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Phosphorus Removal in Wastewater Treatment Plants Utilizing USALCO 38 (liquid sodium aluminate, 38% solids)

INTRODUCTION

Phosphorus removal is an important aspect of municipal and industrial wastewater treatment. Regulatory agencies often require removal of 90% of the incoming phosphorus to a treatment plant and may also require a phosphorus concentration of no more than 1 mg/L (ppm) in plant effluent, particularly when treated wastewater is discharged to a small stream, lake or wetlands. Phosphorus is in short supply in the environment and, when discharged to natural waters, stimulates the growth of aquatic plants, at times to the detriment of the environment.

Detergents containing phosphate builders account for 50 to 70% of the phosphorus in domestic wastewater, the remainder comes from food and human wastes. Domestic wastewater contains between 3 and 15 ppm phosphorus, distributed as follows:

	ppm as P
Orthophosphate	50%
Polyphosphate	
Pyrophosphate	10%
Tripolyphosphate	30%
Organic Phosphates	10%

Contact with microorganisms in secondary treatment converts the polyphosphate fraction to orthophosphate; in this form, phosphate is readily chemically removed from wastewater.

USALCO 38 (liquid sodium aluminate, 38% solids) is a highly stable liquid sodium aluminate manufactured by USALCO. It is widely used throughout the United States and Canada as a chemical agent for the removal of phosphorus from wastewater. **USALCO 38**, in its liquid form, has the advantage of direct feed and does not require the addition of lime or caustic soda. Sodium aluminate combines with orthophosphate to form insoluble aluminum phosphate as a precipitate. It also reacts with water to form a variety of compounds that combine to form hydrous aluminum floc particles. Simplified chemical reactions for the two processes are as follows:

$$Al^{3+} + PO_4^{3-} \quad <=> \quad AlPO_{4(p)}$$
$$Al^{3+} + 3(OH^-) \quad <=> \quad AlOH_{3(s)}$$

At normal wastewater pH values the various aluminum hydroxide (hydroxo-aluminum) complexes become insoluble and aid in the removal of poorly settling aluminum phosphate, but the formation of aluminum hydroxide floc renders aluminum inaccessible for phosphate precipitation. Mixing, such as occurs in aeration basins, tends to liberate aluminum from the hydroxo-aluminum complexes and make it available for phosphate removal.

The fraction of aluminate combining with phosphorus or forming hydroxide flocs depends upon the rate of each reaction and the treated water's pH. Determining optimum sodium aluminate dosages for treatment or comparison with alum/lime and/or other treatment regimens requires laboratory testing. For sufficient phosphorus removal Al:P ratios between 1:1 and 2:1 are most common.

ADVANTAGES OF USALCO 38 TREATMENT

Cost Savings - Cost savings for wastewater treatment plants can come in two forms: 1) cost of chemical savings, and 2) operational savings.

First, because **USALCO 38** contains over twice the amount of active ingredient as alum (20% Al_2O_3 vs. 8.3% Al_2O_3) and over three times that of acidified alum (20% Al_2O_3 vs. 6% Al_2O_3), wastewater treatment plants converting to **USALCO 38** typically yield immediate chemical cost savings. In addition, because of **USALCO 38**'s high Al_2O_3 concentration, fewer chemical deliveries are required; therefore, less freight is incurred by the plant.

Second, because a **USALCO 38** treatment program will typically replace a coagulant (alum, ferric, etc.) *and* an alkali (lime, soda ash, and/or caustic) treatment program, unnecessary chemical feed equipment is eliminated; therefore, all of the costs associated with the operation and maintenance of this equipment is eliminated.

Reduced Sludge Generation - Because a **USALCO 38** treatment program will typically replace two chemicals (a coagulant and an alkali), the generation of solid residuals is greatly reduced. This can translate to dramatic cost savings in sludge transport and disposal.

Contributes Alkalinity - **USALCO 38**, unlike other coagulants, adds alkalinity to the treated water. Although **USALCO 38** can be used in conjunction with other treatment chemicals for pH control, it is most often used alone for phosphorus and turbidity removal, as well as pH control.

Efficiency - In a secondary treatment (or activated sludge) process, unreacted aluminate and/or insoluble hydroxo-aluminum compounds are "reused" for phosphorus removal via the recirculating sludge.

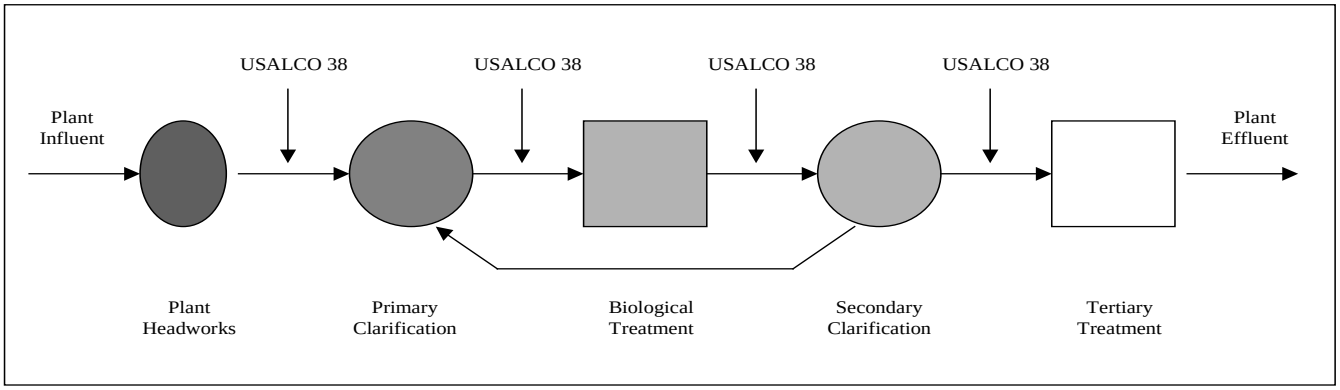
Improves Dewatering Characteristics - **USALCO 38** added to a secondary process increases sludge density, enhances settling and dewatering and, in most cases, reduces the plant's level of solids production.

Flexibility - **USALCO 38** may be used alone or in combination with other coagulants for phosphorus removal, pH control and flocculation.

CHEMICAL ADDITION

Phosphorus removal can be accomplished after the addition of **USALCO 38** liquid sodium aluminate in primary, secondary or tertiary clarifiers. Alternate locations for chemical addition are shown in **Figure 1**.

Figure 1



Primary Treatment Addition: Addition of **USALCO 38** at the inlet to a primary clarifier provides phosphate removal and increases the removal of suspended solids (turbidity) and BOD in the primary process. Chemical addition in primary treatment reduces solids and BOD loading in secondary processes and increases the volume of primary sludge.

Secondary Treatment Addition: After biological treatment, more phosphorus is in the orthophosphate form and total phosphate concentrations can be reduced to meet regulatory requirements. At secondary treatment facilities, **USALCO 38** is added either at the inlet to an aeration tank, or at some point in the aeration tank, or at the upstream end of the aeration tank effluent channel. This permits adequate mixing and formation of aluminum phosphate precipitate. There are distinct advantages of chemical addition at these locations and of using **USALCO 38** in particular.

Tertiary Treatment Addition: If a plant has tertiary or nitrification processes, **USALCO 38** can be added at the inlet to the aeration tanks. This enhances aluminum phosphate formation and results in excellent phosphorus removal and chemical/biological floc settling characteristics.

CHEMICAL DOSAGE

Initial Plant Dosages for Start-Up: A 24-hour composite sample is collected and total phosphorus concentration should be determined by laboratory analysis. **USALCO 38** dosage can be determined by utilizing the following example procedure and the calculations in **Table 1**.

Example:
Assume that a waste water treatment plant processes 2 million gallons of water per day (MGD) with an initial (total) phosphorus concentration is 11 ppm, and a final desired phosphorus concentration of 1 ppm (a reduction of 10 ppm). Assume also that the initial desired concentration of aluminum to phosphorus is 2:1.

Table 1

Wt. Of P/day:	=	2 MGD x (10 ppm) x (8.34 lbs/gal)
	=	**167 lbs/day**
Al Atomic Wt.:	=	27 g/mole
P Atomic Wt.:	=	31 g/mole
Al_2O_3 Atomic Wt.:	=	102 g/mole
% Al_2O_3 in **USALCO 38**		20%
USALCO 38 Density	=	12.3 lbs/gal
Desired Al:P ratio:		2
Required Al/day:	=	(Wt. Al) ÷ (Wt. P) x (Al:P ratio) x (lbs P/day)
	=	27/31 x 2 x 167
	=	**291 lbs/day**
% Al in **USALCO 38**	=	{[2 x (Wt. Al)] ÷ (Wt. Al_2O_3) x (% Al_2O_3 in **USALCO 38**)} x 100
	=	2 x 27/102 x 0.20 x 100
	=	**10.6%**
USALCO 38 Dosage:	=	(Wt. Al/day) ÷ [(Wt. **USALCO 38**/gal) x (% Al in **USALCO 38**)]
	=	291/(12.3 x 0.106)
		223 gallons/day