AMERICAN RARE EARTHS

in Wastewater Treatment

Introduction

As clean water becomes increasingly vital, wastewater treatment facilities face mounting pressure to remove harmful contaminants—especially phosphorus (P), which typically enters water systems in the form of phosphate (PO_4^{3-}). When discharged in excess, phosphorus acts as a nutrient source for algae, triggering harmful algal blooms that release toxins, deplete oxygen, threaten aquatic life, and compromise drinking water safety.

To combat these environmental and public health risks, regulatory agencies are imposing significantly lower phosphorus limits on treated effluent. However, meeting these limits with traditional iron- or aluminum-based coagulants often requires high dosages, results in excess sludge generation, and may fall short of compliance goals.

Implementing **American rare earth products like SK300 and SK856** not only improves treatment outcomes but also reduces reliance on foreign-sourced wastewater chemicals. These next-generation coagulants, use lanthanum (La) and cerium (Ce)—two elements with a high affinity for phosphorus—sourced entirely from domestic U.S. deposits. These American rare earths offer greater purity and consistency while being produced under strict U.S. environmental and labor regulations, providing confidence in both performance and supply integrity.

Most rare earth-based treatment products today are imported from countries with limited oversight and volatile supply chains. **American-made solutions** offer a smarter alternative: high-performance options that support U.S. industry, ensure long-term reliability, and align with environmental stewardship and infrastructure resilience goals.

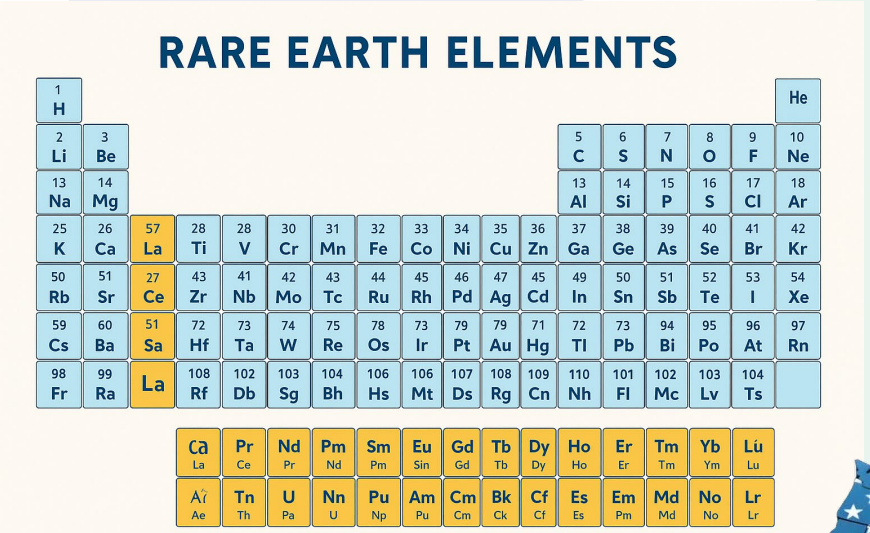
In addition to municipal applications, **rare earth coagulants like SK856** provide significant advantages for industrial wastewater treatment. In industries such as food processing, dairy, and pharmaceuticals, traditional coagulants can denature proteins, emulsify fats, and degrade valuable byproducts—making recovery and reuse difficult. By contrast, the rare earth chemistry in these products targets phosphorus without disrupting organic molecules, **allowing for the preservation and recovery of high-value components** such as proteins and fats. This enhances both the sustainability and economic value of industrial wastewater operations by enabling better resource recovery alongside regulatory compliance.

This paper outlines the chemistry, application, and environmental advantages of **American rare earth-based coagulants** for both municipal and industrial

wastewater treatment—and highlights how adopting these technologies supports a more sustainable, secure, and effective approach to phosphorus removal

American Rare Earth Chemistry in Wastewater Treatment

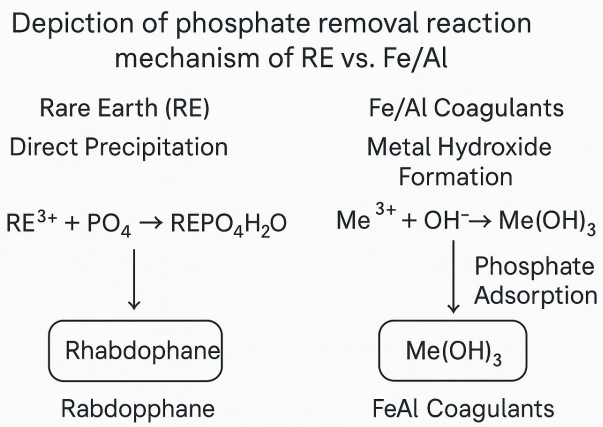
Rare earth elements (REEs), which include atomic numbers 57–71 and yttrium (Y, 39), have emerged as powerful tools for phosphate removal due to their strong affinity for oxyanions. Among them, lanthanum (La) and cerium (Ce) are especially effective, forming highly stable and insoluble compounds with phosphate, carbonate, hydroxide, and fluoride. With increased access to **American-mined rare earths**, facilities can now rely on a **domestic, secure, and more environmentally responsible supply chain**, reducing dependency on foreign sources while improving treatment performance.



Traditional coagulants like ferric or alum form metal hydroxides that adsorb phosphate onto their surfaces. However, REE-based coagulants like SK300/SK856 remove phosphorus through direct precipitation.

The reaction:

$$RE^{3+} + PO_4^{3-} \rightarrow REPO_4 \cdot H_2O$$



This forms rhabdophane—a naturally occurring, stable mineral. This reaction is highly favored, resulting in more efficient phosphorus removal with lower molar ratios (typically 1:1 RE:P vs. 2.5:1 for Fe or Al).

Furthermore, REEs in SK300 react with multiple anions commonly found in wastewater, such as carbonate (CO_3^{2-}), hydroxide (OH^-), and fluoride (F^-), forming similarly stable precipitates.

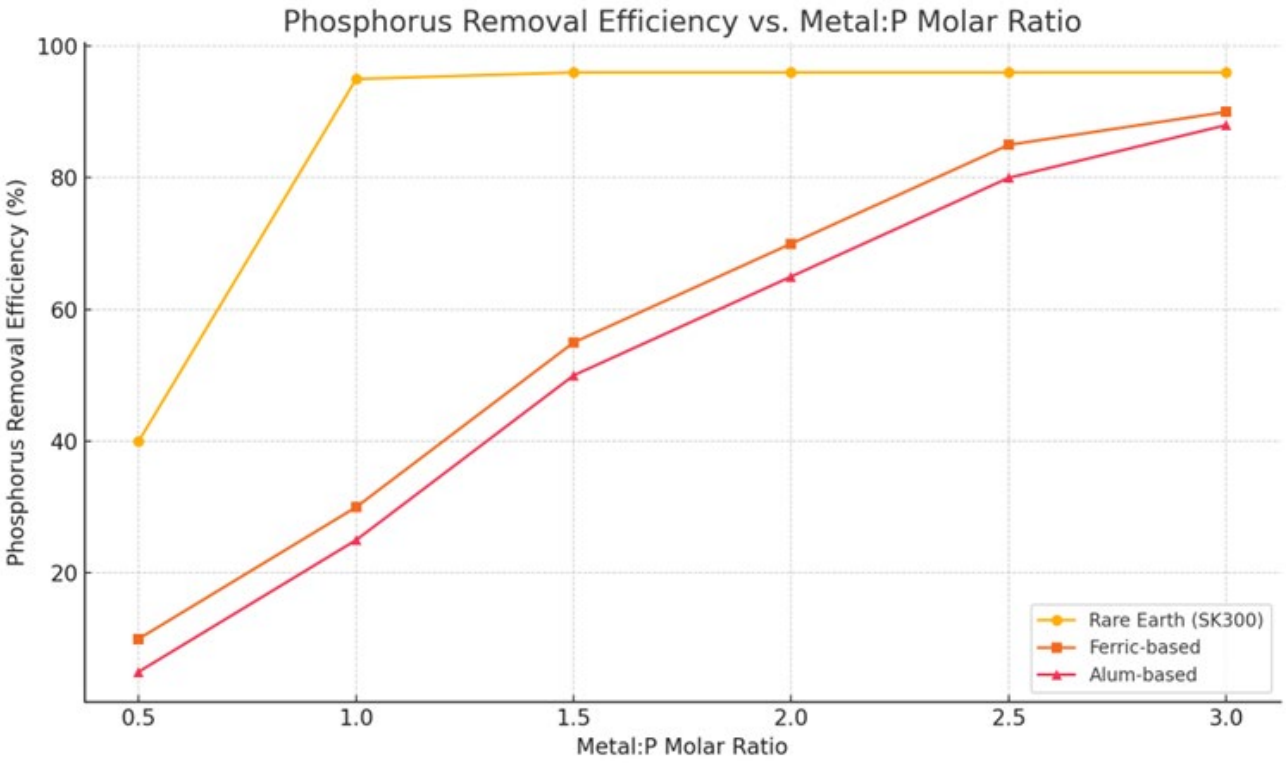
These reactions occur effectively within typical effluent pH ranges (6–9), and studies show that RE phosphate precipitates have extremely low solubility (Ksp ≈ 10^{-26}), making them more stable and less likely to re-dissolve.

This direct precipitation chemistry, combined with the high selectivity and lower required dosage, makes SK300 a uniquely powerful and efficient coagulant for phosphorus control and beyond.

Comparison to Iron and Aluminum Coagulants

SK300 achieves phosphorus removal at near 1:1 molar ratios of RE to P.- Iron and aluminum-based coagulants require at least 2.5:1 molar ratios.-

Lower dosage means less sludge, better settling, and fewer filtration issues.



Case Studies

Indiana Municipal Plant (2 MGD)

Faced with new ultra-low phosphorus limits (<0.075 mg/L), this Indiana facility previously relied on ferric and PAC, dosing 180 gallons per day. After switching to SK300:
- Effluent TP dropped below the permit limit within 7 days
- Coagulant usage reduced by over 80%, from 180 GPD to 35 GPD
- Estimated Annual Chemical Savings: $34,401
- Estimated Sludge Hauling Savings: $5,000
- Total Estimated Annual Savings: $39,401

Central Indiana Utility (3 MGD)

With seasonal phosphorus spikes reaching 5 mg/L, this plant struggled to maintain consistent compliance using ferric-based chemistry. During the SK300 trial:
- Effluent TP remained <0.075 mg/L throughout high loading periods
- Estimated Annual Chemical Savings: $24,911
- Estimated Sludge Hauling Savings: $7,000
- Total Estimated Annual Savings: $31,911

Southeastern Michigan Watershed Facility

Operating under dual constraints—<1.0 mg/L phosphorus and <1.1 mg/L aluminum—this facility found ferric and PAC ineffective due to aluminum discharge limits. After switching to SK300:
- Both TP and Al targets were met with moderate dosing
- Estimated Annual Chemical Savings: $30,842
- Estimated Sludge Hauling Savings: $9,000
- Total Estimated Annual Savings: $39,842

Metro Michigan Tertiary Filtration Plant (30 MGD)

Looking to improve performance without major infrastructure changes, this large tertiary plant transitioned from alum to SK300:
- Effluent TP improved from 0.09 mg/L to 0.07 mg/L
- Lower dose rates extended filter life and reduced operational strain
- Estimated Annual Chemical Savings: $142,350
- Estimated Sludge Hauling Savings: $25,000
- Total Estimated Annual Savings: $167,350

Toxicity and Environmental Safety

Since 2019, SK300 has been evaluated through comprehensive Whole Effluent Toxicity (WET) testing at more than 40 permitted wastewater facilities across the United States. WET testing, as regulated by the U.S. EPA, measures the aggregate biological effects of treated effluent on aquatic organisms, providing an integrated indicator of environmental safety.

Table II. LC_{50} Values of Al, Fe, and RE Coagulants for Aquatic Species

Coagulant	LC_{50} for *Daphnia magna**	LC_{50} for *Oncorhynchus mykiss* (rainbow trout)
Al	0.3–0.6	0.3–1.0
Fe	7.2	4.4–18.3
RE	9.2	107.3

Test Scope and Methodology:
Independent laboratories have assessed SK300 using multiple freshwater species commonly used in toxicity testing, including:

- *Ceriodaphnia dubia* (small water flea)
- *Pimephales promelas* (fathead minnow)
- *Oncorhynchus mykiss* (rainbow trout)

- *Daphnia magna* and other standard bioindicators

These species are tested under both:

- **Acute Conditions** – Short-duration exposure (24–96 hours) measuring lethal concentration thresholds (LC_{50})
- **Chronic Conditions** – Prolonged exposure assessing subtle biological impacts such as reproductive inhibition and reduced growth (NOEC/IC_{25} metrics)

Performance Summary:

- SK300 consistently meets WET testing benchmarks with no observable toxicity in either acute or chronic assessments.
- Residual concentrations of rare earth phosphate ($REPO_4$) in treated effluent remain below **12 mg/L**, comfortably under the EPA's ecological guidance limit of **14 mg/L**.
- Independent assessments confirm **no adverse effects on key microbial processes**, including nitrification and denitrification, with **EC_{50} values exceeding 1000 mg/L** for denitrifying organisms.
- In land application scenarios, **field studies show no impact on crop performance** or nutrient availability. Corn yield and phosphorus uptake remain unaffected when biosolids from SK300-treated effluent are applied to soil.

Conclusion:
The toxicological profile of SK300 supports its safe use in municipal and industrial wastewater systems. Its compatibility with aquatic ecosystems, microbial populations, and agricultural reuse applications makes it a strong candidate for facilities seeking to balance performance, compliance, and environmental responsibility.

Human Health Safety

The rare earth elements used in SK300—lanthanum (La) and cerium (Ce)—are supported by a robust body of toxicological data indicating **low human health risk** when applied in wastewater treatment. These elements, particularly in their phosphate-bound forms, are chemically stable, poorly absorbed, and non-toxic at environmental concentrations.

Lanthanum Carbonate and Medical Applications

Lanthanum carbonate has been approved by the U.S. Food and Drug Administration (FDA) as an oral phosphate binder under the trade name Fosrenol® for use in patients with chronic kidney disease [1]. The approval demonstrates that lanthanum compounds are considered safe for ingestion in medically vulnerable populations.

This therapeutic use also supports the conclusion that lanthanum poses minimal risk to human health under regulated exposure levels.

Insolubility and Low Bioavailability

Lanthanum and cerium phosphates ($LaPO_4$ and $CePO_4$) are **highly insoluble in water**, which substantially limits their environmental mobility and bioavailability [2][3]. Due to their chemical stability, they are not readily absorbed via dermal contact, ingestion, or inhalation under normal environmental exposure scenarios [4]. These insoluble forms also reduce potential for accumulation in food chains or drinking water supplies.

Toxicological and Genotoxicity Studies

Extensive toxicological evaluations have found **no evidence of genotoxicity, mutagenicity, or carcinogenicity** for lanthanum and cerium compounds when tested under OECD guidelines [5]. Subchronic and chronic studies in animal models show high NOAELs (No Observed Adverse Effect Levels), often at doses well above any expected exposure in wastewater treatment applications [6].

Occupational and Environmental Exposure Considerations

Neither lanthanum nor cerium phosphates are regulated as hazardous substances under OSHA or EPA regulations for typical end-use concentrations [7]. Airborne exposure limits (e.g., ACGIH TLVs) apply primarily in industrial manufacturing contexts, not in field applications such as wastewater coagulant dosing.

References

1. U.S. Food and Drug Administration. (2004). *Fosrenol® (lanthanum carbonate): Approval Package.* NDA #021468. https://www.accessdata.fda.gov
2. PubChem. (2023). *Lanthanum phosphate ($LaPO_4$).* National Center for Biotechnology Information. https://pubchem.ncbi.nlm.nih.gov/compound/Lanthanum-phosphate
3. ATSDR (Agency for Toxic Substances and Disease Registry). (2023). *Toxicological Profile for Rare Earth Elements (Draft for Public Comment).* U.S. Department of Health and Human Services. https://www.atsdr.cdc.gov

4. World Health Organization. (2011). *Rare Earth Elements in Drinking-Water: Background document for development of WHO Guidelines for Drinking-water Quality.*

5. Zhu, W., et al. (2005). “Toxicity and bioaccumulation of rare earth elements in zebrafish embryos.” *Toxicology and Applied Pharmacology*, 202(3), 301–311.

6. Oberdörster, G. et al. (1995). “Subchronic inhalation toxicity of cerium oxide in rats.” *Fundamental and Applied Toxicology*, 28(1), 53–65.

7. U.S. Department of Labor, OSHA. (2020). *OSHA Chemical Sampling Information: Lanthanum Compounds.* https://www.osha.gov

Conclusion

American rare earth products deliver superior phosphorus removal at lower doses with fewer operational challenges. Its ability to form highly stable precipitates, minimal environmental impact, and proven safety in agriculture make it a future-forward replacement for traditional ferric and alum coagulants. Made in the USA, SK300 also supports domestic manufacturing and supply chain resilience.