

Understanding the Dissolution of Layered Double Hydroxides in Applications of Wastewater Treatment



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Research Question & Motivation

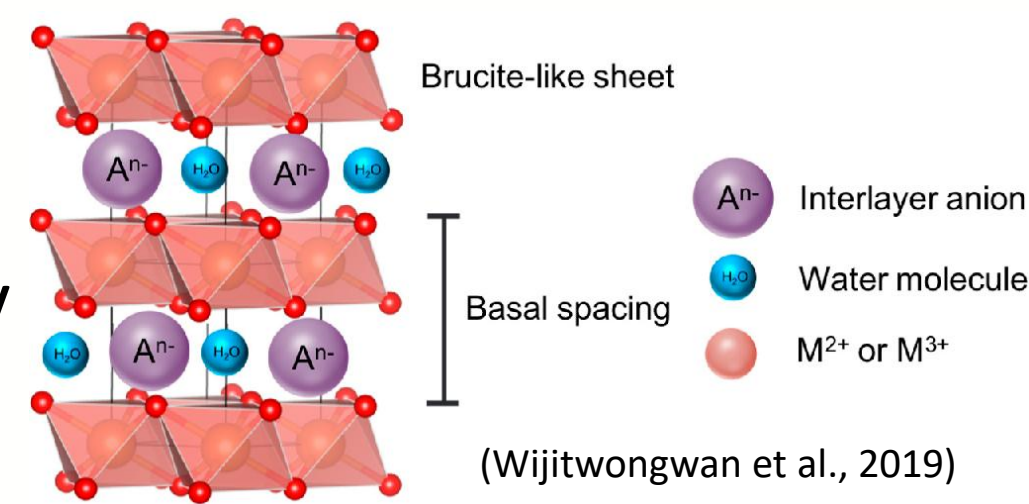
Waterway Contamination by Nitrates:

- Rain & Irrigation carry nitrates from nitrogen-based fertilizers into waterways
 - Results in metal leaching, health complications, and ecosystem disruption
- Current research focus on ion-exchange for treatment

Layered double hydroxides (LDHs) are anionic ion-exchangers composed of di/trivalent (+) charged metal hydroxide sheets

- Highly tunable
- Inexpensive precursors

Challenge: LDHs exhibit stability issues during ion-exchange



Research Question: What ion-exchange conditions influence layered double hydroxides degradation in solution?

Approach & Methodology

4:1 Mg:Al LDHs were synthesized via hydrothermal treatment method from aluminum and magnesium chloride precursors

This project evaluates LDH degradation under the following solution parameters:

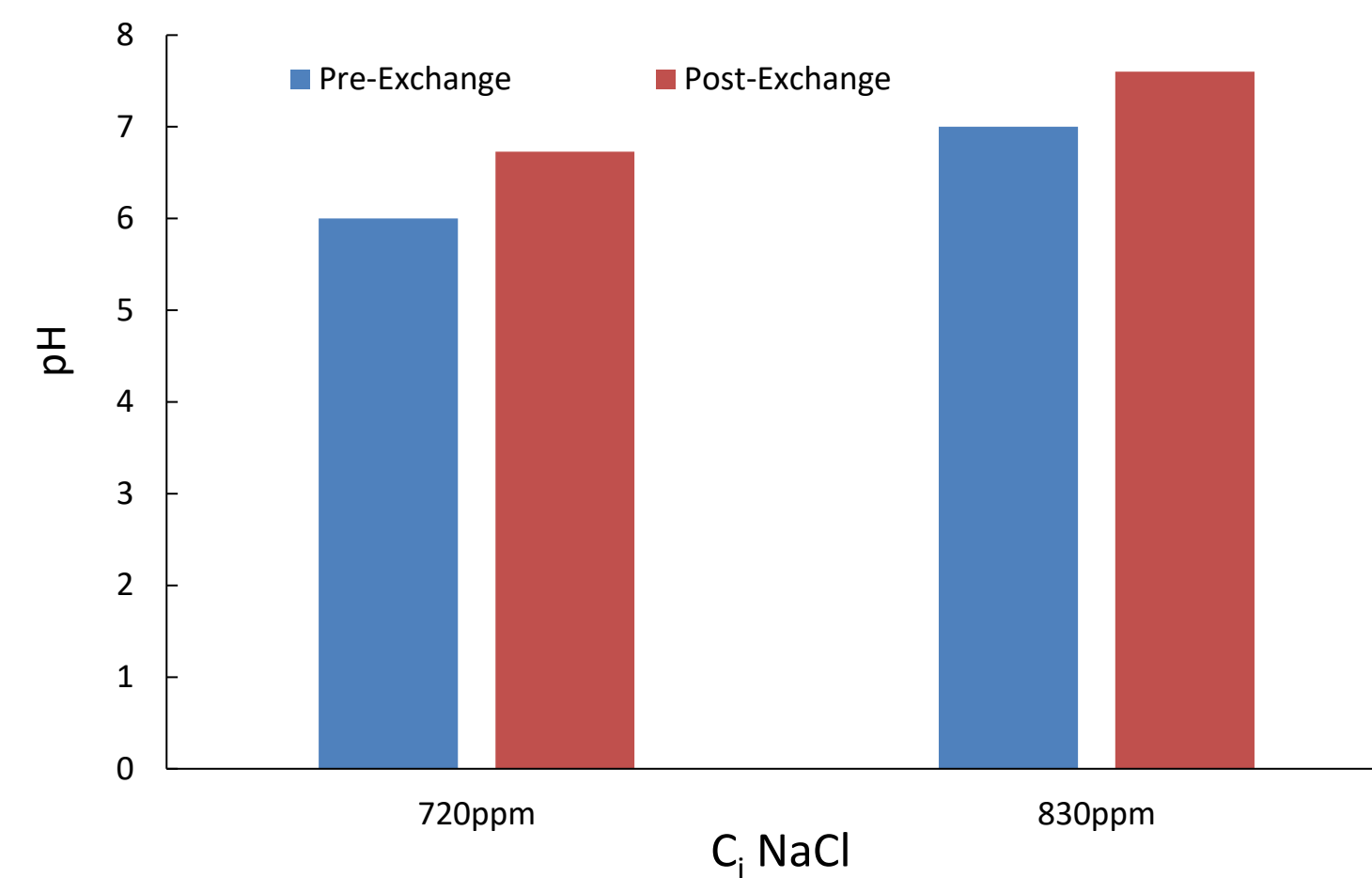
- Increasing (NaCl) ion concentrations ranging from 0-2000 ppm

Extent of degradation was measured using:

- X-Ray Diffraction (XRD)* for structural changes in LDH crystallinity (qualitative)
- pH meter* for release of structural hydroxides (quantitative)
- Chloride Strips* for release of interlayer Cl⁻ (quantitative)
- Inductively Coupled Mass Spectroscopy (ICPMS)* for release of Aluminum and Magnesium (quantitative)

Results & Discussion

pH change after Ion-Exchange

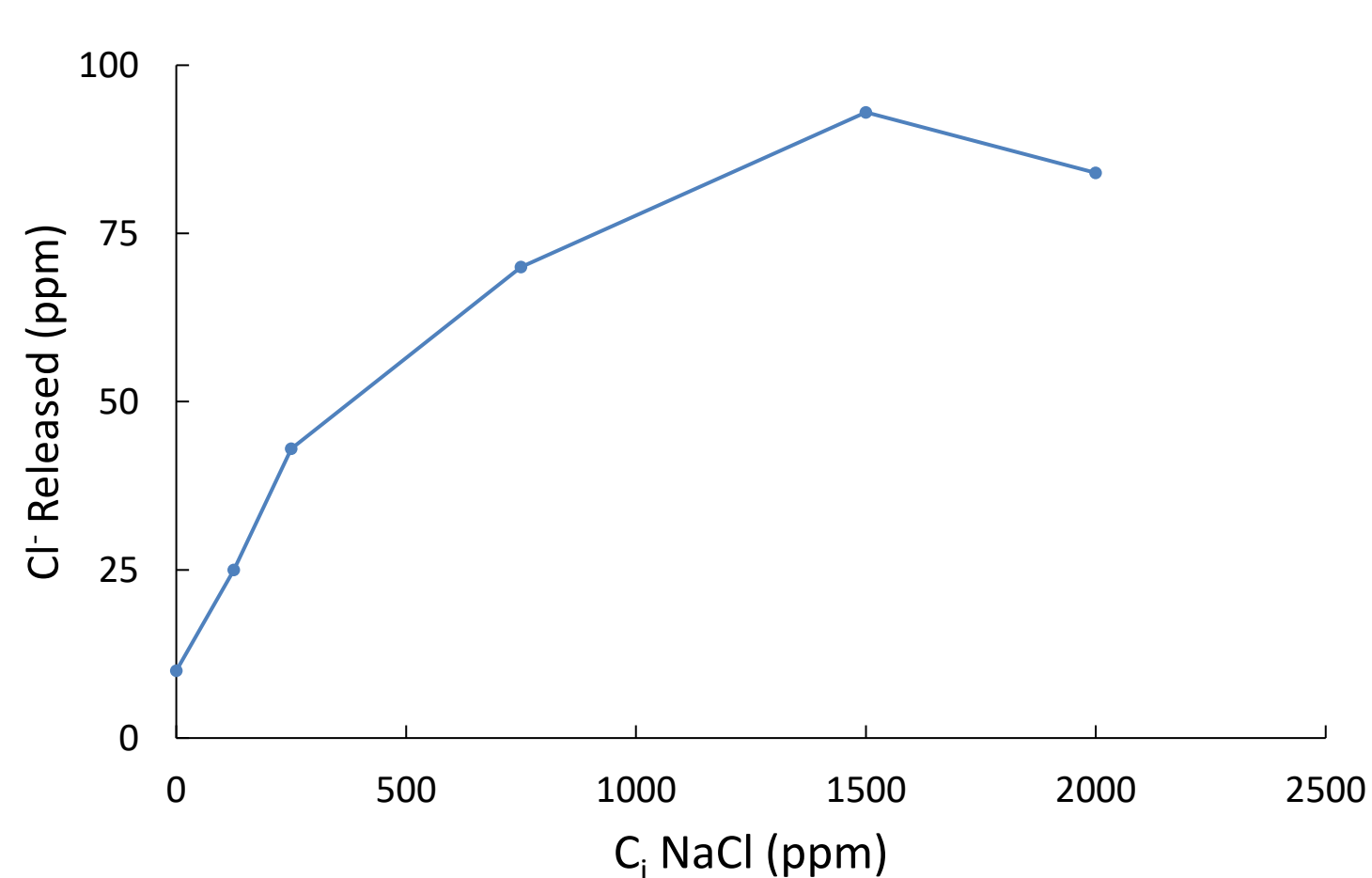


Conditions:

- 300 mg LDH
- 300 RPM stirring

- Significant unexpected increase in pH
- Typically, solution pH decreases due to CO₂ adsorption

Chloride release with ion concentration



Conditions:

- 10 mg LDH
- 300 RPM stirring

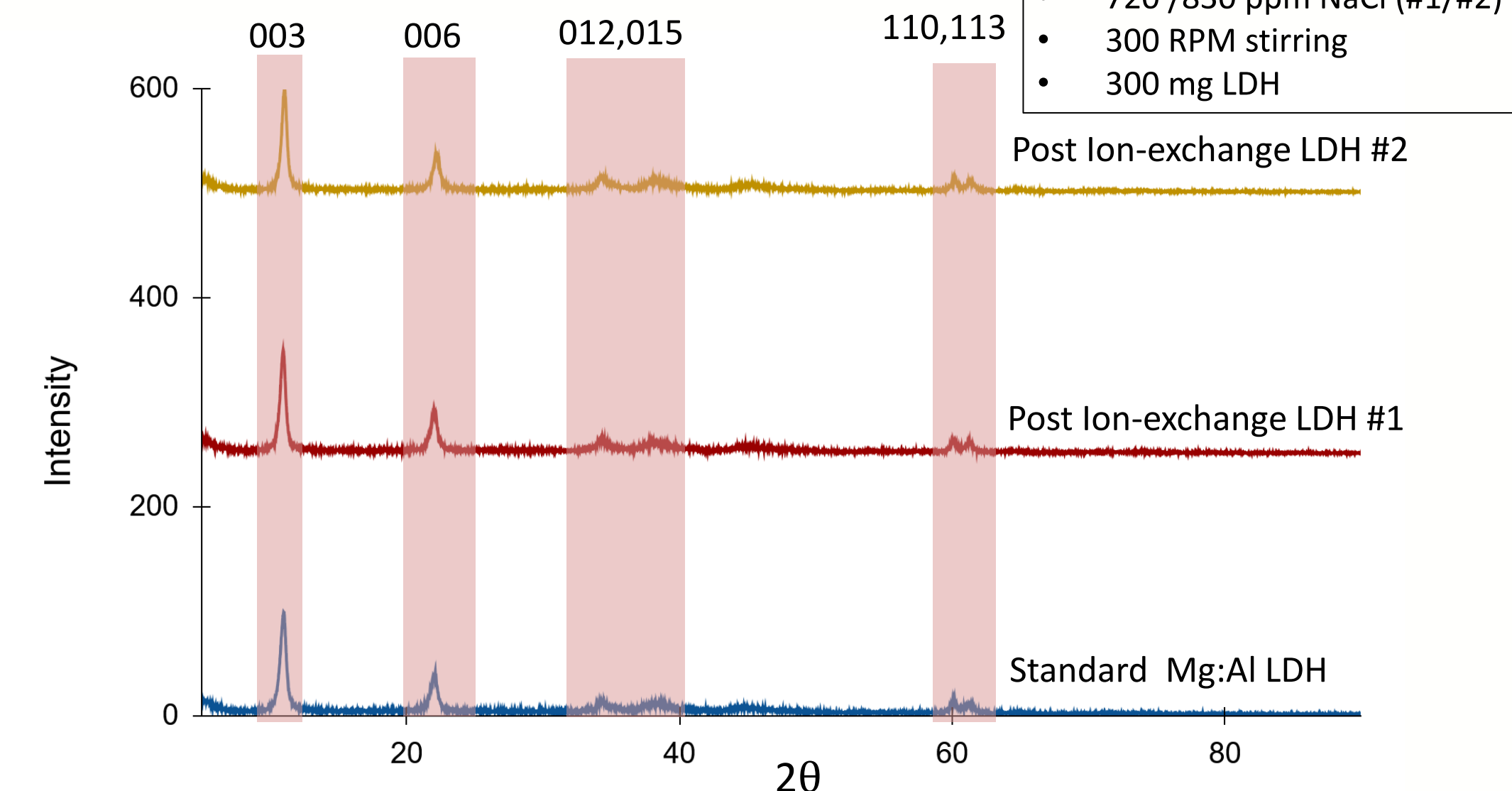
- High conc. dependence in trace ionic solutions
- Plateau at higher conc.
- Chloride release thermodynamically disfavored. Implies degradation

Elemental analysis of Post-Exchange Supernatant

Element	Mg	Al
Concentration (ppb)	34996	51

- Presence of Mg & Al confirm framework degradation
- Signs of preferential Mg leaching or Al precipitation

XRD of Pre and Post exchange LDH



- Characteristic reflections of Mg:Al LDH remain largely unchanged
- Implies that crystal structure remains intact despite degradation

Conclusion & Future Work

- Ionic Influence:** Ions within solution contribute to the degradation of LDHs
- Metal leaching from framework:** Incongruent amounts of Mg and Al detected by ICP-MS could be due to preferential degradation of framework magnesium or precipitation of Al species onto the LDH framework
- Implications:** LDHs should only be used for ion-exchange in trace solutions for wastewater treatment

It is hypothesized that the observed LDH degradation is driven largely by electrostatic interactions between charged ions and LDH layers. To confirm this, future work should examine:

- Influence of solution pH on LDH degradation during ion-exchange
- Speciation of degraded LDH components
 - i.e. Ions, individual nanosheets, or metal oxides