Direct extraction lithium processes: The challenges of spent brine disposal

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Outline

- Introduction to brine hosted lithium deposits
- Direct vs conventional extraction processes
- Spent brine disposal management
- Case study example
- Conclusion
Lithium brine deposits

Bradley et al., 2013
Brine mining particularities

- Valuable elements contained in a mobile environment
- Brine flows – either naturally or by pumping –
- Brine composition varies – space and time –
- Complex hydrodynamics
- Weather: precipitation can affect grade distribution
- Potential for dilution
Brine resource & reserve estimation

- Specialized hydrogeological knowledge needed
  - Hypersaline solution theories for groundwater dynamics modelling
- Chemical processing knowledge needed
  - Brine processing for high purity lithium carbonate extraction
- Adequate engineering
  - Brine recovery: What part of the resource is economically extractable?
  - Fresh water availability: project demand conditioned by site hyper-arid conditions
  - Spent brine handling
Lithium extraction processes

• Conventional evaporation process
  – Increase concentration of lithium through solar evaporation
    • Large evaporation areas
    • Longer ramp-up periods
    • Dependence on meteorological conditions

• Direct extraction processes
  – Raw brine goes ‘straight’ to chemical process
    • Reduction on pre-evaporation requirements
    • Shorter period between extraction and final product first
    • Reduced dependence on climate
Spent brine disposal management

- Conventional processes
  - Reduced spent brine volume – large volumes evaporated in processing

- Direct extraction processes:
  - Large amounts of spent brine – high density and low Li$^+$ –
  - Additional fluid source

Disposal strategies:
1. Pumping back into basin
2. Disposal in evaporation ponds
Disposal of spent brine – Pumping into basin

- Traditional solution used in conventional evaporation process
- Brine returned to original environment
- No overland impact
- For direct extraction processes:
  - Large volumes may affect lithium concentrations
  - Additional fluid sources becomes part of resources model inputs
  - Balance between extraction and disposal wells – rates and location – is needed
Disposal of spent brine – Evaporation ponds

• Counter intuitive?
  – Direct extraction process intended to reduce the need for extensive evaporation ponds and use of expensive liners

• A holistic approach
  – Design that balances evaporation, crystallization and seepage to control recycled brine inflow rate and grade
  – Hybrid evaporation pond / salt stack using reject materials
## Disposal of spent brine – Evaporation ponds

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
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<tbody>
<tr>
<td>• Lower risk of diluting lithium concentration</td>
<td>• Impact on surface – development of salt landforms</td>
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<tr>
<td>− Reduction in inflow rate</td>
<td>• Cost of land to be commissioned for salt stack</td>
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<tr>
<td>− Potential increase in mineral content of spent brine</td>
<td>− Relative to production and climatic conditions</td>
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<td>• Reduced complexity of production plan design</td>
<td>• Cost of earthworks and disposal pipelines</td>
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<td>• Allows for more robust estimation of resources and reserves</td>
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Disposal design strategy: Case study

**Design parameters:**

- Lithium production rate: 25ktpa Li₂CO₃
- Average raw brine concentration: 400–700 mg/L
- Production efficiency: ~50%
- Spend brine disposal rate: 1,500–3,000 m³/hr of brine
- Brine evaporation rates in the lithium triangle: 4–8 mm

**Evaporation area**

500 to 1000 ha
Disposal design strategy: Case study

Critical design aspects

• Disposal area sizing
  – Linked to evaporation capacity of site;
  – Expected spent brine flow

• Tolerance for seepage and infiltration (quality and quantity)

• Brine storage volume kept at minimum
  – Avoid increasing earthworks
  – Maintain low hydraulic head/ seepage
Conclusion

• Lithium mining from highly enriched brines is significantly different to classic hard-rock mining

• Given the nature of this type of projects, brine resource and reserve estimation requires the application of specialised hydrogeological knowledge

• Direct extraction technologies arisen as an alternative to the conventional production processes.

• Larger amounts of spent brine are to be managed adequately to avoid potentially affection of the resource.
Conclusion

• Cost-efficient disposal solutions can be achieve, but require a holistic approach in terms their design

• Hybrid evaporation pond / salt stack can be developed balancing evaporation, crystallisation and seepage to keep the recycled brine inflow to the basin at a controlled rate

• There is place for massive scale economy, when the used of locally available materials is considered and the reduction in transport/ construction costs is achieved
Thank you

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