Wat. Sci. Tech. Vol. 27, No. 11, pp. 261–264, 1993.
Printed in Great Britain.

0273–1223/93 $24·00

COMPARISON OF LIME AND ALUM TREATMENT OF MUNICIPAL WASTEWATER

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ABSTRACT

The performance of lime alum as coagulants in municipal wastewater treatment are examined.

KEYWORDS

Alum, coagulation, lime, municipal wastewater.

Over the years a number of different substances have been used as a coagulants, the most common being alum, ferric chloride, ferric sulfate and lime.

When lime is added to wastewater, calcium precipitates as a dense crystalline solid with low and negatively charged surface area. Organic contaminant removal from wastewater proceeds by colloid destabilization and precipitation. Also, a complex array of chemical reaction such as precipitation of phosphates, heavy metals and magnesium in addition to microorganism removal takes place (6,7).

When alum is used as a coagulant a different distribution of the contaminant removed compared with that obtained by lime as can be expected as a result of the higher surface area of aluminium hydroxide flocs having neutral or positive charge and different precipitation reactions taking place (7).

In this work the removal of COD, phosphate, magnesium, alkalinity and total dissolved solids from municipal wastewater was comparatively studied for both lime and alum. Floc removal were achieved by sedimentation and dissolved air-flotation (DAF) in a continuous operation. DAF process is described elsewhere (3).

The diagram of the apparatus is shown in Fig 1. In the experimental part coagulant was dosed to a continuous flow of sewage (untreated or secondary effluent) under mixing for 1-2 minutes and then settled for 1-2 hours previous to a DAF. Composite samples were taken from inflow and final effluent water and analyzed according to standard methods (1). The total primary and froth sludge volume produced and its solid concentration in each experiment were also measured.

In all experiments floc formation were observed immediately after mixing. The settling was fast with a supernatant exhibiting variability in suspended solids. In the flotation cell the residence time varied between 10 to 12 minutes, the recirculation ratio (R/Q) between 0.09 to 0.2 and the saturator gauge pressure fixed at 3.2 bar. These parameters are discussed elsewhere (3). The float layer was removed periodically by vacuum as illustrated in Fig 1.

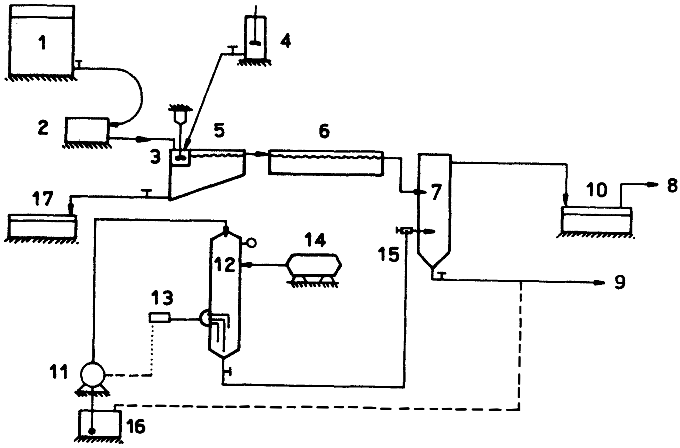

Fig 1. Schematic diagram of experimental apparatus 1)Storage vessel 2)Peristaltic pump 3)Stirred vessel 4)Lime or alum vessel 5)Settler 6)Holding vessel 7)Flotation cell 8)To vacuum 9)Final effluent 10)Froth vessel 11)Metering pump 12)Saturator 13)Level control 14)Air compressor 15)Needle valve 16)Recirculating vessel 17)Sludge vessel.

Higher suspended solids removal efficiency by DAF were observed for alum flocs (Fig 2). This implies a better bubble to floc attachment or/and lower density than lime flocs. The existing relationship between floc effective density and its diameter (9) by which density decrease as particle size increase, and the lower SS removal efficiencies observed by DAF at low SS (Fig 2), suggest that bubble entrapment is an important mechanism for bubble-floc attachment, specially for large flocs which would exhibit larger internal void cavities. Since lime flocs have low surface area entrapment would probably not play any significant role in flotation. For alum extensive evidence exists supporting the fact that organic matter removal by alum is mainly due to adsorption on aluminium hydroxide surface flocs favouring a surfactant action (4,7).

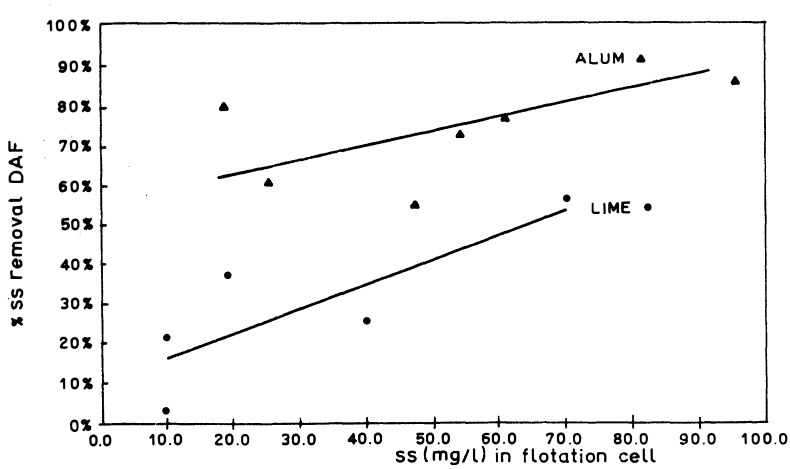

Fig 2.- Suspended solid removal by alum or lime combined with DAF

Although low floc density is a desirable characteristic to increase DAF performance, a particular problem concerning handling larger sludge volume arises as a result. In fact, for alum a concentration of 7 mg/l for froth sludge was obtained in comparison with 40 mg/l for lime. Settler and froth sludge did not differ in solid concentration.

Table 1. Raw wastewater treatment by coagulant and DAF. In each run a common batch of secondary effluent or raw sewage was used in experiments with lime and/or alum. Dos: coagulant dose, RT: retentiom time, SS: suspended solids, COD: chemical oxygen demand, Phos: phosphate Mg:magnesium, Alk: alkalinity, **Cond: conductivity.**

Temp: 23 - 24 ^{o}C									
Proc	**Dos**	**RT**	**pH**	**SS**	**COD**	**Phos**	**Mg**	**Alk**	**Cond**
	mg/l	**hour**		**mg/l**	**mg/l**	**mg/l-P**	**mg/l**	**mg/l**	**μmho/cm**
RUN#1									
Raw sew.			7.5	83	243	15.5	24	188	1567
LIME	700	1.5	10.9	24	120	0.1	2.5	230	-
ALUM	500	1.5	5.5	21	122	1.1	9.5	54	1475
ALUM	500	24	6.8	9	53	0.3	9.0	-	1431
RUN#2									
Raw sew.			8.3	175	602	17	18	260	1560
LIME	800	2	11.1	51	270	1.5	2.8	420	2090
LIME	800	24	10.5	23	250	0.05	2.2	240	1239
LIME	800	48	8.8	23	241	0.04	2.5	120	1187
RUN#3									
Sec.ef.			7.0	18	62	-	11.3	168	829
LIME	600	2	10.9	38	31	-	2.5	226	1221
ALUM	270	2	5.5	21	23	-	9.5	39	900
RUN#4									
Sec.ef.			7.1	19	79	4.3	19	234	1297
LIME	500	2	11.1	23	42	0.1	1	300	1847
LIME	500	24	10.2	7	42	0.05	0.5	76	980
ALUM	600	2	4.9	15	42	1.1	15	-	1249
RUN#5									
Raw sew.			7.6	123	332	13	23	208	1552
ALUM	890	2	5.8	12	124	0.9	12	54	1509
ALUM	890	24	7.1	-	-	-	-	-	1514

According to the results (some of them indicated in table 1) different distribution of contaminant removed is observed. Alum is slightly better than lime to remove COD, but lime performs better than alum in removing phosphate and magnesium. The disadvantage of lime is the high pH of the treated water. More than 48 hours under quiescent condition, were needed to bring the pH from 11 to 8. Lime is quite unique among coagulants for its ability to remove total dissolved solids. Alum, on the other hand although it removes dissolved compounds, sulfate ions remaining in solution tend to increase the total dissolved solids concentration.

From table 1 it is seen that most of the COD, phosphate and magnesium is removed in the first 2 hours when lime is used. Subsequent removal by longer retention time in the holding vessel (Fig 1) is not significant.

Two aspects of importance related to these results are: a) removal of contaminants by mechanism of sweep coagulation of $CaCO_3$ and adsorption-coagulation of stable colloids by $Mg(OH)_2$ (5), b) inhibition of residual calcium carbonate precipitation by phosphate which explain the long time required for pH stabilization (8). In this respect higher contaminant removal or/and faster stabilization for lime treated wastewater could be achieved if lime is combined with previous step using a coagulant to remove phosphate whereas keeping precipitation of magnesium at a minimum level. Alum as it is seen in table 1, is a coagulant that produces such a result.

The hypothesis above indicated was verified in several experiments, where alum treated effluent was further treated with lime. For example, alum treated effluent from RUN#1 was dosed with 400 ppm of lime (pH 10.7), settled and kept under quiescent conditions for 24 hours. During this period pH dropped to 8.1 with a SS and COD of 2.6 and 31 mg/l respectively. Phosphate and magnesium were not detected. The low values of SS and COD achieved, suggest that colloidal destabilization ability of the magnesium hydroxide in primary lime treatment of wastewater, is also inhibited by the presence of phosphate.

It is interesting to note that complete color elimination of secondary effluents, was achieved only by alum coagulation. In this respect, it is known that color in biologically treated sewage effluents is produced by the presence of certain humic substances which can be removed in great extent by coagulation with alum (2).

Conclusions

No significant superiority as a wastewater coagulant-flocculant for alum or lime is concluded when coagulation is combined with DAF. However, in light of the advantages and disadvantages concerning selective removal of contaminants from municipal wastewater, inhibition of precipitation reactions, DAF efficiency and sludge characteristics, lime and alum can be combined in order to further improve effluent quality.

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