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John W. Koenst and Doye E. Blane

April 30, 1976

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Miamisburg, Ohio

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Abstract

A series of tests was run on influent to the waste treatment facility, using various polyelectrolytes and organic polymeric coagulant aids. The influent wastewater originates in chemical process areas, janitorial sinks, process-area locker room showers, floor drains, and from the laundry. Previous tests on this waste had shown that Fe^{+3} and Ca^{+2} at pH 11.3 gave improved product quality. However, a suitable coagulant aid for use at high pH's was needed to obtain a rapid settling rate in the flocculation/sedimentation process. Results of the tests showed that Nalco-C627 gave a good decontamination factor while yielding rapid settling rates. Betz-1175 gave the best decontamination factors; however, its settling rate needs to be improved. Test results revealed decontamination was greater at pH 11.3 than at pH 10.1. It is recommended at this time, that Nalco-C627 be used with the Fe^{+3} , Ca^{+2} high pH system, and that further tests be performed on the Betz-1175.

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Introduction

Impurities in water vary in size by at least six orders of magnitude, namely, from a few Angstroms (for soluble substances) to a few hundred microns (for suspended materials). The removal of large portions of these impurities in wastewater treatment is accomplished by sedimentation. However, because many of the impurities are too small for gravitational settling alone to be an effective removal process, the aggregation of these particles into large, more readily settleable, aggregates is essential for successful separation by sedimentation. This process of aggregation is termed coagulation.

Recognition that the success of other processes for wastewater treatment often involves or depends upon successful coagulation has stimulated a considerable amount of research on this process in the past two decades. New concepts have been developed, and a large quantity of laboratory and field data have been obtained. Of principal importance are the new coagulants that have been developed. These materials are synthetic organic polymers having high molecular weights. The application of these new concepts and new materials constitutes a major contribution to the technology of wastewater treatment.

The aggregation of colloidal particles involves two separate and distinct steps: 1) particle transport to effect interparticle contact, and 2) particle destabilization to permit attachment when contact occurs. Theories of particle transport are based on fluid and particle mechanics; theories of particle destabilization are based on colloid and surface chemistry. The design of structures and flocculation equipment for a coagulation process is influenced by a consideration of interparticle contacts; the selection of the type and dosage of coagulant is based on a consideration of particle destabilization. The design of the overall coagulation process must provide for both of these steps.

Despite attempts to apply theory to practice, coagulation remains as much of an art as a science. Theories from the fields of colloid chemistry and fluid mechanics cannot be used alone in the design of coagulation processes; experience and experiments are also required.

Mound Laboratory Waste Disposal System

The radioactive waste disposal system currently in operation at Mound Laboratory is the same one originally initiated when the Laboratory first started in October 1948. Initially, this process was developed at Mound for the removal of ^{210}Po ; however, at this time, the main contaminant is ^{238}Pu . The treatment process consists of coagulation, sedimentation, and rapid-sand filtration.

1. Coagulation and Settling Coagulation involves the formation of chemical flocs that bring together finely divided suspended matter. The addition of coagulants will result in the precipitation of some of the soluble constituents in the waste as metal hydroxides. Coagulation is effective for the removal of most cations of valence 3, 4, or 5, including the rare earths group, and is not effective for the removal of elements of Groups IA and IIA. Coagulation is more effective in removing particulate associated radioactivity, as for example, radioactivity associated with the turbidity found in most wastewaters. Organic polyelectrolytes are added to aid in settling the floc. The removal of soluble, radioactive, organic complexes, (those adsorbable on carbon) may be enhanced by the addition of activated carbon with the usual coagulants and coagulant aids.

2. Rapid Sand Filtration Except for removal by simple straining or by sorption, sandfilters have been ineffective for removing radioactive materials. Their major function is to remove the radioactivity previously incorporated in the floc. In order to aid filtration and to give supplemental adsorption, activated carbon is added prior to the sandfilter.

The influent wastewater originates in chemical process areas, janitorial sinks, process-area locker room showers, floor drains, and from the laundry. From all of these sources, the wastewater flows to one of four 30,000-gal influent holding tanks. The pH of the waste stream ranges from 6 to 8, and the radioactivity level averages about 5000-10,000 dis/min/ml. At the present time, about 12,000-15,000 gal of influent wastewater are processed per day. Since the waste disposal system at Mound Laboratory has

not been significantly modified in over 20 yr, it was decided to study a modification to the present process that would include treatment at a higher pH (from 8 to 11.3) along with the use of an alternate polymeric coagulant aid (since the presently used coagulant aid is ineffective at pH greater than 10). This modification should reduce the amount of sludge generated and improve effluent quality.

Dosage and Process Control The quality of treated water and the costs of chemicals for its production are dependent on proper control of the coagulation-flocculation process. Laboratory and in-plant control are essential to proper coagulation treatment for two basic reasons: first, plants that employ coagulation usually treat waters that may be subject to wide variations in quality; and second, the best and most economical treatment of such waters cannot be predicted from known relationships but must be checked by one or more testing or monitoring techniques. Coagulation and flocculation of wastewater are influenced by a number of interrelated factors such as pH, color, turbidity, mineral content and composition, temperature, and duration and degree of agitation during flocculation, and finally, the characteristics of the

coagulant or flocculation aid in use. Unfortunately, the optimum conditions for coagulation cannot be determined from the results of a chemical and physical analysis of the wastewater but must be determined empirically.

The single most widely used test to determine dosage and other parameters at Mound Laboratory is the "jar test." The jar test attempts to simulate the full-scale coagulation-flocculation process and has remained the most common control test in this laboratory since its introduction. The jar test simply consists of a series of sample containers, the contents of which can be stirred by individual mechanically-operated stirrers. The wastewater, which is to be treated, is placed in the container; and the treatment chemicals are added while the contents are being stirred. After a short (1 to 5 min) period of rapid stirring, to ensure complete dispersion, the stirring rate is decreased and flocculation is allowed to continue for a variable period (10 to 30 min or more). The stirring is then stopped, and the flocs are allowed to settle for a selected time. The supernatant is then filtered (to simulate sand-filter operation) and analyzed for a variety of parameters.

Results

A series of tests were run on raw influent using various polyelectrolytes and organic polymeric coagulant aids. Previous tests had shown that Fe^{+3} and Ca^{+2} at pH 11.3 gave improved effluent quality (Table 1). However, for comparison purposes, alum (Al^{+3}) treated influent was tested at pH 6.3 and 4.8 with such coagulant aids as aluminosilicate complex (expressed in ppm SiO_2), cationic polymeric coagulant aids, and nonionic polymeric coagulant aids (Tables 2 and 3). Using various polymeric coagulant aids (Tables 2 and 3), to improve performance of the process and to find a suitable coagulant aid at the higher pH's, Fe^{+3} and Ca^{+2} were evaluated at pH 11.3 and 10.1. The alum results were disappointing in that decontamination factors were quite low (ranging from a low of 51 to a high of 1183); also, settling rates were very slow and the supernatant remained slightly turbid. As a result, further work with alum was discontinued. Iron (Fe^{+3}) and calcium (Ca^{+2}) without any coagulant aids gave a DF ~3670, which was then used as a basis for evaluating the performance of coagulant aids. Iron and calcium by themselves, however, gave a slow settling rate to the floc. The best settling rates were obtained with Nalco-C627 combined with DOW-N20 (DF=7339). Using Nalco-C627 as the

sole coagulant aid with Fe^{+3} and Ca^{+2} , gave a DF=13,333 along with a good settling rate. However, the supernatant had a slightly cloudy appearance, which was subsequently filtered out by the 2 μ filter. Tests revealed decontamination at pH 11.4 was greater than at pH 10.1, using the same coagulant aids. DF's obtained were DF=3126 at pH 10.1 and DF=7340 at pH 11.4. Both tests were run on the same influent feed, using Nalco-C627 and DOW-N20 as coagulant aids. The best decontamination factors were obtained using Betz polymers. Betz-1190 demonstrated a DF-168,800, whereas Betz-1175 resulted in a supernatant that measured less than background. However, the two Betz polymers settled at a slower rate than the Nalco-C627. The settling rates of the Betz polymers were, however, greater than that of Fe^{+3} and Ca^{+2} without coagulant aid.

In summary, it is recommended that Nalco-C627 be used with the high pH (Fe^{+3} , Ca^{+2}) system. However, clarifier performance (with respect to sludge settling characteristics and carry-over) and filter performance (with respect to removal of the remaining cloudy appearance in the supernatant) will be carefully monitored. Also, further studies on improving the settleability of the Betz-1175 (without greatly sacrificing DF) will be continued.

Table 1

RESULTS OF ELEVATED pH TREATMENT

<u>Feed</u>	<u>pH</u>	<u>Filtration</u>	<u>Final Effluent (dis/min/ml)</u>
Effluent from Mix Box	6.7	9 in. sand	4.1
Supernatant from Clariflocculator (Elevated to pH 11.3)	11.3	9 in. sand	0.46

Table 2

COAGULANT AIDS USED IN TREATABILITY STUDY

Actasol	Complex aluminosilicate form (reported as SiO_2)
Betz 1175	High molecular weight, strongly cationic, organic polyelectrolyte
Betz 1190	Strongly cationic, polymeric polyelectrolyte
Dow C31	High molecular weight, cationic, organic polyelectrolyte
Dow N20	High molecular weight, nonionic, organic polyelectrolyte
Nalco C610	Cationic, organic polyelectrolyte
Nalco C627	Cationic, organic polyelectrolyte

Table 3
TREATABILITY STUDY

Test No.	Date	Raw Influent Counts (dis/min/ml)	Initial pH	Electrolytes (ppm)	Coagulant Aids (ppm)	Adjusted pH	Supernatant after settling and 2 μ Filtration (dis/min/ml)	DF = $\frac{\text{Influent Counts}}{\text{Supernatant Counts}}$
1	4/29	2000	7.5	Al ⁺ ³ (100)	SiO ₂ (30)	6.2	2.02	990
2	4/29	2000	7.5	-	-	-	39.33	51
3	4/29	2000	7.5	Al ⁺ ³ (100)	-	6.3	1.69	1183
4	4/29	2000	7.5	Al ⁺ ³ (100)	SiO ₂ (30) C31 (5) N20 (7)	4.8	7.28	275
5	4/29	2000	7.5	Fe ⁺ ³ (100) Ca ⁺ ² (200)	C610 (10)	11.35	0.6	3333
6	4/29	2000	7.5	Fe ⁺ ³ (100) Ca ⁺ ² (200)	C627 (20)	11.35	0.15	13333
7	4/29	Added 2 ppm N20 to No. 6 and remixed					0.5	4000
8	4/29	2000	7.5	Fe ⁺ ³ (100) Ca ⁺ ² (200)	SiO ₂ (50)	11.35	0.37	5405
9	4/30	1688	8.1	Fe ⁺ ³ (100) Ca ⁺ ² (200)	C627 (10) N20 (2)	11.4	0.23	7339
10	4/30	1688	8.1	Fe ⁺ ³ (100) Ca ⁺ ² (200)	Betz 1190 (20)	11.4	0.01	168800
11	4/30	1688	8.1	Fe ⁺ ³ (100) Ca ⁺ ² (200)	Betz 1175 (20)	11.4	<Background	∞
12	5/1	1688	8.1	Fe ⁺ ³ (100) Ca ⁺ ² (200)	-	11.4	0.46	3670
13	5/1	1688	8.1	Fe ⁺ ³ (100) Ca ⁺ ² (200)	C627 (10) N20 (2)	10.1	0.54	3126
14	5/1	1688	8.1	Fe ⁺ ³ (100) Ca ⁺ ² (200)	Betz 1175 (20) N20 (2)	11.4	0.18	9378

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