Small, Safe, Sustainable (S3) Public Water Systems through Innovative Ion Exchange

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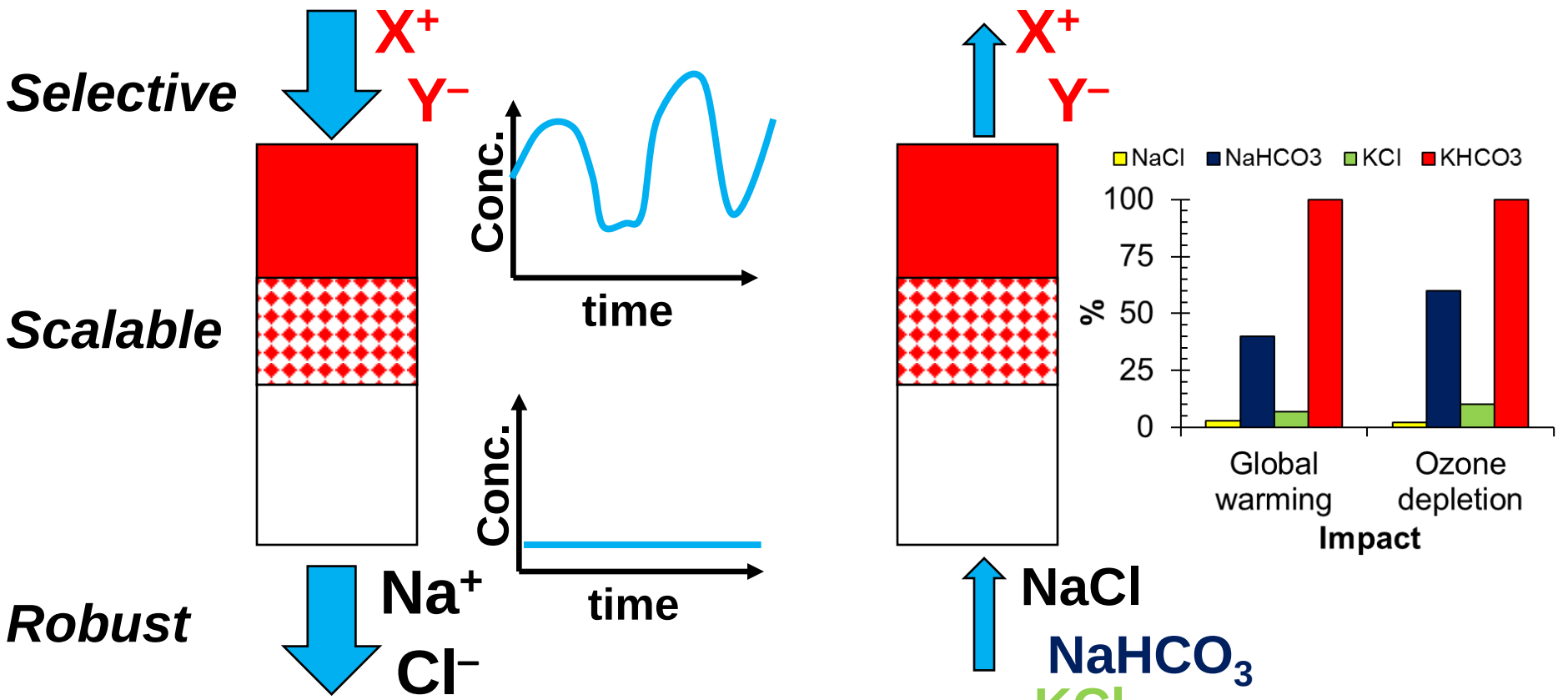

This research is funded by U.S. EPA - Science To Achieve Results (STAR) Program
Grant # R835334

Small, Safe, Sustainable (S3) Public Water Systems through Innovative Ion Exchange

- EPA grant number: **R835334**
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- EPA Project Officer: **Barbara Klieforth**
- http://cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.abstractDetail/abstract/9745/report/0

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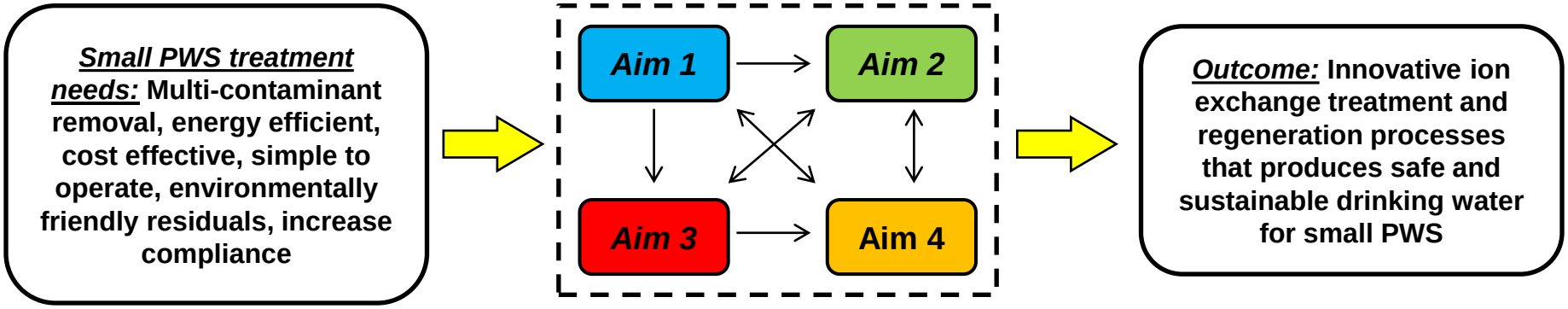
Research objective

Identify and test ion exchange processes that can treat groups of chemical contaminants and evaluate their sustainability



Aims

1. Identify **combined anion and cation exchange** processes that can treat groups of chemical contaminants in an **environmentally friendly way**

2. Develop an **ion exchange process model** that includes multi-contaminant treatment and regeneration efficiency

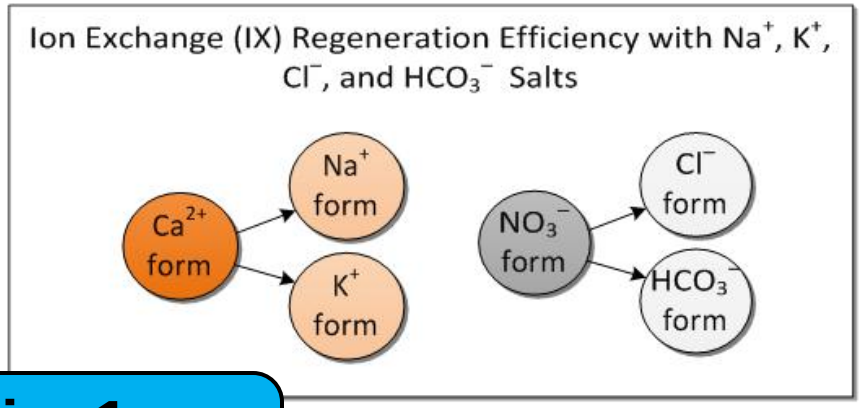
3. Demonstrate the performance of the ion exchange treatment and regeneration processes through **pilot-scale testing at a small PWS**

4. Evaluate the environmental, human health, and economic impacts of the ion exchange treatment and regeneration processes through life cycle assessment (**LCA**) and life cycle cost analysis (**LCCA**)

Approach

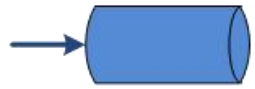
- Laboratory-scale experiments (Aim 1, years 1–2)
- Develop and apply ion exchange process model (Aim 2, years 2–4)
- Pilot plant study at small PWS (Aim 3, years 3–4)
- LCA and LCCA (Aim 4, Years 1–4)

Year 1

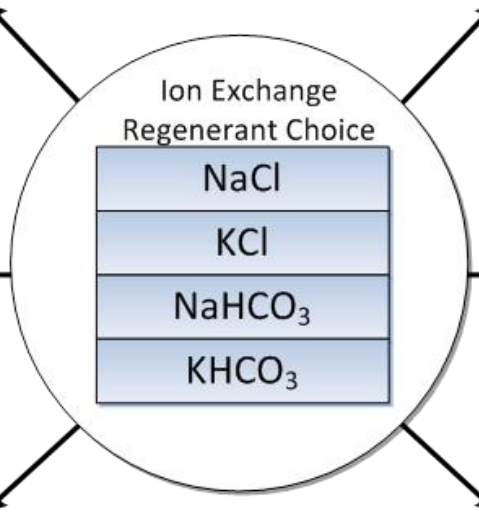


Aim 1
Ion exchange

Impacts to Aquatic Systems



Corrosion Potential

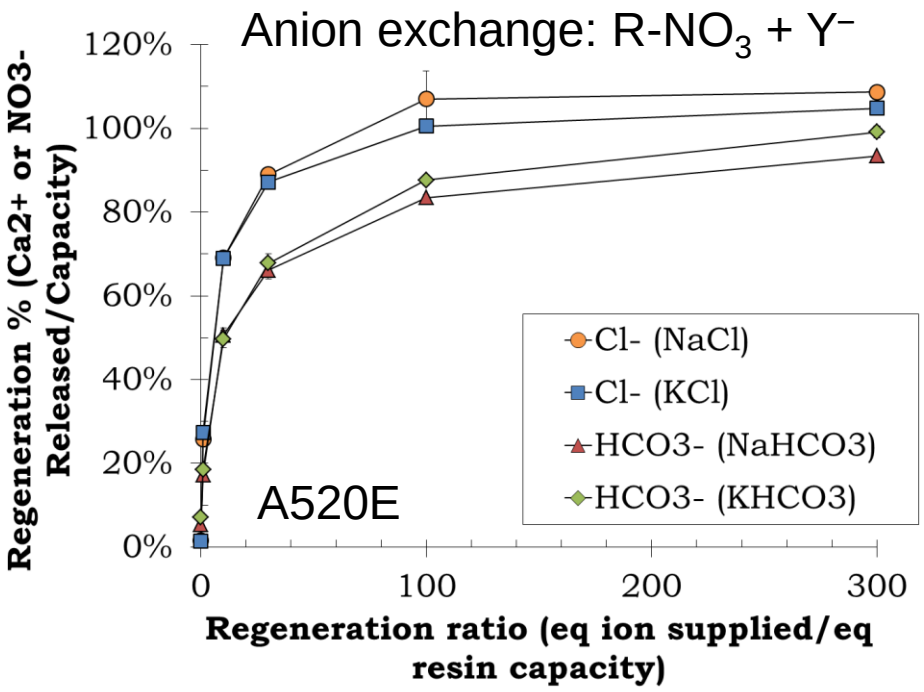


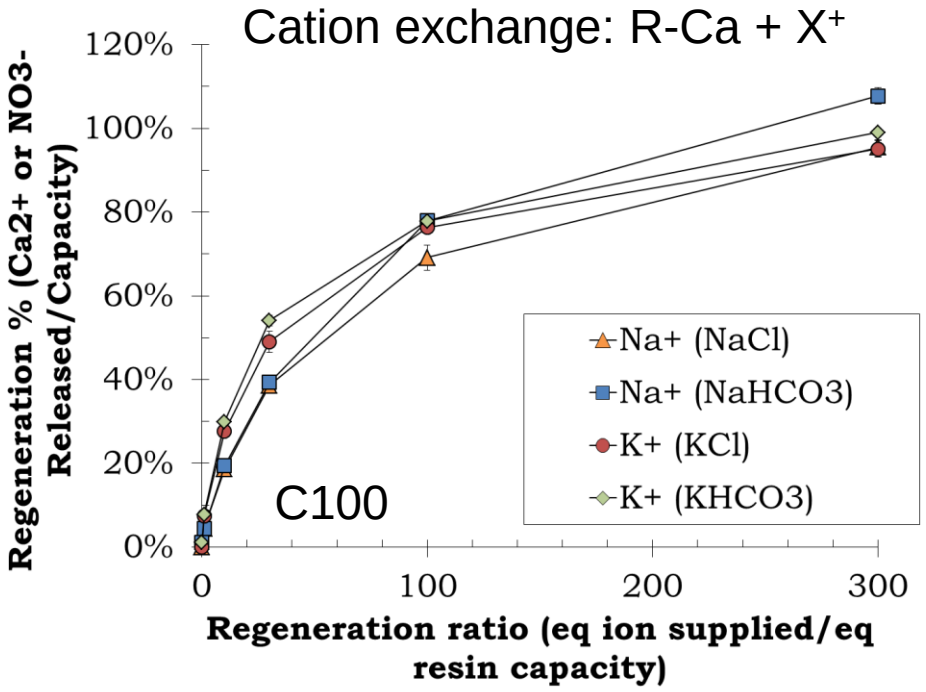
Impacts to Soils/ Agricultural Systems

Aim 4
LCA, LCCA

Impacts to Wastewater Systems

Aim 1



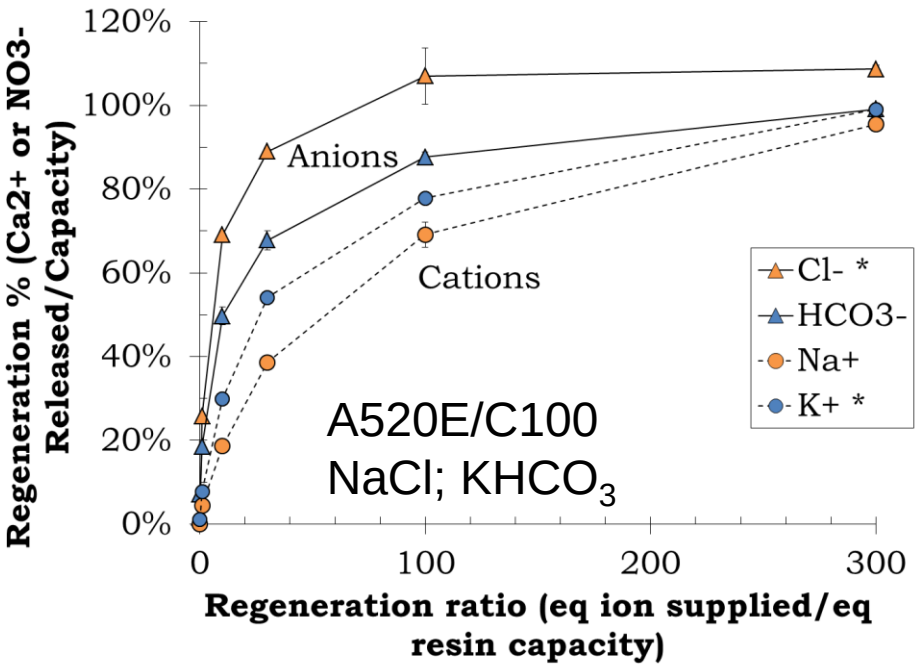


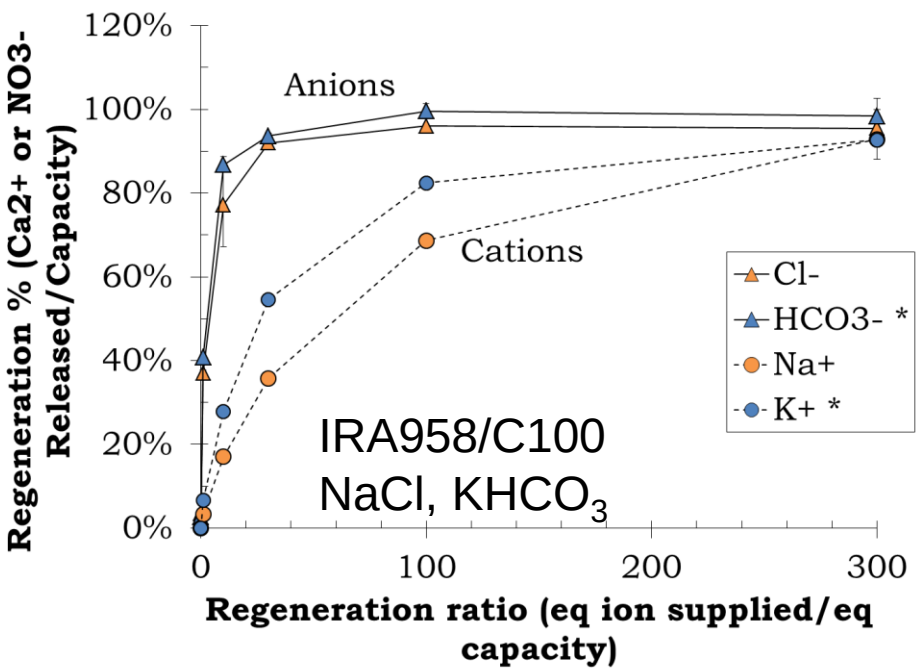
- Anion exchange regeneration (A520E): NaCl ≈ KCl; $NaHCO_3$ ≈ $KHCO_3$
- Cation exchange regeneration (C100): NaCl ≈ $NaHCO_3$; KCl ≈ $KHCO_3$

Anion exchange: R-NO_3 + Y^-

Cation exchange: R-Ca + X^+

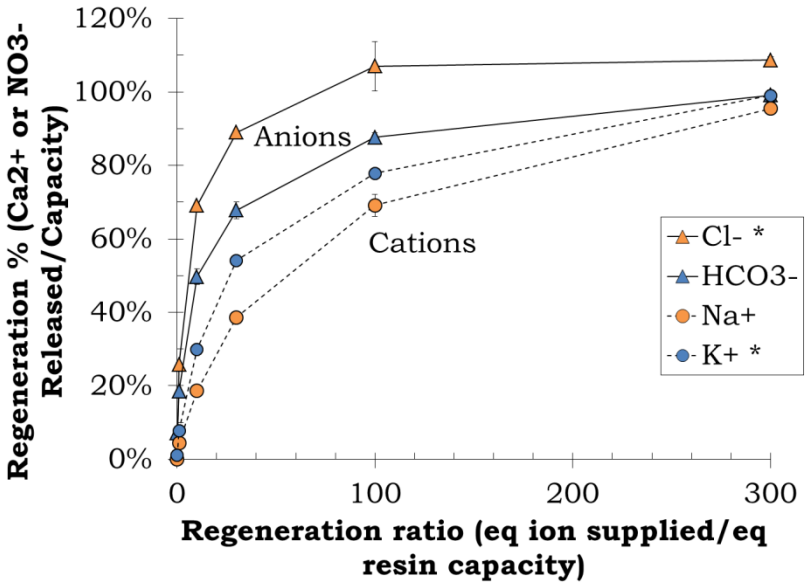
Aim 1





- Polystyrene resin (A520E) regeneration: $Cl^- > HCO_3^-$
- Polyacrylic resin (IRA958) regeneration: $HCO_3^- > Cl^-$
- Cation exchange regeneration: $K^+ > Na^+$

Aim 1



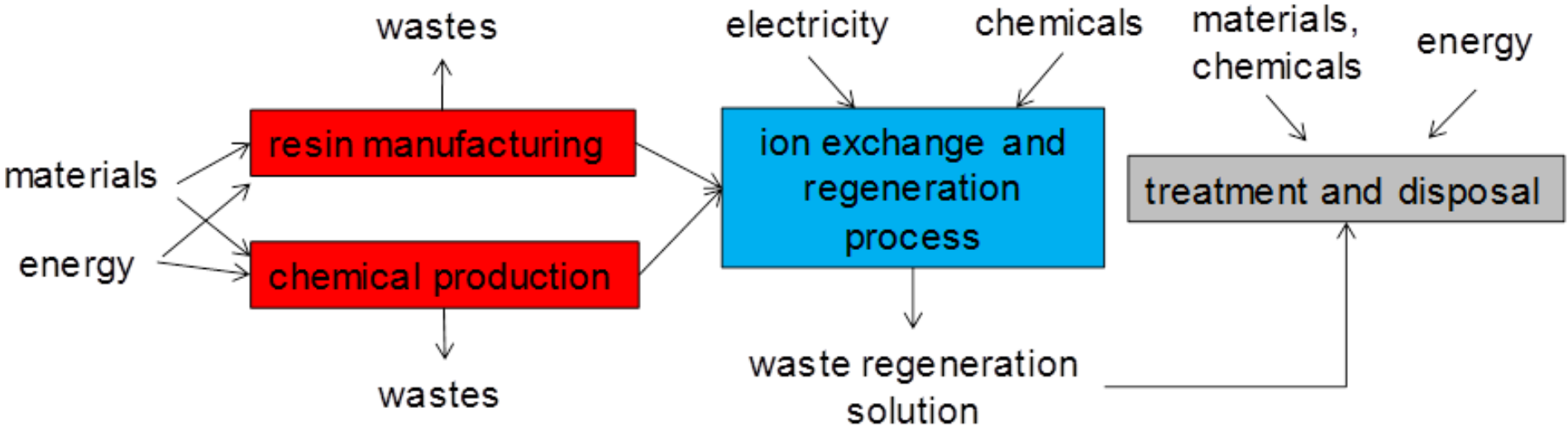
Aim 3
Pilot testing

- Anion exchange: NOM, Br^-, NO_3^-, Cr(VI), ClO_4^-, SO_4^{2-}
- Cation exchange: Ba^{2+}, Cd^{2+}, Ca^{2+}, Co^{2+}, Sr^{2+}
- Regeneration: NaCl, $NaHCO_3$, KCl

Aim 1

- **$NaHCO_3$ regeneration**
  - High **corrosion** potential in water distribution system; chronically **acidified** receiving waters; **nitrification** limited by low alkalinity; difficulty maintaining neutral **pH** in activated sludge process
- **KCl regeneration**
  - **Crops** with high demand for K^+ and Cl^- tolerance; dilution is not sufficient to allow for sewer discharge; softening regenerant brine and low regenerant toxicity
- $KHCO_3$ regeneration not recommended

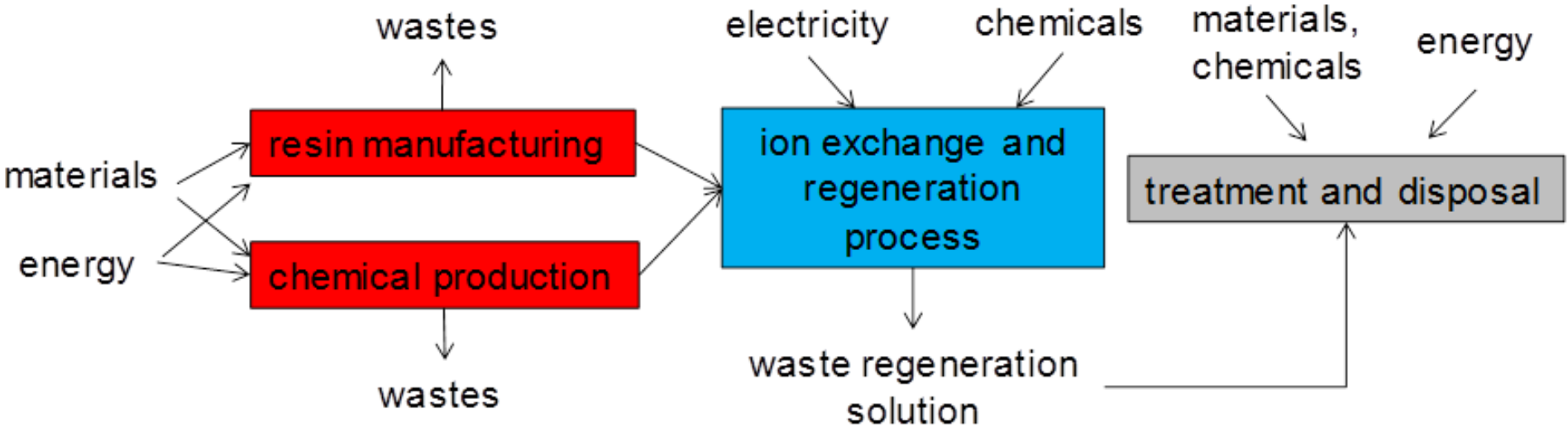
Aim 4



Upstream **Operation** **Downstream**

Aim 2
Process model

Aim 4



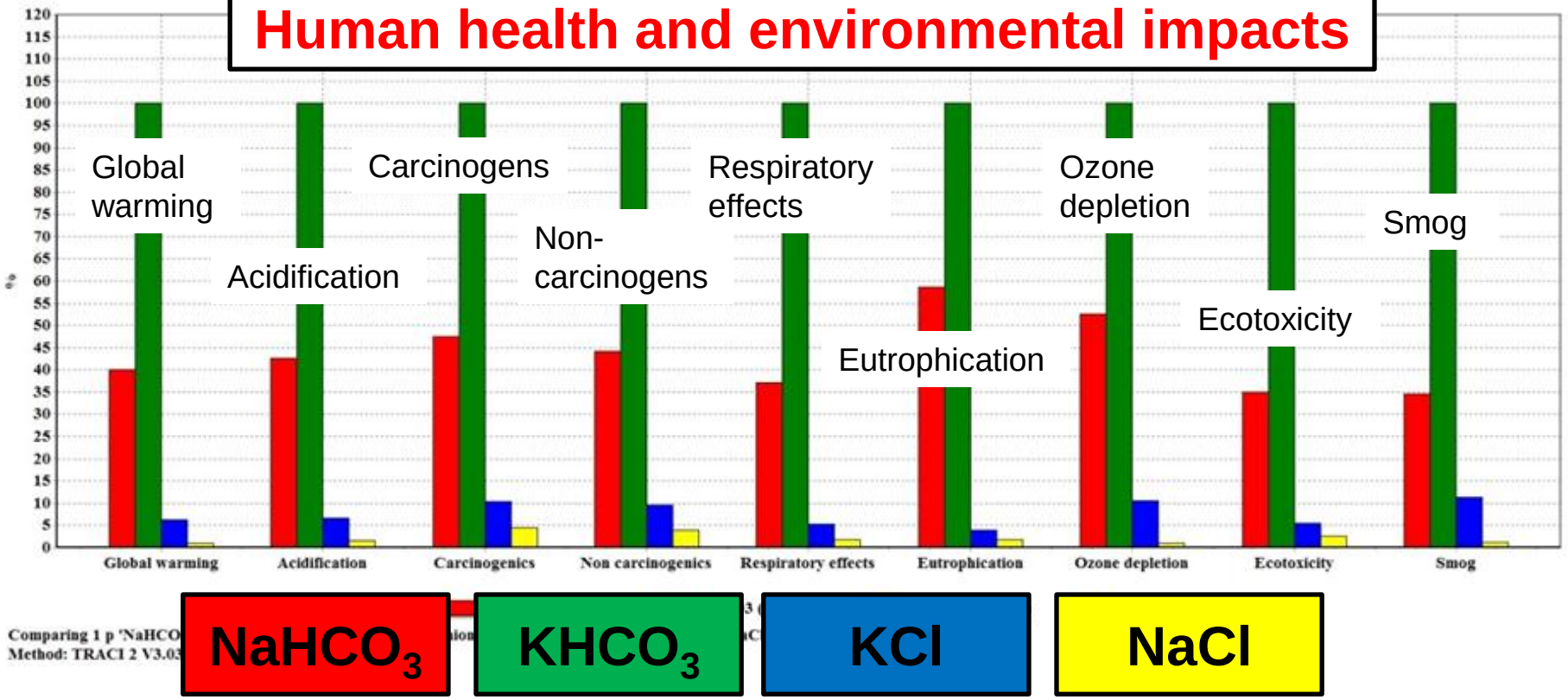
Raw material extraction, manufacturing, transportation,

Regeneration agents, 80% regeneration efficiency; resins not included

Disposal not included

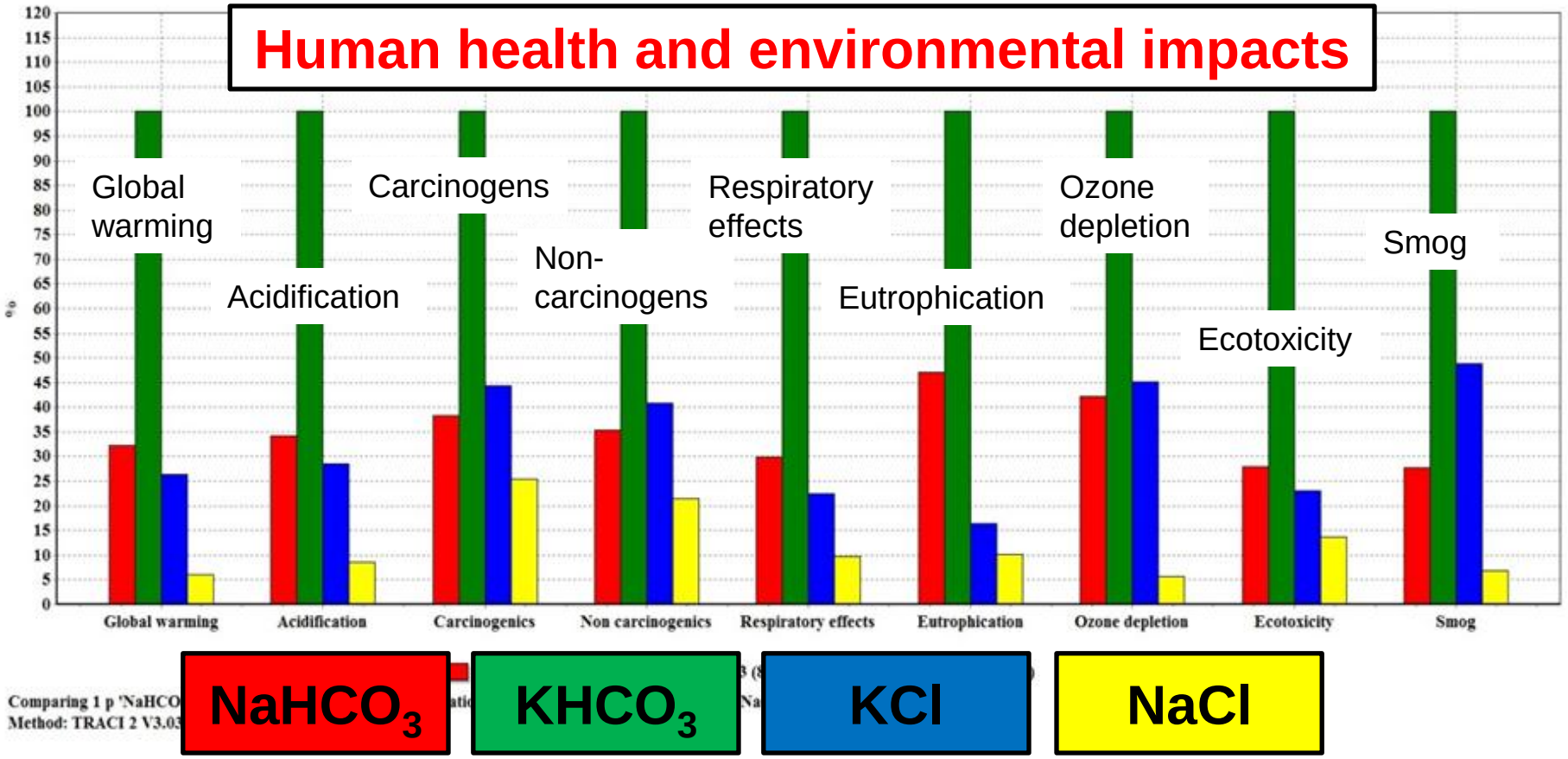
Aim 4

Human health and environmental impacts



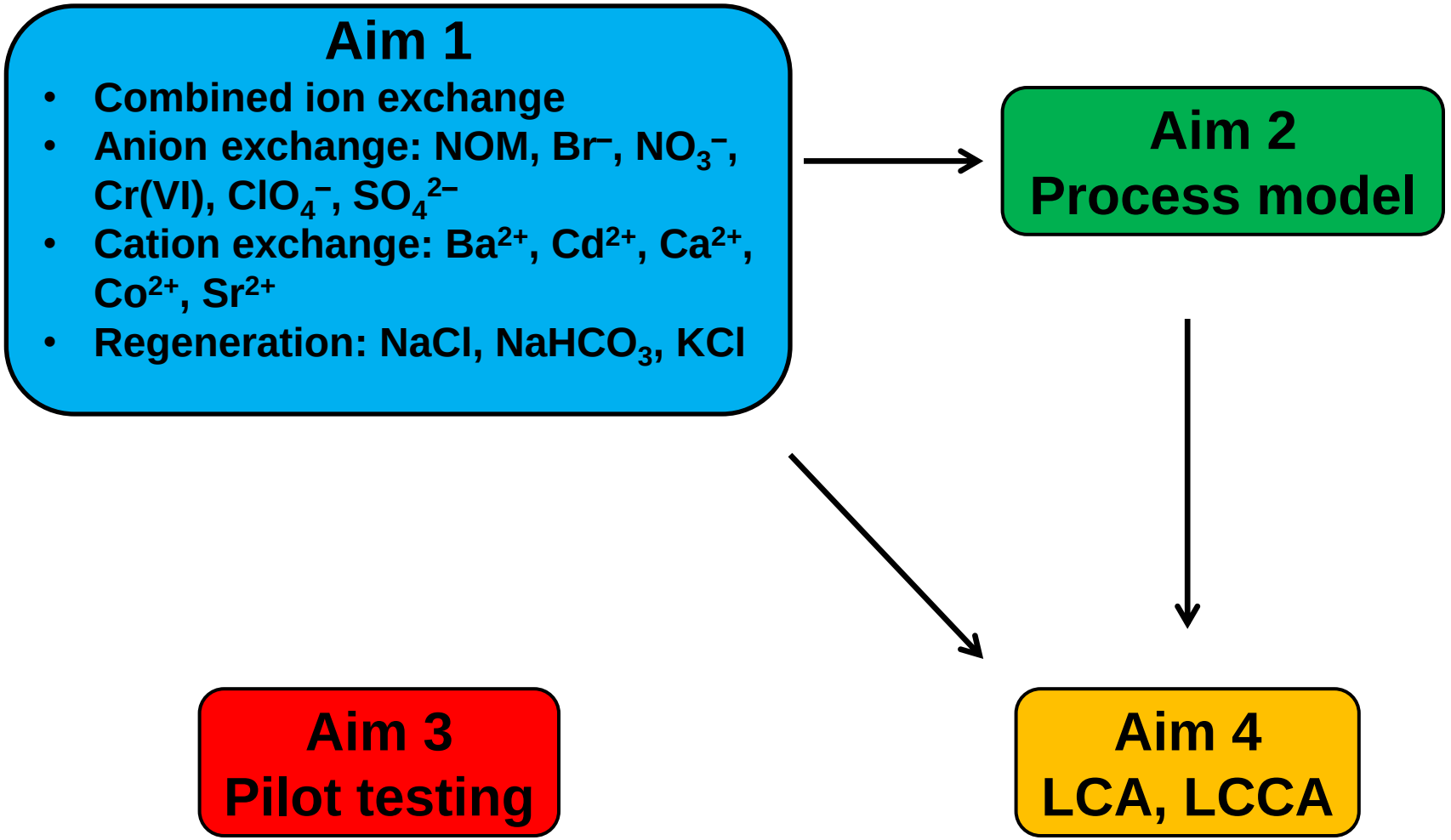
- Anion exchange/nitrate regeneration
- Impact: $KHCO_3$* > $NaHCO_3$* > KCl > NaCl
- *Polystyrene resin regeneration: Cl^- > HCO_3^-
- Does not include disposal

Aim 4



- Cation exchange/calcium regeneration
- Impact: $KHCO_3$ > $NaHCO_3$ ≈ KCl > NaCl
- Does not include disposal

Year 2


Aim 1
• Combined ion exchange
• Anion exchange: NOM, Br^-, NO_3^-, Cr(VI), ClO_4^-, SO_4^{2-}
• Cation exchange: Ba^{2+}, Cd^{2+}, Ca^{2+}, Co^{2+}, Sr^{2+}
• Regeneration: NaCl, $NaHCO_3$, KCl
Aim 2
Process model
Aim 3
Pilot testing
Aim 4
LCA, LCCA