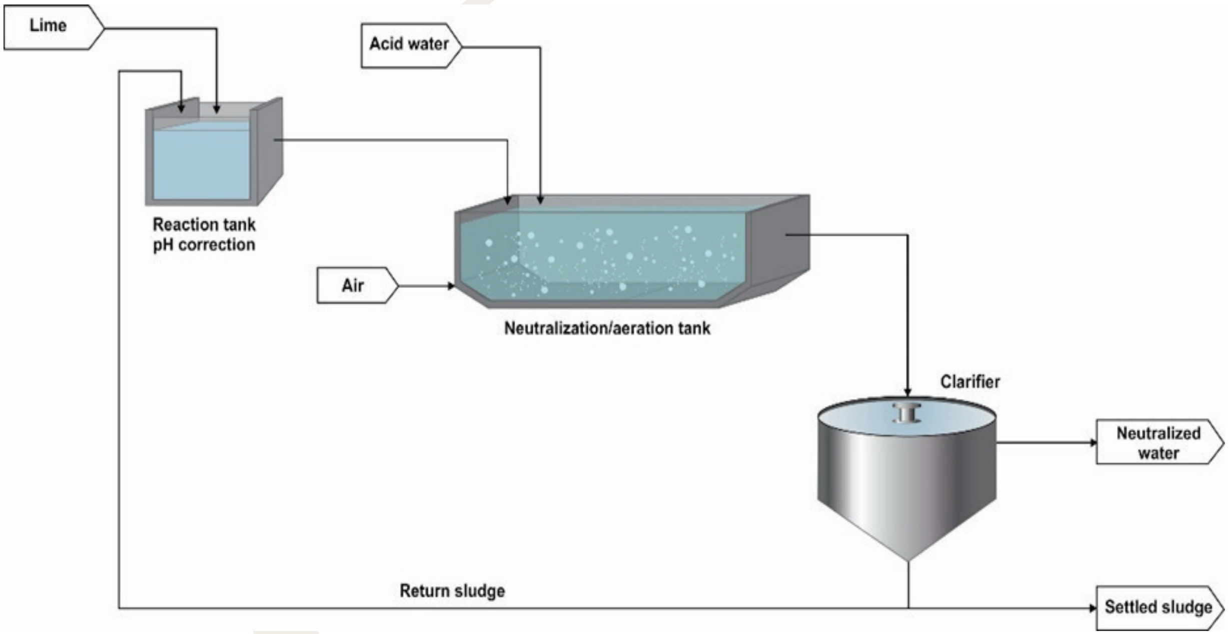



Figure 3: HDS configuration

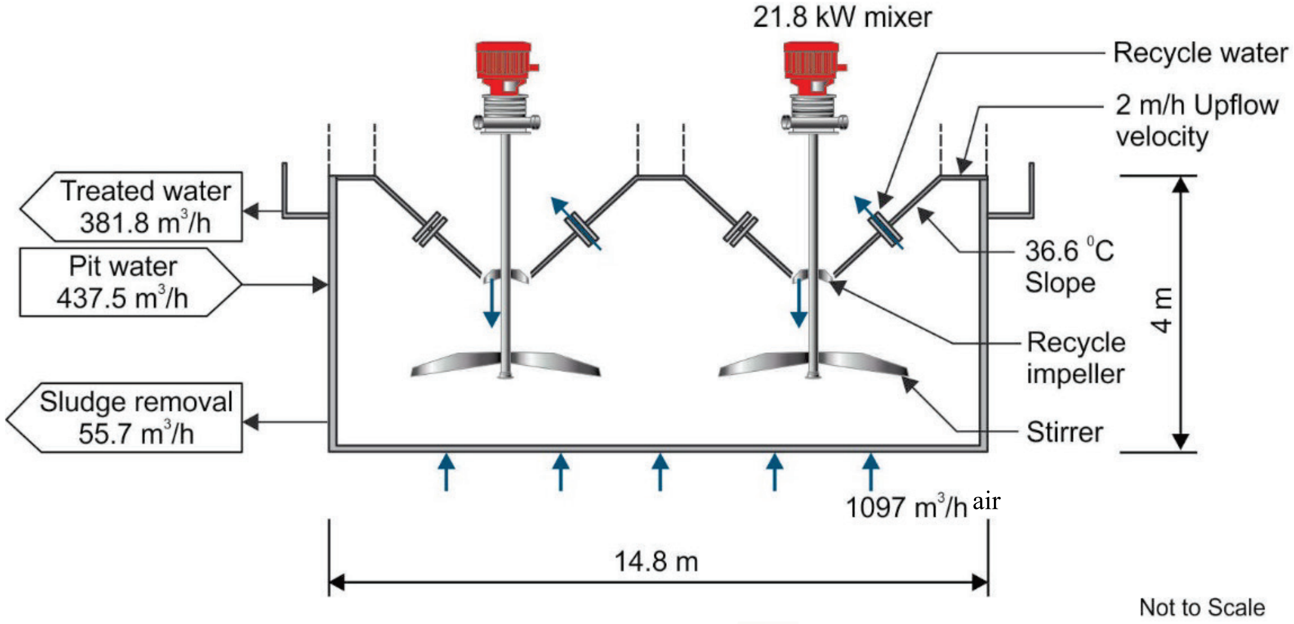



Figure 4: Proposed configuration

# FEASIBILITY STUDIES

**Table 2: Alkali cost for different treatment options**

| Parameter | Option | |
|---|---|---|
| | $CaCO_3$/ $Ca(OH)_2$ | Only $Ca(OH)_2$ |
| $CaCO_3$ dosage (mg/L) | 3 703.0 | |
| $Ca(OH)_2$ dosage (mg/L) | 498.0 | 3 496.0 |
| $CaCO_3$ cost (R/$m^3$) | 4.57 | |
| $Ca(OH)_2$ cost (R/$m^3$) | 2.31 | 16.25 |
| Total cost (R/$m^3$) | 6.89 | 16.25 |
| Cost ratio | 42.4 | 100.0 |
| Total cost (R/month) | 4 397 637 | 10 371 522 |

Notes:

| | |
|---|---|
| $CaCO_3$ purity (%) | 85.0 |
| $Ca(OH)_2$ purity (%) | 85.0 |
| $CaCO_3$ price (ZAR/t) | 1 050.0 |
| $Ca(OH)_2$ price (ZAR/t) | 3 950.0 |
| Flow (ML/d) | 21.0 |

NB. ($1.00 = ZAR 19.04 (16/04/2024)

# FEASIBILITY STUDIES CONTINUE…

**Table 3: Comparison between feasibility of conventional and proposed treatment**

| Parameter | Proposed | Conventional |
|---|---|---|
| Capital cost (R/(ML/d) | 1 809 309 | 9 000 000 |
| Capital cost (R/(21ML/d) | 37 995 484 | 797 905 173 |
| Capital redemption cost (R/m$^3$) | **0.79** | **3.91** |
| Chemical cost (R/m$^3$) | **6.89** | **16.25** |
| Electricity (kW/(ML/d)) | 8.38 | 8.38 |
| Electricity price (ZAR/kWh) | 2.00 | 2.00 |
| Electricity (kWh/m$^3$) | 0.60 | 1.00 |
| Electricity (ZAR/m$^3$) | **1.20** | **2.00** |
| Labour (20 labourers; R10 000/month) | **0.31** | **0.31** |
| Project management, Admin, Assurance (R100 000/m) | **0.16** | **0.16** |
| Total (R/month) | **9.34** | **22.63** |
| Ratio | **41.30** | **100.00** |

NB. ($1.00 = ZAR 19.04 (16/04/2024)

# CONCLUSION

- $CaCO_3$ can be used for removal of $Fe^{2+}$, $Fe^{3+}$ and $Al^{3+}$ and lime for removal of $Mn^{2+}$ and other metals at a cost of R6.89/$m^3$  compared to $Ca(OH)_2$ alone which cost of R 16.25/$m^3$
- the combined Reactor-Clarifier design, together with a slimes dam, can be used as an alternative to the conventional complete-mixed reactor/clarifier at reduced capital cost (R 1.91 million for a 1 ML/d plant versus R 9.0 million in the case of the conventional design,
- the total cost of Option 1 ($CaCO_3$ and $Ca(OH)_2$ and the new design amounts to R 9.34/$m^3$ compared to R 22.63/$m^3$ in the case of Option 2 ($Ca(OH)_2$) alone and the conventional design.

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