A Review of Sulphate Treatment Technologies for Mine Drainage

2. Case Studies

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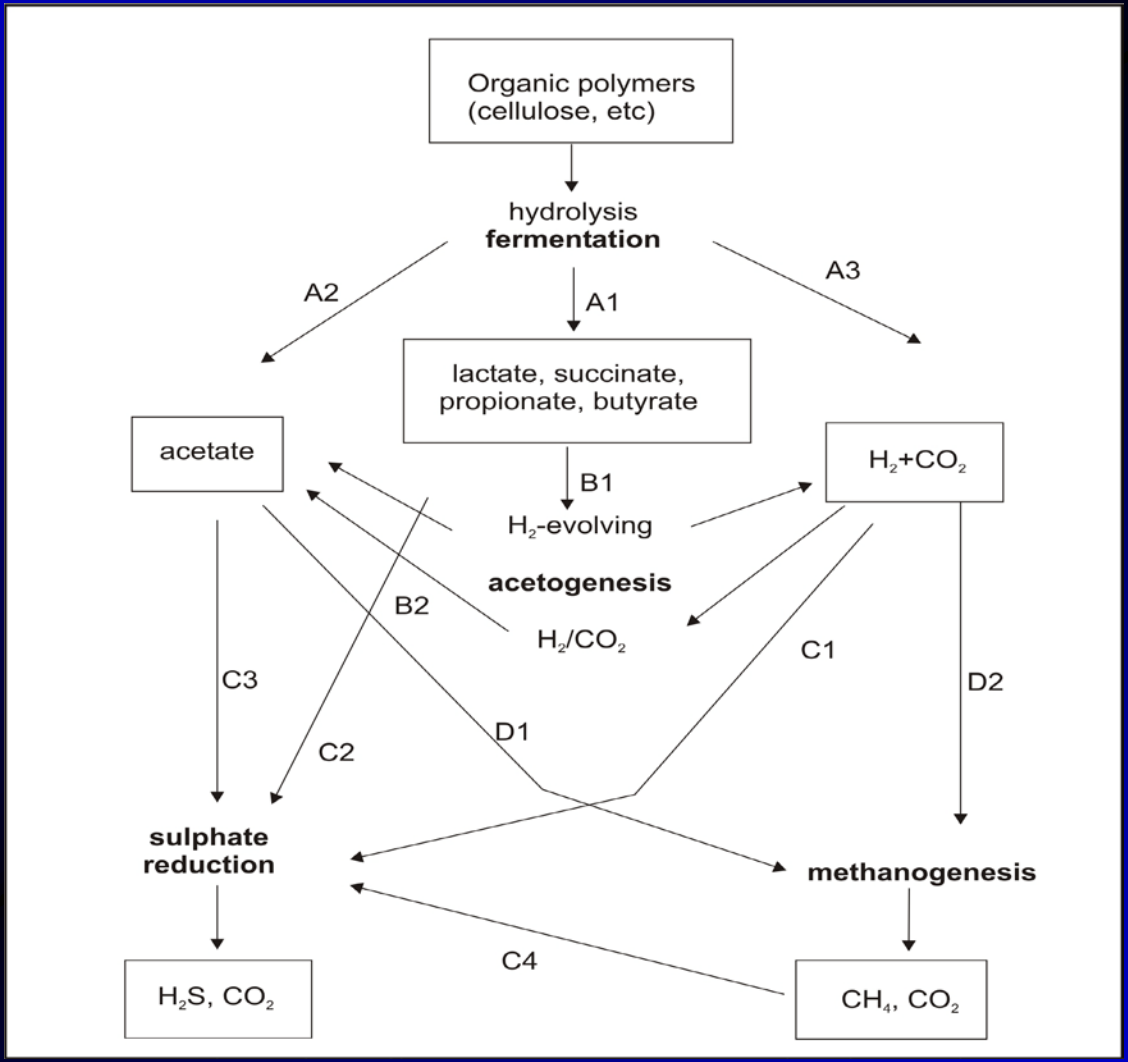
Anaerobic Pathways



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Important Bioreactor Issues

- **Carbon and Energy Source (Substrate) used**

    COD: Sulphate Ratio > 0.67
    Quality (cost, availability, rest-pollution)
    Competition for substrate

- **Toxicity of Waste Stream to Microorganisms**

    Acidity
    $H_2S(g)$ concentrations
    Dissolved (trace) metal concentrations

- **Type of Bioreactor and Process Design**

    use of separate, successive reactors

Case Studies

- Problem
- Treatment Process
- Results
- Costs
- Advantages/Disadvantages
- Future Needs/Improvements
- References

Bioreactor Case Study – *Problem*

- **Landau Coal Mine near Witbank (South Africa)**
- **$20 \cdot 10^3$ t/day raw coal: product $15.5 \cdot 10^3$ t/day**
  coal discard $3.0 \cdot 10^3$ t/day
- **72.5 ha dump with $4.3 \cdot 10^6$ t coal discard**
- **Coal Discard Leachate:**

pH	1.8
SO_4	8,342 mg/L
Fe	2,500 mg/L

- **SO_4: 24 t/day enters drainage network**

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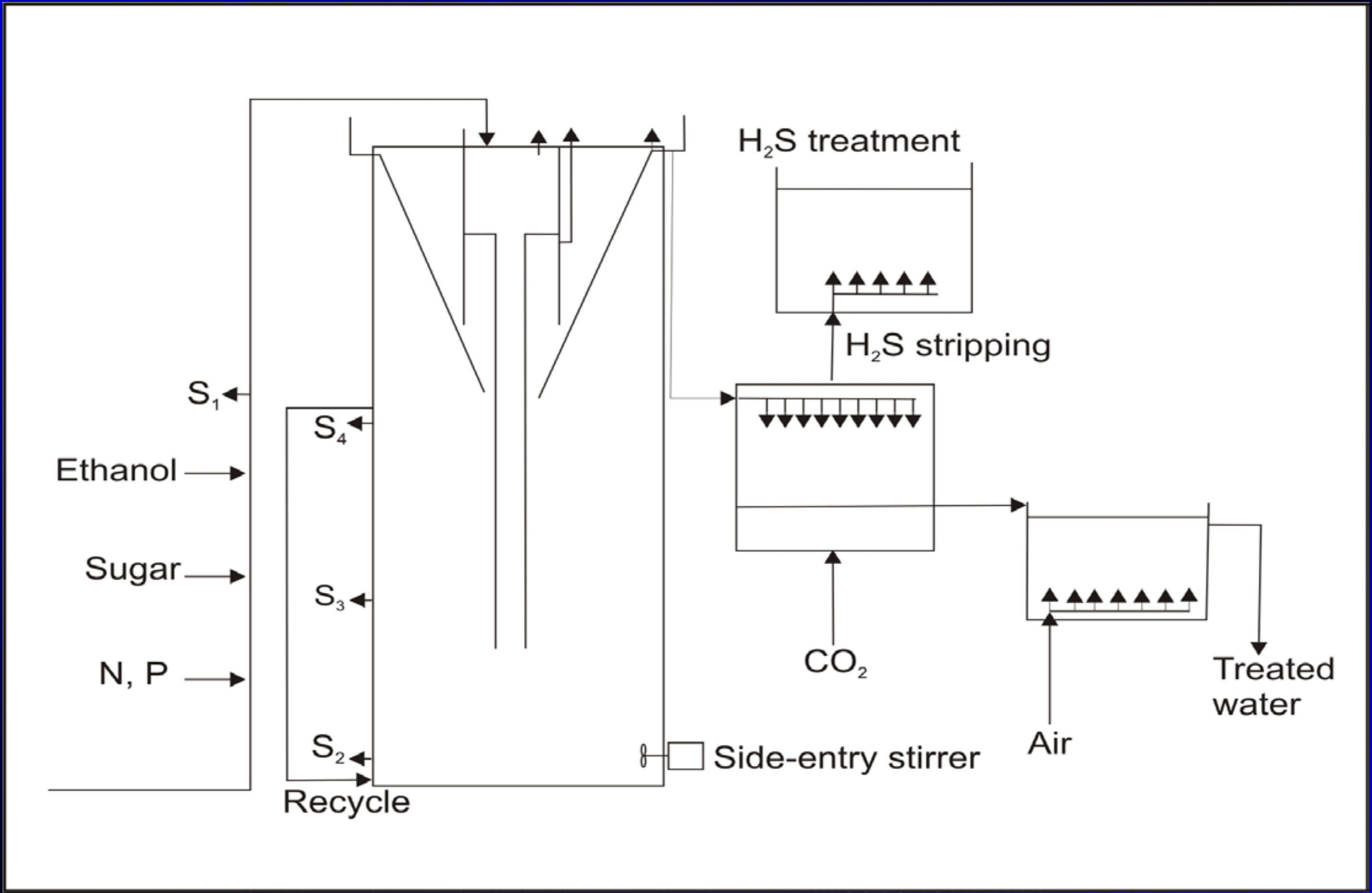
Bioreactor Case Study – *Treatment Process*

Treatment Process Stages:

- **$CaCO_3$ Handling and Dosing System**
- **$CaCO_3$ Treatment**
- **Biological Sulphate Reduction**

Bioreactor Case Study – *Treatment Process*

Bioreactor Case Study – *Treatment Process*



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Bioreactor Case Study – *Treatment Process*

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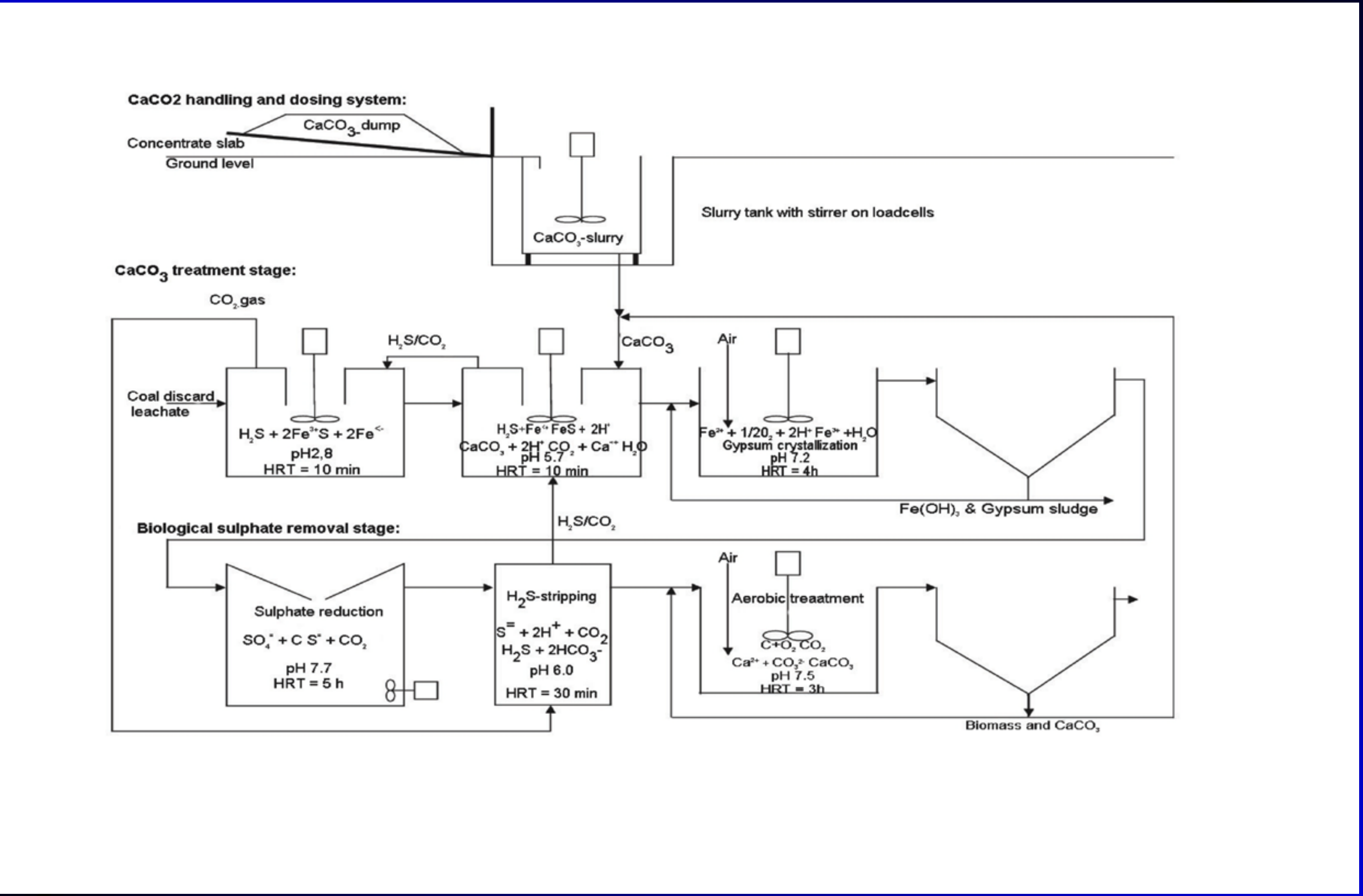

Bioreactor Case Study – *Treatment Process*

- **$CaCO_3$ Treatment Stage:**

  iron reduction
  sulphide and iron oxidation
  FeS, Fe-hydroxide and gypsum precipitation

- **Sulphate Removal Stage:**

  biological sulphate reduction
  removal of residual O.M.
  $CaCO_3$ precipitation

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Bioreactor Case Study – *Results*

$CaCO_3$ Treatment Stage		Feed	Treated
pH		1.8	6.6
Acidity*	mg/L	7,300	100
SO_4	mg/L	8,342	1.969
Cl	mg/L	27	30
Fe(II)	mg/L	2,500	<56
Fe(tot)	mg/L	2,500	<56

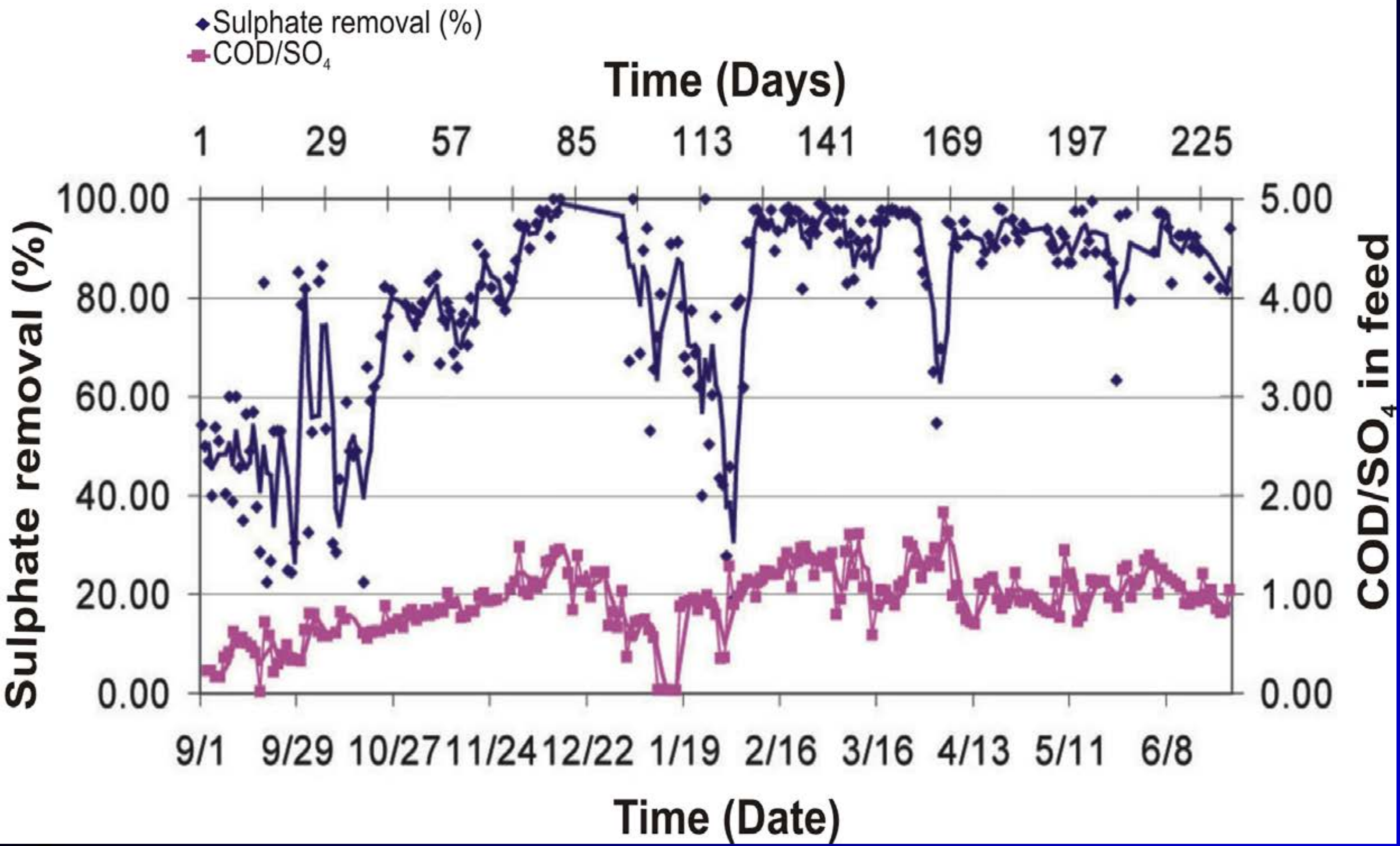
* as $CaCO_3$

Bioreactor Case Study – *Results*

Sulphate Reduction Step		Feed	Treated
pH		7.2	7.7
Alkalinity*	mg/L	60	2,065
SO_4	mg/L	2,203	198
HS	mg/L	0	606
Ethanol	mg/L	690	0
Acetate	mg/L	0	218
Formate	mg/L	0	5
VSS	mg/L	0	9,000

* as $CaCO_3$

Bioreactor Case Study – *Results*



Bioreactor Case Study – *Results*

- **Partial and Complete Oxidation of Substrate by SRB:**

$$2C_2H_5OH + 2H^+ + SO_4^{2-} = 2CH_3COOH + H_2S(g) + 2H_2O$$

$$2CH_3COOH + 4H^+ + 2SO_4^{2-} = 4H_2CO_3 + 2H_2S(g)$$

+

$$2C_2H_5OH + 6H^+ + 3SO_4^{2-} = 3H_2S(g) + 4H_2CO_3 + 2H_2O$$

- **Theoretical COD/SO_4 ratio is 0.67**
- **Measured COD/SO_4 ratio between 1.0 and 1.2**

- **Theoretical Alk./SO_4 ratio (mass) is 1.04**
- **Measured Alk./SO_4 ratio (mass) ~ 1.0**

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Bioreactor Case Study – *Costs*

- **Capital Cost** — **BSR-plant treating 2 kg SO_4 per m^3 water**

  R2.3* million per 1,000 m^3/day

- **Operating Cost** — **R2.54* per m^3 water**

  (which includes R2.22* per m^3 water

  for Energy and Carbon source)

* R1=USD 0.105 (Nov., 2002)

Bioreactor Case Study – *Advantages/Disadvantages*

- inexpensive SO_4 removal to 2,000 mg/L with $CaCO_3$
- acid neutralization
- additional SO_4 removal to 200 mg/L by sulphate reduction
- CO_2(g) and H_2S(g) produced, are recycled and used in other steps of the treatment process

Bioreactor Case Study – *Future Needs/Improvements*

Development and Testing

of

Alternative Sources of Carbon and Energy

Bioreactor Case Study – *References*

CSIR, Division of Water,
P.O. Box 295, Pretoria 0001, South Africa

Website: www.csir.co.za

Sulphate Reduction Rates

• Bioreactor:	12-30	g/(L,day)
• Constructed Wetland:	0.3-197	mg/(L,day)
• Alk. Producing Systems:	0 ?	mg/(L,day)
• Permeable Reactive Barrier:	10.5-15.3	mg/(L,day)

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Biological Sulphate Reduction

- **Dissimilatory sulphate reduction by SRB:**

$$4CH_3OH + 3SO_4^{2-} = 4HCO_3^- + 3HS^- + H^+ + 4H_2O$$

- **Sulphide oxidized to elemental sulphur (S) by:**

  - Chemotrophs: $2HS^- + O_2\,(g) + 2H^+ = 2S\,(s) + 2H_2O$

  - Phototrophs: $2HS^- + CO_2\,(g) + 2H^+ = 1/6C_6H_{12}O_6 + 2S\,(s) + H_2O$

- **Sulphide removal also by:**

  - precipitation as metal sulphides (MeS)
  - H_2S (g) stripping