WRF 4973 Fact Sheet: ID 1850

Strategy: Chemical Savings

Reuse Chemical Sludge

Coeur d'Alene Tertiary MBR with Chemical Sludge Aging.
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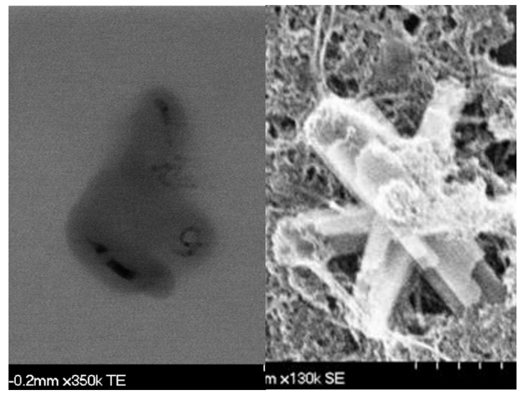

Image of Aged vs Fresh Chemical Sludge.
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Chemical use can be the source of significant operational costs at nutrient removal water resource recovery facilities (WRRFs) for nitrogen (N) and/or phosphorus (P) removal. Chemical sludges from the addition of alum or iron produce hydrous metal oxides (HMOs) that will form covalent bonds and tie up phosphate (PO_4). Because of this, these HMOs in the chemical sludge can be used to remove phosphorus at many locations within a WRRF process, including the primary clarifiers, secondary clarifiers, and/or solids processing, without requiring the addition of more chemicals. While the reuse of these HMO solids can help to attenuate variability in influent P concentrations and/or lower the amount of chemical needed for chemical P removal, removing phosphorus through the reuse of this chemical sludge will make the phosphorus unavailable for recovery.

This fact sheet series focuses on ways to reuse chemical sludge to optimize chemical addition at WRRFs. See the Additional Information section below for details about some approaches that can be used and the related fact sheets for more details.

Fact Sheet Application Checklist

R = fact sheet relevant to item
PR = fact sheet is potentially relevant to item depending on application, existing conditions, etc.

Category		Intensification
	R	Chemical addition
		Carbon management
		I&C strategies
		Sidestream mgmt.
		Energy savings
	R	Chemical savings
	R	Operational savings
		Other means of NutRem
Nutrient		Ammonia
		NOx
		TN
	R	Ortho-P
	R	TP
Scale (design flow)		Small (<1 mgd)
	R	Medium (1–10 mgd)
	R	Large (>10 mgd)

Goal	R	Improve reliability
	R	Reduce nutrient
	R	Reduce O&M cost
Group	R	Optimize existing CNR
	R	Optimize existing TNR
	R	NutRem in secondary plant
Process		Small
		Pond
	PR	Fixed film (secondary)
	PR	Conventional act. sludge (CAS)
	R	Nitrifying act. sludge (NAS)
	R	Conventional NutRem (CNR)
	R	Tertiary NutRem (TNR)
		Other

CAS = conventional activated sludge (BOD only)
NAS = nitrifying activated sludge (without denitrification)
CNR = conventional nutrient removal no chemical/no filter, etc.
TNR = tertiary nutrient removal with chemical, filter, etc.

Technology Summary Evaluation

Footprint	1	Compared to conventional (1 = much smaller; 3 = conventional; 5 = much larger)
Development status*	5	Technology ranking based (LIFT) see below*
Energy use	2	Scale 1–5: 1 = use much less; 3 = use similar to conventional; 5 = use much more
O&M cost	2	Scale 1–5: 1 = cost much less; 3 = cost similar to conventional; 5 = cost much more
Material/consumables	1	Scale 1–3: minimal = 1; some = 2; significant = 3 (e.g., UV lamps/membranes)
Chemical use	1	Scale 1–3: minimal/none = 1; some = 2; significant = 3 (e.g., chemical process)

* Technology ranking based on Leaders Innovation Forum for Technology (LIFT) Water Research Foundation (WRF) Technology Development Level (TDL) definitions:
1 = bench research and development
2 = small-scale pilot
3 = full-scale pilot (demonstration)
4 = pioneer stage (production and implementation)
5 = conventional

Descriptions/Evaluation

Strategy	Beneficial use of chemical sludge
Description	Chemical sludge generated from commonly used coagulants forms HMOs that remove orthophosphate (PO_4-P) through surface complexation covalent bonding. Aluminum addition produces hydrous aluminum oxides (HAOs) and iron addition produces hydrous ferric oxides (HFOs). Chemical sludge from tertiary or sidestream treatment can be returned to primary clarifiers to remove P in the clarifier. Similarly, if HMO sludges generated in water treatment plants are discharged into the collection system, those sludges will also precipitate the P on the HMOs.
Application	This is applicable at any WRRF with chemical sludge from metal salt addition for tertiary P removal or other sources (such as water treatment plants).
Constituents removed	PO_4-P, total suspended solids (TSS)
Development status*	LIFT TDL 5 The potential benefits of chemical sludge for P removal have been known and used in full-scale applications. P removal has been achieved unintentionally at many water reuse facilities that return alum or ferric solids from the tertiary treatment to the influent of the WRRF.
O&M considerations	Recycled tertiary clarifier or filter backwash solids will impact the receiving unit process: • Higher solids load on clarifiers or thickeners • Higher mixed liquor suspended solids (MLSS) when returned to biological nutrient removal (BNR) basins
Benefits	Fresh HMOs from iron (HFO) and aluminum (HAO) chemical sludge have significant P removal potential through surface complexation and covalent bonds. These HMOs can be used to remove PO_4-P in the influent, reject waters, or other locations. Along with providing more reliable or additional treatment, this strategy provides the additional benefit of reducing the chemical addition needed and lowering the chemical cost for the process. Reducing P at the preliminary or primary treatment process will improve the biochemical oxygen demand (BOD):P ratio and makes enhanced biological phosphorus removal (EBPR) more reliable. Using HMOs for P removal does not consume alkalinity at the point where HMOs are introduced. This strategy improves reliable performance in tertiary P processes with chemical sludge aging (maintaining a chemical sludge inventory).
Limitations	Chemical sludge retains the PO_4, making it unavailable for recovery.
Design considerations	Consider directing alum or iron sludge to a location with high PO_4 concentrations or where undesirable P release may occur (blend tanks, storage tanks, thickeners)
Potential fatal flaws	Chemical sludge retains the PO_4, making it unavailable for recovery and reducing the P recovery potential
Footprint requirements	None
Residuals	No changes overall. Only changes are in the sludge routing.
Cost considerations	Requires some capital investment and operational costs to return chemical sludge to the selected dose point.
Past experience	Coeur d’Alene, Idaho: designed chemical solids contact basin ahead of tertiary membrane process Las Vegas, Nevada: capture and return chemical sludge from filter backwash to primary clarifier

	Parkway Wastewater Treatment Plant, Washington Suburban Sanitary Commission (WSSC), Maryland: use upstream water treatment plant chemical sludge discharge into collection system to remove P
Publications	Benisch, M., D. Clark, and J.B. Neethling. 2013. "Tertiary MBR for Nitrification and Low Level Phosphorus Removal." Nutrient Removal and Recovery Conference. Vancouver, British Columbia: WEF/IWA. Bill, K., M. Benisch, H. Falconer, M-L. Pellegrin, H.S. Fredrickson, C. Fisher, B. Carleton, JB Neethling, and D. Clark. 2012. "Achieving ultralow phosphorus Concentrations Coeur d'Alene, Idaho, tests a tertiary membrane filter demonstration pilot system." www.wef.org/magazine August 2012: WE&T. Selock, K., C. Bott, and J.B. Neethling. 2008. "Achieving Limit of Technology for Effluent Total-Nitrogen and Effluent Total-Phosphorous at WSSC's Parkway Wastewater Treatment Plant." Presented in Workshop W101 at WEF's 81st Annual Technical Exhibition and Conference. Chicago, Illinois: WEFTEC.
Related fact sheets	1320: Chemical Phosphorus Removal 1630: Sidestream Phosphorus Treatment, Control, and Recovery 1801: Overview of Chemical Saving Strategies 1901: Optimize Operation and Maintenance
Date updated	9/10/2022
Contributors	Mario Benisch, Eric Evans, Justin Macmanus, JB Neethling, Anand Patel

Note

* Technology ranking based on LIFT WRF TDL definitions:
1 = bench research and development
2 = small-scale pilot
3 = full-scale pilot (demonstration)
4 = pioneer stage (production and implementation)
5 = conventional (https://www.waterrf.org/sites/default/files/file/2019-07/LIFT%20Scan%20Application-LIFT%20Link%2BHub_0.pdf : accessed September 2020)

Additional Information

Coeur d'Alene Case Studies

The City of Coeur d'Alene, Idaho, is facing very low effluent total phosphorus (TP) permit limits (0.034 microgram per liter [µg/L] based on predicted future flows) at its WRRF, which primarily consists of trickling filters and solids contact basins. To meet this limit, multiple chemical addition points and a tertiary polishing step have been integrated into this WRRF's treatment process. Normally, chemicals are added in the primary clarifier effluent, secondary clarifier feed, and tertiary treatment. Alum can also be fed at the headworks, primary clarifier influent or effluent, secondary clarifier, or tertiary treatment locations.

The tertiary treatment process consists of an alum feed, solids contact basin, and submerged microfiltration. The fed alum forms HAO flocs, which are captured through the microfiltration treatment step and returned to the solids contact basin from there. In doing so, the HAO chemical solids accumulate in the solids contact basin and provide a buffer for the influent PO_4. Prior testing showed that the chemical feed can be completely shut down for 3 days without having a significant, negative effect on the effluent TP concentrations (approximately 5%–10% increase in effluent TP without chemical addition).

The solids contact/microfiltration process also doubles as a nitrification bioreactor to meet effluent ammonia limits.

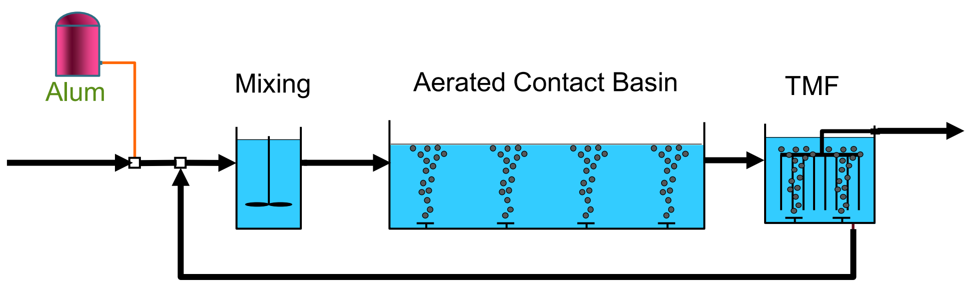

Figure 1. Coeur d'Alene Chemical Solids Contact Process to Meet Low P Limit Reliably.
Source: Printed with permission from HDR Engineering, Inc.

References

Benisch, M., D. Clark, and J.B. Neethling. 2013. "Tertiary MBR for Nitrification and Low-Level Phosphorus Removal." Nutrient Removal and Recovery Conference. Vancouver, British Columbia: WEF/IWA.

Bill, K., M. Benisch, H. Falconer, M-L. Pellegrin, H.S. Fredrickson, C. Fisher, B. Carleton, JB Neethling, and D. Clark. 2012. "Achieving ultralow phosphorus Concentrations Coeur d'Alene, Idaho, tests a tertiary membrane filter demonstration pilot system." www.wef.org/magazine August 2012: WE&T.

Abbreviations

µg	Microgram(s)
BNR	Biological nutrient removal
BOD	Biochemical oxygen demand
CAS	Conventional activated sludge: BOD removal only
CNR	Conventional nutrient removal
EBPR	Enhanced biological phosphorus removal
HAO	Hydrous aluminum oxide
HFO	Hydrous ferric oxide
HMO	Hydrous metal oxide
I&C	Instrumentation and controls
L	Liter(s)
LIFT	Leaders Innovation Forum for Technology (now RIC and RISE)
mgd	Million gallons per day
MLSS	Mixed liquor suspended solids
N	Nitrogen
NAS	Nitrifying activated sludge
NO_x	Oxidized nitrogen (nitrate + nitrite)
NutRem	Nutrient removal
O&M	Operations and maintenance
P	Phosphorus
PO_4	Phosphate
PO_4-P	Orthophosphate
RIC	Research & Innovation Committee
RISE	Research and Innovation for Strengthening Engagement
TDL	Technology Development Level
TN	Total nitrogen
TNR	Tertiary nutrient removal
TP	Total phosphorus
TSS	Total suspended solids
UV	Ultraviolet
WRF	The Water Research Foundation
WRRF	Water resource recovery facility
WSSC	Washington Suburban Sanitary Commission